Nature-Nurture Journal of Psychology (2025)
(NNJP 5: 2; 2025) DOI: 10.53107/nnjp.v5i2.121

RESEARCH ARTICLE Open Access

Cognitive Debt in the ChatGPT Era: How Ethical and Emotional Use Shapes Cognitive Function in Emerging Adults

Kiran Shehzadi, Khalida Khan & Muhammad Imtiaz Chaudhry

Abstract

Background: The accelerated use of large language models like ChatGPT has revolutionized human emotional and cognitive involvement, yet its neuropsychological implications remain poorly known. The present study proposes the concept of cognitive debt, the accumulated strain on attention, memory, and metacognitive control triggered by sustained AI engagement. This study investigated how distinctive patterns of ChatGPT involvement spanning usage frequency, emotional and cognitive engagement, and ethical reflection predict cognitive dysfunction across four user typologies: low–moderate, minimal/unhealthy, balanced–cognitive, and ethically reflective users.

Method: This study employed a purposive sampling strategy within a web-based cross-sectional design to recruit 300 emerging adults (aged 18–25 years) from universities in Rawalpindi and Islamabad, Pakistan, between June 25 and July 12, 2025. Participants completed two standardized psychological instruments examining ChatGPT usage and cognitive dysfunction via an online survey administered on Google Forms. The survey link was disseminated through multiple digital platforms, including WhatsApp, Facebook, and official university email network to ensure broad accessibility and voluntary participation.

Results: The results revealed that higher ChatGPT usage, specