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EFFECTS OF USING CHATGPT ON WORKING MEMORY PERFORMANCE FROM THE PERSPECTIVE OF UNIVERSITY STUDENTS

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ABSTRACT

This study identified the effects of using ChatGPT on working memory performance from the perspective of university students. The study sample comprised 220 university students in the second and third levels at the Faculty of Education, Helwan University, (n=73, 32.2%) males, (n=147, 66.8%) females, with a mean age and standard deviation of 19.72 and 2.39, respectively. The study used a self-constructed questionnaire for data collection; this questionnaire comprised the positive and negative effects of using ChatGPT on working memory performance. Results showed the existence of many positive effects of using ChatGPT on working memory performance from the perspective of university students, which were presented in providing diverse solutions to problems and academic tasks, performing academic duties, and saving time and effort. The findings also indicated the existence of some negative effects, especially in remembering steps, numbers, and details after completing the required task, and in general, the occurrence of negative effects on working memory performance in the long term owing to continuous reliance on ChatGPT for educational tasks, Also results showed that the majority of participants (88.2%) use GBT chat daily, with multiple uses including studying and daily life (58.2%). The study findings are useful for retailing the positive and negative effects from the perspective of university students, drawing the attention of educators, university faculty, and artificial intelligence program developers to these effects, to work on formulating a strategy for using artificial intelligence tools in the educational process, especially those that directly affect the working memory performance of university students.

KEYWORDS: Effects of using, ChatGPT, working memory, university students.

1. INTRODUCTION

Working memory is central to the cognition required for university studies, owing to its functions in encoding, storage, retrieval, and processing. Feldman (2007) defined working memory as a temporary storage unit processing and retrieving information practically and quickly; the central executive is the most essential element in this memory type because it coordinates three types of information: verbal, visual, and event-based. Thus, working memory organizes the information from the surrounding environment through senses and information retrieved from long-term memory for decision-making and problem-solving (Al-Hammouri & Khasawneh, 2011).

The end of 2022 marked a notable technological milestone with the public release of the generative pre-trained transformer chatbot, ChatGPT. This artificial intelligence (AI)-driven system is capable of generating contextually relevant and human-like responses to a wide range of user queries. Owing to its widespread accessibility and multilingual capabilities, ChatGPT has reduced several barriers to technology adoption, particularly within educational environments among both instructors and students (Bucaioni et al., 2024; Mizumoto & Eguchi, 2023). Consequently, the integration of generative AI tools into higher education has introduced both promising opportunities and emerging challenges, as students and faculty increasingly explore their potential to enrich learning experiences, facilitate knowledge acquisition, and enhance academic performance (Rojas, 2024).

Due to the numerous advantages offered by ChatGPT, its use by both students and teachers within the educational process has increased considerably. Several studies have explored its potential in enhancing learning outcomes. For instance, Al-Amr and Al-Dahlan (2025) employed ChatGPT to support the development of understanding, analysis, and representation of mathematical concepts among a sample of ninth-grade students in Saudi Arabia. Their findings indicated that the use of ChatGPT was effective in improving students' comprehension of mathematical concepts. Moreover, ChatGPT contributes to saving time and effort while also enhancing students' academic self-efficacy and academic self-esteem. As a result, both researchers and students have increasingly relied on ChatGPT to perform a variety of academic tasks, including generating ideas, summarizing scholarly literature, and composing academic essays (Bin-Nashwan et

al., 2023).

For instance, Darif and Obeidi (2023) reported that translations generated by ChatGPT closely resemble those produced by human translators. This similarity can be attributed to its reliance on advanced deep learning mechanisms and deep neural networks, which enable the system to generate linguistically accurate and contextually appropriate translations. Consequently, ChatGPT has emerged as a valuable tool in the field of translation.

The broad range of information provided by ChatGPT—whether related to academic content, completing assignments, solving tasks, or language learning—offers students access to diverse, extensive, and accurate knowledge. Such features highlight its growing importance and facilitate its widespread use among students across different educational levels. However, many of these academic tasks rely heavily on cognitive processes, particularly working memory. Therefore, it is reasonable to expect that the increasing use of ChatGPT may influence the functioning of working memory during task performance.

2. LITERATURE REVIEW

2.1. ChatGPT

ChatGPT is an advanced chatbot built on OpenAI's generative pre-trained transformer architecture, specifically the GPT-3 family of large language models, and has been further refined through supervised learning and reinforcement learning techniques (Hong, 2023). Currently, ChatGPT is considered one of the most sophisticated AI-powered conversational systems available. It was developed by the Microsoft-backed research organization OpenAI and officially launched in November 2022 (Al-Obaydi et al., 2025).

The GPT series developed by OpenAI includes several successive models, such as GPT-1, GPT-2, GPT-3, and GPT-4. These models are based on a machine learning architecture known as the transformer, which relies on self-attention mechanisms to process and generate predictions from large volumes of textual data. Additionally, these models employ a combination of large-scale pretraining and subsequent fine-tuning to improve performance across various tasks (Bai et al., 2023).

As an important AI-based educational tool, ChatGPT has been designed to assist users in addressing cognitive challenges and supporting diverse learning styles (Fitria, 2023). In recent years, research examining students' attitudes toward the use of artificial intelligence tools, including

ChatGPT, has indicated generally high levels of satisfaction and positive perceptions regarding their use in academic contexts (Pikhart *et al.*, 2024; Song & Song, 2023; Van Horn, 2024).

Similarly, Ajloun *et al.* (2023) conducted a survey involving 623 university students in Jordan to examine their perceptions of the ease of using ChatGPT. The findings revealed that participants held positive attitudes toward its usability and expressed a strong willingness to adopt it as an important tool within the educational process. Likewise, students at the Arab East College for Graduate Studies demonstrated favorable attitudes toward the integration of ChatGPT into their academic environment. However, they also emphasized the need to address certain challenges that may hinder the effective utilization of ChatGPT in educational settings (Al-Omran & Jadu, 2024).

Students' sense of satisfaction with ChatGPT appears reasonable given the wide range of support it provides across various learning contexts. The system delivers information rapidly, offers access to multiple sources of knowledge, and allows users to compare and refine information according to their preferences. Moreover, ChatGPT provides speed and accuracy while enabling users to either summarize or expand information as needed, thereby granting learners greater autonomy and flexibility in managing their learning processes. Through continuous interaction and feedback, ChatGPT also promotes self-directed learning and contributes to the development of students' skills and competencies, ultimately enhancing the overall learning experience (Mizumoto & Eguchi, 2023; Xiao & Zhi, 2023).

Similarly, Solak (2024) reported that ChatGPT can improve the learning process by supporting both academic engagement and learners' psychological well-being. In particular, it enhances communication opportunities for students, especially introverted learners who may find direct interaction in traditional educational environments challenging. In the same context, Al Shamsi (2023) found that the use of ChatGPT contributed to the development of Arabic language skills among twelfth-grade students. The study also revealed a positive association between the use of ChatGPT and improvements in self-directed learning and critical thinking among participants in the experimental group.

The widespread adoption of ChatGPT further reflects its perceived usefulness among users. For example, the platform surpassed 100 million users worldwide within a short period following its

release (Saville, 2023). Demographic statistics indicate that approximately 60% of users are aged 34 years or younger, with individuals aged 25–34 representing the most active user group, followed by those aged 25 years and under. These figures highlight the increasing interest in technological innovations and their applications among younger populations. Additionally, about 70% of ChatGPT users worldwide report using the platform at least once per month (Thormundson, 2024).

ChatGPT has been shown to enhance creativity, critical thinking, and motivation by generating multiple and diverse responses in educational contexts (Huang & Mizumoto, 2025). For example, a study by Abahussain and Al-Amri (2024) demonstrated improvements in critical thinking skills, teaching and learning practices, and scientific research capabilities among faculty members at Saudi universities following a structured training program on ChatGPT usage.

Despite its considerable advantages, numerous concerns regarding ChatGPT remain. Ethical issues, intellectual property rights, potential misuse, and plagiarism continue to be highlighted as significant challenges (Miao *et al.*, 2023). Research also indicates that while students who actively employ ChatGPT for self-directed learning tend to exhibit increased motivation, deeper understanding of course material, and greater confidence in independent learning, over-reliance on the tool may negatively affect critical thinking and originality (Giray *et al.*, 2025; Guo & Lee, 2023).

This finding aligns with Abu-Lafi and Rayan's (2025) comparative study of ChatGPT and Gemini in solving randomly selected multiple-choice chemistry questions. The researchers observed that ChatGPT sometimes produced inconsistent answers when questions were repeated, with GPT-4 achieving 84.2%, GPT-4o 85.3%, and Gemini 87.5% accuracy. Arithmetic questions demonstrated the greatest decrease in accuracy. Nonetheless, ChatGPT's ability to interpret solutions logically offered valuable support for understanding chemistry concepts and arithmetic operations, particularly for pharmacy students.

Several studies have also reported limitations in AI models regarding biases and contextual understanding. Ahmed (2025) noted that ChatGPT exhibits challenges in interpreting emotional contexts and maintaining neutrality in text translation. Similarly, Zheng (2024) highlighted demographic biases in GPT-3.5 Turbo when recommending university majors, with disparities related to race, gender, socioeconomic status, and

educational background influencing the model's outputs.

Concerns about students' dependence on AI tools are further supported by recent literature. Excessive reliance on ChatGPT may reduce motivation, hinder thinking and creativity, and impair critical and creative thinking skills, potentially affecting the overall quality of human resources over time, especially given its widespread adoption from primary to higher education (Basha, 2024; Camilleri, 2024; Murtiningsih et al., 2024; Bai et al., 2023). In addition, Ben-Nashwan et al. (2023) indicated that ChatGPT use in academic work can compromise academic integrity, recommending collaboration among academic institutions, publishers, and AI developers to establish guidelines and ethical frameworks.

The need for institutional regulation is further emphasized by Bissessar (2023), whose study of students and faculty highlighted the importance of policies governing the use of AI tools, particularly ChatGPT. Similarly, Suchanek and Kralova (2025) proposed a model of student satisfaction with AI, demonstrating that students' perceived quality of learning and expectations significantly influence their overall satisfaction. The study suggests that thoughtful integration of AI into the educational process, along with clear usage boundaries, enhances learning quality and satisfaction, whereas outright bans may have the opposite effect.

In response to these challenges, Hamed (2023) proposed a strategic approach to mitigate risks associated with ChatGPT in education, based on a SWOT analysis framework.

In conclusion, these findings raise important questions regarding the impact of students' use of AI tools, particularly ChatGPT, on cognitive functions such as working memory. While ChatGPT offers numerous educational benefits, working memory remains a cognitive capacity that develops through active use and may deteriorate with disuse. Understanding how ChatGPT influences this critical function is therefore essential for optimizing its educational applications.

2.2. Working Memory

Tulving (2000) defined memory as "a neuropsychological capacity to encode, store, and retrieve information," and suggested the existence of several separate memory systems that fit this definition.

Johnson et al. (2003) defined working memory as "all the schemas that represent an individual's

repertoire that can be activated instantaneously enough to affect ongoing mental processing." According to their view, mental capacity is one source of activation for these schemas, while other activation sources include differences in learning and field factors. Therefore, the size of working memory is always larger than mental capacity.

Baddeley and Hitch (1974) (in: Logie, 2011) proposed a working memory system as an attentional control system that holds and activates memory representations, switches attention between tasks, suppresses irrelevant information, and eliminates unnecessary responses. These functions can be seen as a reflection of central execution processes within a multicomponent system.

Abu Al-Diyar (2012) stated that the function of working memory is determined by storing and processing information temporarily at the same time, and the various components of working memory are associated with different functions. Thus, working memory and its components are responsible for perception, attention, maintenance and retrieval of information, and execution of various visual/spatial functions, such as maintaining orientation in space and maintaining the tracking of changes in the visual field over time. The results of several studies indicate that the efficiency of working memory is related to the ability to process information. Working memory dysfunction is also associated with the basic problems encountered by children and adults who suffer from problems in the learning process, such as learning difficulties, as the results of studies indicate that they are characterized by a low working memory capacity.

A set of fundamental processes that occur in memory includes:

2.2.1. Encoding (the Code-Transformation Process)

This is the process by which memory traces are formed, ensuring the retention of information. Encoding is considered the first process an individual performs after perceiving information presented to them in various situations. At this stage, the information is transformed from its natural form into a set of images or symbols, essentially becoming a code with a specific meaning associated with that information. Researchers distinguish between memory code models as follows:

- Visual Code: Information is represented in memory by its visual appearance.

- Auditory Code: Information is represented in memory by its auditory aspect, or by what its name signifies.
- Haptic Code: Information is represented in memory by its tactile characteristic.
- Semantic Code: Information is represented in memory by its meaning.

2.2.2. Storage

This refers to the process by which memory retains information transferred from the previous stage, keeping it until the individual needs it.

2.2.3. Retrieval

This refers to the individual's ability to retrieve information previously stored in memory (Al-Sharqawi, 1992, pp. 152-153).

2.3. Baddeley's Model of Working Memory

Many models have been developed to describe the components and processes of working memory, such as those by Daneman and Carpenter (1980), Hasher and Zack (1988), Wright (1993), and Schneider (1999). However, the model developed by Baddeley and Hitch (1974) is considered the most testable and experimental (in: Abu Al-Diyar, 2012).

Baddeley (1992, p. 556) proposed that the working memory is a mental system that provides us with temporary storage and processing of the information necessary for all complex cognitive tasks, such as language comprehension, learning, and reasoning. Working memory consists of a main component, the central processing unit or executive control system, and two supporting components: the auditory loop and the visuospatial sketchpad. The central processing unit is responsible for basic control and decision-making, assimilation, re-encoding, and transferring information to the long-term memory. The auditory loop handles verbal processing and recycles information for immediate retrieval, while the visuospatial sketchpad handles visualization, imagery, and visual search. He also pointed out that differences in visual working memory capacity among individuals play a significant role in differentiating learning processes, such as reading comprehension and the reasoning skills required by intelligence tests like Raven's Matrix.

Working memory, especially visual memory, is, therefore, central to many cognitive abilities, and increasing our understanding of it provides us with insight into more general cognitive functions (Brady *et al.*, 2011).

Baddeley (2002) further developed his theory of

working memory by adding a fourth component called the episodic buffer, which is a subcomponent for storing information controlled by the executive control system. This buffer is episodic, as it maintains transitional phases through which information is integrated. It is a bridge between a group of systems, as it processes information from the two subsystems and long-term memory, and then sorts the information into a small number of large chunks to reduce the burden on working memory.

2.4. Components of Working Memory in Baddeley's Theory

2.4.1. The Central Executive

This is a crucial for working memory, playing a vital role in information processing. Some researchers consider it responsible for cognitive control because it governs cognitive flexibility and inhibition, falling under the functions of working memory and are themselves controlled by the central executive. The central executive has garnered notable attention from scientists and researchers. Baddeley and colleagues studied the central executive using the dual-task approach, helping researchers identify two functions of this component: (a) focusing on new information and providing space for its storage and processing, and (b) distributing attention among the different elements of the situation and shifting attention between those elements (Al-Ansari & Suleiman, 2013).

2.4.2. Phonological Loop

This component stores limited verbal information and comprises two subcomponents: First, the phonemic (sound) store, which retains stimuli in their auditory or phonemic form that fades in a few seconds. Second, a component performing the auditory repetition of speech. This process retrieves or re-expresses the content stored in the phonemic store and refreshes the memory traces. Although verbal input enters the phonemic store automatically, information entering from other directions is only re-encoded into a phonemic form. This re-encoding process occurs instantly, and the phonemic store capacity is limited by the number of words that can be formed in the time available before their auditory traces fade. In the auditory repetition loop, long-term learning is influenced by similar meaning rather than sound. Furthermore, unrelated sounds negatively affect the recall process, reducing the number of words that can be recalled (Repovš & Baddeley, 2006).

2.4.3. Visuospatial sketchpad

The visuospatial sketchpad is defined as “a limited-capacity system that temporarily holds information about objects in the current visual environment” (Drew, McCollough, & Vogel, 2006). However, if its processing capacity is added to this definition, visual working memory can be defined as “a processor and temporary storage of visual information” (Todd et al., 2012). It is also defined as “the ability to store visual information in a processed format that is easily and quickly accessible.” It is a central component of almost all human activities, playing a crucial role in direct movement control, integrating visual information through eye movements and visual searching, and correcting eye movements after a blink error (Sims et al., 2012).

The visuospatial sketchpad uses visual attention mechanisms to select relevant visual information from the external world and actively retain it as internal mental representations. It consists of two stores:

1. The temporary passive visual store

This is responsible for the temporary retention of visual information properties.

2. The visuospatial rehearsal mechanism (Chun, 2011).

Therefore, it can be said that visuospatial memory represents a distinct component of working memory, which can be further divided into subcomponents, each with its own separate and independent storage mechanisms for retention and processing. Both are linked to forms of visual attention, and the encoding of visual information is clearly influenced by both perceptual features and prior experience, such as learning categorization. While visual memory is closely related to visual perception, visuospatial memory is more closely linked to attention and action (Repovš & Baddeley, 2006).

The results of the study by Fockert et al. (2001) indicate that working memory plays a significant role in controlling selective visual attention. Visual working memory is affected by the complexity or simplicity of the visual information. Complexity leads to a decrease in visual working memory capacity (Eng et al., 2005).

Visual working memory is characterized by its limited capacity, ranging between 3 and 4 items. However, studies indicate that this limited capacity does not decrease when subjects are asked to retain other characteristics of the items, such as color and direction (Sims et al., 2012, p. 807).

The results also indicate that visual working

memory changes throughout a person’s life; it peaks at age 20 and declines sharply at age 55 (Brockmole & Logie, 2013).

2.4.4. Episodic buffer

This represents a separate, limited-capacity buffer that uses a multi-modal code. It acts as a bridge because it holds information integrated through several systems, including working memory subsystems and long-term memory, transforming it into complex and coherent structures. The buffer is also phased because it serves as an intermediary between subsystems using different codes, which are transformed into multidimensional representations. Furthermore, the processes of holding and processing information in the phased bridge depend on the limited capacity of the attentional system, called the central port. The information retrieval process relies on conscious perception, connecting complex information from different sources side-by-side, along with the ability to create and process new representations. Moreover, it creates space for mental modeling, enabling us to then consider potential outcomes and providing the basis for planning future action (Repovš & Baddeley, 2006).

The episodic buffer has limited storage capacity but can integrate information from short- or long-term memory into a single packet. It is consciously accessible and multidimensional, reflecting its integrative function of mapping-related information from senses, working memory, and long-term memory. Its capacity is limited by the number of multidimensional packets it can hold simultaneously.

In addition, the episodic buffer includes a system for storing and processing representations; simultaneously, it has an active system allowing creative processing and reconstruction of representations in long-term memory by interacting with the central interface (Baddeley et al., 2009).

In conclusion, working memory can be described as a multicomponent cognitive system comprising subsystems (central executive, phonological loop, visuospatial sketchpad, and episodic buffer). Each memory storage subsystem has a specific function, and working memory is characterized by its high degree of specialization and limited storage and processing capacity. The working memory functions can be summarized as encoding received information, storing it, and processing it, and its performance efficiency is measured by its precision. This efficiency depends on its interaction with internal and external factors.

2.5. Research question

This study aimed to answer the following research question:

What is the effect of using ChatGPT on working memory performance from the participants' perspective?

3. METHODOLOGY

3.1. Research design

A descriptive analytical approach was used because it was appropriate to the nature of the research problem, determined as identifying the effect of using ChatGPT on working memory performance from the perspective of university students. The researchers built a questionnaire achieving this goal, and an electronic questionnaire was used as the main means of collecting research data, owing to the ease and effectiveness of the method and to ensure accuracy in collecting, encoding, and analyzing the data.

3.2. Participants

The number of participants in the research was 220 university students from the Faculty of Education, Helwan University, comprising 73 (32.2%) men and 147 (66.8%) women with second- and third-level specializations ($n = 58$, 26.4%), second level specialization in chemistry (English) ($n = 34$, 15.5%), second level specialization in chemistry (Arabic) ($n = 87$, 39.5%), second level specialization in physics (Arabic) ($n = 41$, 18.6%) (Table 1), with a mean and standard deviation of the sample being 19.72 and 2.39, respectively.

Table 1: Demographic characteristics of the participants.

Demographic	Category	Frequency (N)	Percentage (%)
Gender	Male	73	32.2
	Female	147	66.8
Major	Educational psychology	58	26.4
	Chemistry (English)	34	15.5
	Chemistry (Arabic)	87	39.5
	Physics (Arabic)	41	18.6
Levels	Second	166	75.5
	Third	54	24.5

3.3. Procedures

3.3.1. Questionnaire Construction

The questionnaire identified the impact of using ChatGPT on working memory performance from

the perspective of university students. Working memory performance was defined based on relevant theoretical frameworks. The questionnaire items were formulated and reviewed by a panel of 10 experts, resulting in minor modifications to some items. The final questionnaire comprised 25 items distributed across two dimensions.

3.4. Data Collection

The questionnaire was developed electronically using Google Forms and distributed to participants.

3.5. Data Analysis

The data were collected, encoded, and analyzed using SPSS v25. The psychometric properties of the questionnaire were verified by calculating its factor validity (exploratory factor analysis). Table 2 presents the indicators.

Table 2: Structure Matrix.

Items	Factor 1	Factor 2
item1		.721
item2		.716
item3		.709
item4	.660	
item5		.735
item6		.652
item7	.719	
item8		.655
item9	.668	
item10	.690	
item11	.607	
item12	.783	
item13		.714
item14		.717
item15	.760	
item16		.565
item17		.728
item18	.657	
item19		.702
item20		.761
item21		.631
item22		.773

item23		.736
item24	.748	
item25	.705	

Extraction Method: Principal Component Analysis. Note: Rotation Method: Promax with Kaiser Normalization)Extraction sums of squared loadings (% of Variance whole questionnaire = 51.996, Factor 1 = 34.622, Factor 2 = 17.373). Rotation sums of squared loadings (Factor 1 = 8.199, Factor 2 = 5.713).

Internal homogeneity: The internal homogeneity of the factors resulting from the exploratory factor analysis was calculated as illustrated in Table 3.

Table 3: Internal homogeneity of the factors resulting from the exploratory factor analysis (N = 220).

Items	Factor 1(positive effects)	Factor 2(negative effects)
item1	.708**	
item2	.705**	
item3	.705**	
item4		.690**
item5	.746**	
item6	.655**	
item7		.721**
item8	.659**	
item9		.668**
item10		.722**
item11		.647**
item12		.774**
item13	.715**	
item14	.722**	
item15		.744**
item16	.585**	
item17	.730**	
item18		.677**
item19	.703**	
item20	.764**	
item21	.640**	
item22	.775**	
item23	.735**	

item24		.729**
item25		.679**

Table shows a statistically significant correlation between the individual components of each factor and the total score of the factor at 0.01 significance level.

The questionnaire reliability was calculated using Cronbach’s alpha. The value of Cronbach’s alpha coefficient was .89, .92, and .91 (items = 10, 15, and 25) for the first dimension, second dimension, and whole scale, respectively. Moreover, the skewness and normality of the distribution of the study sample were verified.

4. RESULTS

The primary survey data, relating to the frequency and purpose of using ChatGPT, were analyzed (Table 4).

Table 4: Descriptive statistics for some of the primary questionnaire data (n = 220).

Variable	Category	Frequency (N)	Percentage (%)
Usage of ChatGPT	Yes	214	97.3
	No	6	2.7
Number of times used	1-5 weekly	152	69.1
	6-10 weekly	42	19.1
	More than 10 weekly	26	11.8
The purpose of use	Study	73	33.2
	Daily life	13	5.9
	Work	6	2.7
	All of the above	128	58.2

Table 4 presents that the most participants (97.3%) use ChatGPT, but some (2.7%) do not. Therefore, ChatGPT usage is more prevalent among younger people than older ones, particularly university students (Thormundson, 2024). Moreover, participants readily accept ChatGPT, especially because 33.2% of those who confirmed its use in the study admitted that it is an important educational tool, in addition to its general use in everyday life.

Furthermore, the frequency of use shows almost daily usage, with 69.1% using it 1-5 times per week. Thus, the participants’ believe in ChatGPT and use it as an essential tool.

The results were analyzed to answer the research question, “What are the effects of using ChatGPT on working memory performance from the perspective of university students?”

Table 5: Descriptive statistics of participants' memory responses (Factor 1: Positive effects of ChatGPT appear in performance from the perspective of university students)n = 220).

Items	Mean	Standard deviation	Attitude
Recalling information from ChatGPT facilitates information processing.	3.84	.780	Agree
Using ChatGPT makes it easier to find solutions.	3.88	.761	Agree
Recalling information from ChatGPT helps consolidate information in working memory.	3.69	.883	Agree
ChatGPT helps reduce errors caused by lapses in attention while working on complex tasks.	3.46	.957	Agree
Overall, using ChatGPT will improve my working memory performance in the long run.	3.12	1.076	Neutral
ChatGPT makes it easier to quickly update or review information when needed.	3.93	.810	Agree
Using ChatGPT improves overall memory performance.	3.15	1.023	Neutral
I can solve problems or perform cognitive tasks faster with ChatGPT.	3.76	.925	Agree
ChatGPT helps reduce cognitive load while studying.	3.60	.918	Agree
ChatGPT has encouraged me to try to do more tasks at once.	3.67	.960	Agree
Using ChatGPT has helped me eliminate distractions while performing a task.	3.30	.953	Neutral
Using ChatGPT has helped me recall information. Information is retrieved from long-term memory more	3.41	.982	Agree

efficiently and quickly.			
Using ChatGPT saved time to think through a problem.	3.84	.898	Agree
The information in ChatGPT helped me quickly integrate previous information with current information.	3.68	.874	Agree
Using ChatGPT improved my working memory retention rate.	3.36	.923	Agree
Total factor (positive effects of ChatGPT)	3.58	.643	Agree

Table 6. Descriptive statistics of participants' memory responses (Factor 2: Negative effects of ChatGPT appear in performance from the perspective of university students) n = 220).

Items	Mean	Standard deviation	Attitude
I have difficulty ignoring unimportant information because I have become accustomed to getting quick answers from ChatGPT.	2.9773	1.06	Neutral
My frequent use of ChatGPT makes me lose focus while performing tasks that require sustained concentration.	2.9727	1.09	Neutral
When I use ChatGPT, I notice I am less adept at mentally refreshing information without its help.	3.2455	.976	Neutral
I have become more reliant on retrieving information from ChatGPT than on memorizing it.	2.9409	1.12	Neutral
Using ChatGPT has reduced my need to temporarily memorize details while studying.	3.1136	1.08	Neutral
I feel my ability to recall short-term information (like numbers or steps) diminishes when I rely heavily on ChatGPT.	3.1500	1.14	Neutral
Despite the speed, I have recently felt that the quality of my recall after completing a task is lower when I rely on ChatGPT.	3.3364	1.06	Neutral
Using ChatGPT has limited my ability to recall details.	3.2045	1.01	Neutral
My ChatGPT use negatively impacted my visual working memory.	3.1727	1.01	Neutral
Overall, using ChatGPT will decline my working memory performance in the long run.	3.40	1.11	Agree
Total factor (negative effects of ChatGPT)	3.14	.754	Neutral

4.1. Discussion

Table 5 presents participants' perceptions regarding the positive impact of using ChatGPT. The overall agreement score for the statements was 3.58, reflecting generally favorable impressions of ChatGPT and its utility in facilitating educational tasks and problem-solving. The highest mean was associated with the statement, "ChatGPT makes it easier to quickly update or review information when needed," highlighting its effectiveness in supporting learners' information management.

Participants also acknowledged the relevance of

ChatGPT in reducing the time required to address academic challenges, as indicated by their agreement with statements such as "Using ChatGPT reduced the time to think through a problem" and "Using ChatGPT makes it easier to find solutions." Importantly, the use of ChatGPT appears to positively influence updating processes within working memory—a core cognitive function that integrates newly acquired information with previously held knowledge to produce accurate and adaptive outcomes. In addition, ChatGPT contributes to reducing cognitive load and

minimizing errors during complex tasks, further supporting efficient learning.

These findings help explain the generally positive attitudes of university students toward using ChatGPT across various educational contexts. Consistent with these results, several prior studies have reported favorable perceptions of ChatGPT among higher education students, who recognize its growing role in performing essential educational functions and supporting academic achievement (Alharbi et al., 2024; Pikhart et al., 2024; Rojas, 2024; Tossell et al., 2024; Van Horn, 2024; Ajloun et al., 2023; Bin-Nashwan et al., 2023; Mizumoto & Eguchi, 2023; Xiao & Zhi, 2023; Song & Song, 2023).

Despite participants' generally positive impressions of ChatGPT, a noticeable decline in agreement was observed for items related to the potential long-term effects on working memory. Specifically, statements such as "Using ChatGPT improves overall memory performance" (mean = 3.15) and "Overall, using ChatGPT will improve my working memory performance in the long run" (mean = 3.12) received comparatively lower scores. These findings suggest that, although participants recognize the immediate advantages of ChatGPT, they harbor concerns regarding its potential negative impact on working memory over time. This aligns with prior studies that have highlighted possible long-term cognitive limitations associated with extensive reliance on AI tools (Basha, 2024; Camilleri, 2024; Murtiningsih et al., 2024).

Table 6 further illustrates participants' apprehensions regarding the adverse effects of ChatGPT on working memory. The statement "Overall, using ChatGPT will decline my working memory performance in the long run" received the highest mean score of 3.40, reflecting a perceived risk of long-term cognitive decline. Supporting this, participants agreed with the statement, "Despite the speed, I have recently felt that the quality of my recall after completing a task is lower when I rely on ChatGPT," indicating that while ChatGPT facilitates rapid task completion, it may impair the retention and retrieval of task-related details. This concern was reinforced by responses to "Using ChatGPT has limited my ability to recall details," suggesting that excessive reliance on the tool may negatively affect working memory and the ability to recall information effectively.

Although the overall mean response was neutral ($M = 3.14$), these results indicate participants' awareness of potential negative effects of ChatGPT on working memory, particularly regarding the retention and recall of steps, numbers, and details

following task completion. Conversely, fewer concerns were reported regarding attentional processes; participants generally perceived that using ChatGPT did not hinder their ability to eliminate distractions and, in some cases, even facilitated focused task engagement.

Participants expressed predominantly positive impressions of ChatGPT in supporting their educational tasks. The platform provided essential assistance in solving academic problems, completing assignments, and managing homework efficiently. It contributed to saving time and effort while offering diverse solutions. Nonetheless, concerns were raised about its potential long-term impact on working memory, specifically in relation to retaining procedural steps and task-related details. Researchers suggest that these student perceptions may be influenced by multiple factors, including academic level, prior familiarity with ChatGPT, previous experiences, pre-existing biases, and instructional design approaches employed by educators (Alsaedi, 2025; Guo et al., 2025; Lee & Esposito, 2025).

These findings underscore the need for coordinated efforts between educators and AI developers, particularly those associated with ChatGPT, to establish clear strategies regulating AI use in educational contexts. Such strategies should aim to mitigate potential risks and address the negative cognitive impacts of AI tools, ensuring that their integration enhances rather than undermines learning processes (Ahmed, 2025; Holzmann et al., 2025; Zhan & Yan, 2025; Acosta-Enriquez et al., 2024; Basha, 2024; Camilleri, 2024; Mohd A'seri et al., 2024; Murtiningsih et al., 2024; Al-Omran & Jadu, 2023; Ben-Nashwan et al., 2023; Bissessar, 2023; Hamed, 2023).

5. CONCLUSION

The findings indicate that participants generally perceive ChatGPT as exerting positive effects on working memory performance, recognizing it as a valuable learning tool that enhances cognitive functioning by providing immediate, diverse, and contextually relevant responses. Participants reported that ChatGPT facilitated learning, supported the completion of academic tasks and assignments, and helped manage distractions during activities, thereby improving overall efficiency in educational settings.

However, despite these positive perceptions, participants expressed concerns regarding potential long-term negative impacts on working memory performance. This concern was particularly evident

in responses to the item, "Overall, using ChatGPT will decline my working memory performance in the long run," which received the highest mean score of 3.40. In contrast, the statement, "Overall, I believe that using ChatGPT will improve my working memory performance in the long run," received a neutral average score of 3.12. These results suggest that while ChatGPT offers immediate cognitive and educational benefits, there is a perceived risk that over-reliance on the tool may compromise the retention and recall of procedural steps and task-specific details over time.

In summary, participants acknowledged the positive contributions of ChatGPT to educational activities, task completion, and focused learning. At the same time, they highlighted potential long-term risks to working memory, emphasizing the need for balanced and informed use of AI tools in educational contexts to maximize benefits while minimizing possible cognitive drawbacks.

5.1. Strengths and Limitations of the Study

This study is distinguished by its focus on one of the most influential AI tools, ChatGPT, and its impact on the working memory performance of university students during educational tasks, assignments, and study activities. By examining both the positive and negative effects of ChatGPT use from the students' perspective, the study provides valuable insights for educators, university faculty, and AI developers. These findings can inform the design of effective strategies for integrating AI tools into the educational process, particularly in ways that optimize cognitive functioning and support working memory performance. Furthermore, the study contributes to the emerging literature on the pedagogical implications of AI in higher education, highlighting practical considerations for balancing technological benefits with potential cognitive risks.

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Data availability: Data generated or analyzed during this study are available from the authors on request.

REFERENCES

Abahussain, W., & Al-Amri, N. (2024). Developing the skills of faculty members and researchers in using

5.2. Suggestions for Future Research

ChatGPT represents one of the most significant artificial intelligence tools, with widespread adoption across various domains of life, particularly in education. The findings of this study indicate that a substantial proportion of university students utilize ChatGPT for academic tasks as well as for daily activities. While the results highlight several positive and beneficial effects of ChatGPT, they also reveal potential negative impacts, particularly on working memory performance. These findings raise important questions regarding the future use of ChatGPT in educational contexts, including strategies to maximize its benefits while minimizing potential cognitive risks. Based on the current results, the following directions for future research are recommended:

1. Investigating the relationship between ChatGPT use and learning disabilities.
2. Examining the effects of ChatGPT on students' attention and concentration.
3. Comparing the impact of different AI applications (e.g., Gemini, ChatGPT) on working memory performance.
4. Exploring the use of AI applications to enhance working memory performance.
5. Assessing the potential of AI applications in diagnosing and treating working memory disorders.
6. Evaluating the effectiveness of AI applications in diagnosing and addressing executive function deficits.

These proposed research directions aim to expand understanding of the cognitive and educational implications of AI tools, thereby informing evidence-based practices for integrating artificial intelligence into higher education.

- ChatGPT in university education: an experimental study. *Journal of Educational Research and Social Sciences*, 25(2), 123-162. <https://ojs.qsm.ac.il/index.php/jamiaa/article/view/995>
- Abu-Lafi, S., & Rayan, A. (2025). An In-Depth Study of the Reliability of ChatGPT and Gemini in Addressing Complex Chemistry Questions in Instrumental Analysis. *Jami'a- Journal in Education and Social Sciences*, 25(2), 123-162. <https://ojs.qsm.ac.il/index.php/jamiaa/article/view/995>
- Acosta-Enriquez, B. G., Arbulú Ballesteros, M. A., Arbulu Perez Vargas, C. G., Orellana Ulloa, M. N., Gutiérrez Ulloa, C. R., Pizarro Romero, J. M., ... & López Roca, C. (2024). Knowledge, attitudes, and perceived Ethics regarding the use of ChatGPT among generation Z university students. *International Journal for Educational Integrity*, 20(1), 10. <https://doi.org/10.1007/s40979-024-00157-4>
- Ahmed, S. (2025). The effectiveness of using artificial intelligence applications in media translation. A case study on the ChatGPT and Gemini applications. *Scientific Journal of Radio and Television Research*, 2025(31), 425-459. <https://doi.org/10.21608/EJSRT.2025.414285>
- Ajlouni, A. O., Wahba, F. A. A., & Almahaireh, A. S. (2023). Students' Attitudes Towards Using ChatGPT as a Learning Tool: The Case of the University of Jordan. *International Journal of Interactive Mobile Technologies*, 17(18). <https://doi.org/10.3991/ijim.v17i18.4175>
- Al-Ansari, B., & Suleiman, A. (2013). Structural modeling of working memory components in Kuwaiti children aged 4 to 12 years. *Journal of Educational and Psychological Sciences*, 14(4), 329-358.
- Al-Diyar, M. (2012). *Working Memory and Learning Difficulties* (1st ed.). Kuwait: Child Evaluation and Education Center.
- Al-Hammouri, F., & Al-Khasawneh, A. (2011). The role of working memory capacity and gender in reading comprehension, *The Jordanian Journal of Educational Sciences*, 7 (3), 221-232.
- Al-Obaydi, L. H., Pikhart, M., & Hossain, M. K. (2025). ChatGPT and the development of core language skills: An exploratory study of EFL college students. *Contemporary Educational Technology*, 17(4), ep591. <https://doi.org/10.30935/cedtech/17242>
- Alsaedi, N. S. (2025). Exploring ChatGPT's role in EFL learning through the technology acceptance model: Perspectives from Saudi students. *Contemporary Educational Technology*, 17(4), ep594. <https://doi.org/10.30935/cedtech/17302>
- Al Shamsi, W. (2024). The effect of using the Chat GPT application on twelfth-grade female students acquiring Arabic language skills and its relationship to developing their self- learning and critical thinking. *Journal of Non-Arabic Speakers*, 7(20), 213-244. <https://doi.org/10.21608/jnal.2024.339464>
- Al-Sharqawi, A (2003). *Contemporary Cognitive Psychology* (2nd ed.). Cairo: Anglo-Egyptian Library.
- Alharbi, M. K., Syed, W., Innab, A., Basil A. Al-Rawi, M., Alsadoun, A., & Bashatah, A. (2024). Healthcare students attitudes opinions perceptions and perceived obstacles regarding ChatGPT in Saudi Arabia: a survey based cross sectional study. *Scientific Reports*, 14(1), 22800. <https://doi.org/10.1038/s41598-024-73359-y>
- Al-Amro, F., & Al-Dhalan, B. (2025). The effectiveness of teaching mathematics using(ChatGPT) in developing conceptual understanding among third-grade intermediate students. *Journal of Educational Sciences and Humanities*, (48), 507-538. <https://doi.org/10.55074/hesj.vi48.1492>
- Al-Omran, A., & Jadu, A. (2024). A proposed model for employing GPT Chat in the educational process at the Arab East College for Graduate Studies. *Journal of Artificial Intelligence and Information Security. Egyptian Society for Technological Development*, 4, 123-174. DOI: 10.21608/aiis.2024.292239.1006
- Baddeley, A. D., Hitch, G. J., & Allen, R. J. (2009). Working memory and binding in sentence recall. *Journal of memory and Language*, 61(3), 438-456. <https://doi.org/10.1016/j.jml.2009.05.004>
- Bai, L., Liu, X., & Su, J. (2023). ChatGPT: The cognitive effects on learning and memory.
- Basha, J. Y. (2024). The negative impacts of AI tools on students in academic and real-life performance. *International Journal of Social Sciences and Commerce*, 1(3), 1-16. <https://doi.org/10.51470/IJSSC.2024.01.03.01>
- Bin-Nashwan, S. A., Sadallah, M., & Bouteraa, M. (2023). Use of ChatGPT in academia: Academic integrity hangs in the balance. *Technology in Society*, 75, 102370.

- <https://doi.org/10.1016/j.techsoc.2023.102370>
- Bissessar, C. (2023). To use or not to use ChatGPT and assistive artificial intelligence tools in higher education institutions? The modern-day conundrum—students' and faculty's perspectives. *Equity in Education & Society*, 27526461231215083. <https://doi.org/10.1177/27526461231215083>
- Brockmole, J. R., & Logie, R. H. (2013). Age-related change in visual working memory: A study of 55,753 participants aged 8–75. *Frontiers in psychology*, 4, 12. <https://doi.org/10.3389/fpsyg.2013.00012>
- Brady, T. F., & Alvarez, G. A. (2011). Hierarchical encoding in visual working memory: Ensemble statistics bias memory for individual items. *Psychological science*, 22(3), 384-392. <https://doi.org/10.1177/0956797610397956>
- Bucaioni, A., Ekedahl, H., Helander, V., & Nguyen, P. T. (2024). Programming with ChatGPT: How far can we go?. *Machine Learning with Applications*, 15, 100526. <https://doi.org/10.1016/j.mlwa.2024.100526>
- Camilleri, M. A. (2024). Factors affecting performance expectancy and intentions to use ChatGPT: Using SmartPLS to advance an information technology acceptance framework. *Technological Forecasting and Social Change*, 201, 123247. <https://doi.org/10.1016/j.techfore.2024.123247>
- Chun, M. M. (2011). Visual working memory as visual attention sustained internally over time. *Neuropsychologia*, 49(6), 1407-1409.
- Darif, & obeidi. (2024). In Evaluating ChatGPT Translation: A Comparative Study of Simplified Scientific Text. *Maalem*, 14(2), 41-56.
- De Fockert, J. W., Rees, G., Frith, C. D., & Lavie, N. (2001). The role of working memory in visual selective attention. *Science*, 291(5509), 1803-1806. DOI: 10.1126/science.1056496
- Drew, T. W., McCollough, A. W., & Vogel, E. K. (2006). Event-related potential measures of visual working memory. *Clinical EEG and Neuroscience*, 37(4), 286-291. <https://doi.org/10.1177/155005940603700405>
- Eng, H. Y., Chen, D., & Jiang, Y. (2005). Visual working memory for simple and complex visual stimuli. *Psychonomic bulletin & review*, 12(6), 1127-1133. <https://doi.org/10.3758/BF03206454>
- Giray, L., Nemeño, J., & Edem, J. (2025). Self-Directed Learning Using ChatGPT Positively Affects Student Engagement. *International Journal of Technology in Education*, 8(3), 667-680. <https://doi.org/10.46328/ijte.1162>
- Guo, F., Zhang, L., Shi, T., & Coates, H. (2025). Whether and When Could Generative AI Improve College Student Learning Engagement?. *Behavioral Sciences*, 15(8), 1011. <https://doi.org/10.3390/bs15081011>
- Guo, Y., & Lee, D. (2023). Leveraging ChatGPT for enhancing critical thinking skills. *Journal of Chemical Education*, 100(12), 4876-4883. <https://doi.org/10.1021/acs.jchemed.3c00505>
- Hamed, D. (2023). A Proposed Strategy to Address the Risks of Artificial Intelligence Applications in Educational Research: GPT Chat as a Model. *Journal of the Faculty of Education, Benha University*, 34(235), 1-74. <https://doi.org/10.21608/jfeb.2023.246785.1781>
- Holzmann, U., Anand, S., & Payumo, A. Y. (2025). The ChatGPT Fact-Check: exploiting the limitations of generative AI to develop evidence-based reasoning skills in college science courses. *Advances in Physiology Education*, 49(1), 191-196. <https://doi.org/10.1152/advan.00142.2024>
- Hong, W. C. H. (2023). The impact of ChatGPT on foreign language teaching and learning: Opportunities in education and research. *Journal of educational technology and innovation*, 5(1). <https://doi.org/10.61414/jeti.v5i1.103>
- Huang, J., & Mizumoto, A. (2025). The effects of generative AI usage in EFL classrooms on the 12 motivational self system. *Education and Information Technologies*, 30(5), 6435- 6454. <https://doi.org/10.1007/s10639-024-13071-6>
- Johnson, J., Im-Bolter, N., & Pascual-Leone, J. (2003). Development of mental attention in gifted and mainstream children: The role of mental capacity, inhibition, and speed of processing. *Child development*, 74(6), 1594-1614. <https://doi.org/10.1046/j.1467-8624.2003.00626.x>
- Lee, J., & Esposito, A. G. (2025). ChatGPT or Human Mentors? Student Perceptions of Technology Acceptance and Use and the Future of Mentorship in Higher Education. *Education Sciences*, 15(6), 746. <https://doi.org/10.3390/educsci15060746>
- Logie, R. H. (2011). The functional organization and capacity limits of working memory. *Current directions in Psychological science*, 20(4), 240-245. <https://doi.org/10.1177/0963721411415340>
- Miao, J., Thongprayoon, C., Suppadungsuk, S., Garcia Valencia, O. A., Qureshi, F., & Cheungpasitporn, W.

- (2023). Ethical dilemmas in using AI for academic writing and an example framework for peer review in nephrology academia: a narrative review. *Clinics and Practice*, 14(1), 89-105. <https://doi.org/10.3390/clinpract14010008>
- Mizumoto, A., & Eguchi, M. (2023). Exploring the potential of using an AI language model for automated essay scoring. *Research Methods in Applied Linguistics*, 2(2), 100050. <https://doi.org/10.1016/j.rmal.2023.100050>
- Mohd A'seri, M. S., Mahmud, M. M., Yaacob, Y., Ahmad, R., Nagasundram, U., & Mustamam, N. I. (2024, September). Beyond the Textbook: A Study of ChatGPT Patterns of Use Perceptions and Experiences Among Students in Higher Education. In *Proceedings of the 2024 the 16th International Conference on Education Technology and Computers* (pp. 110-116). <https://doi.org/10.1145/3702163.37021>
- Murtiningsih, S., Sujito, A., & Soe, K. K. (2024). Challenges of using ChatGPT in education: A digital pedagogy analysis. *Int J Eval & Res Educ ISSN*, 2252(8822), 3467. <https://DOI:10.11591/ijere.v13i5.29467>
- Repovš, G., & Baddeley, A. (2006). The multi-component model of working memory: Explorations in experimental cognitive psychology. *Neuroscience*, 139(1), 5-21. <https://doi.org/10.1016/j.neuroscience.2005.12.061>
- Rojas, A. J. (2024). An investigation into ChatGPT's application for a scientific writing assignment. *Journal of Chemical Education*, 101(5), 1959-1965. <https://doi.org/10.1021/acs.jchemed.4c00034>
- Saville, N. (2023). The future of language learning in the era of ChatGPT. *Journal of e- Learning and Knowledge Society*, 19(3), 6-10. <https://doi.org/10.30935/cedtech/17302>
- Solak, E. (2024). Revolutionizing language learning: How ChatGPT and AI are changing the way we learn languages. *International Journal of Technology in Education (IJTE)*, 7(2), 353-372. <https://doi.org/10.46328/ijte.732>
- Suchanek, P., & Kralova, M. (2025). Generative artificial intelligence expectations and experiences in management education: ChatGPT use and student satisfaction. *Journal of Innovation & Knowledge*, 10(5), 100781. <https://doi.org/10.1016/j.jik.2025.100781>
- Sims, C. R., Jacobs, R. A., & Knill, D. C. (2012). An ideal observer analysis of visual working memory. *Psychological review*, 119(4), 807.
- Thormundson, B. (2024a). Global user demographics of ChatGPT in 2023, by age and gender. *Statista*. <https://www.statista.com/statistics/1384324/chat-gpt-demographic-usage/>
- Todd, J. J., Han, S. W., Harrison, S., & Marois, R. (2011). The neural correlates of visual working memory encoding: a time-resolved fMRI study. *Neuropsychologia*, 49(6), 1527-1536. <https://doi.org/10.1016/j.neuropsychologia.2011.01.040>
- Tossell, C. C., Tenhundfeld, N. L., Momen, A., Cooley, K., & De Visser, E. J. (2024). Student perceptions of ChatGPT use in a college essay assignment: Implications for learning, grading, and trust in artificial intelligence. *IEEE Transactions on Learning Technologies*, 17, 1069-1081. <https://doi:10.1109/TLT.2024.3355015>.
- Tulving, E., & Craik, F. I. (Eds.). (2005). *The Oxford handbook of memory*. Oxford University Press.
- Xiao, Y., & Zhi, Y. (2023). An exploratory study of EFL learners' use of ChatGPT for language learning tasks: Experience and perceptions. *Languages*, 8(3), 212. <https://doi.org/10.3390/languages8030212>
- Zhan, Y., & Yan, Z. (2025). Students' engagement with ChatGPT feedback: Implications for student feedback literacy in the context of generative artificial intelligence. *Assessment & Evaluation in Higher Education*, 1-14. <https://doi.org/10.1080/02602938.2025.2471821>
- Zheng, A. (2024). Dissecting bias of ChatGPT in college major recommendations. *Information Technology and Management*, 1-12. <https://doi.org/10.1007/s10799-024-00430-5>
- English Language Teaching*, 12(1) 44-58. <https://doi.org/10.15294/elt.v12i1.64069>
- <https://doi.org/10.1016/j.neuropsychologia.2011.01.029>
- Fitria, T. N. (2023, March). Artificial intelligence (AI) technology in OpenAI ChatGPT application: A review of ChatGPT in writing English essay. In *ELT Forum: Journal of*
- Pikhart, M., Klimova, B., & Al-Obaydi, L. H. (2024, July). Exploring university students' preferences and satisfaction in utilizing digital tools for foreign language learning. In *Frontiers in Education* (Vol. 9, p. 1412377). Frontiers Media SA. <https://doi.org/10.3389/feduc.2024.1412377>
- of Educational and Qualitative Research*, 25(25.2), 1-26. <https://doi.org/10.21608/JEOR.2024.353873>
- Brain-X*, 1 (3), e30. <https://doi.org/10.1002/brx2.30>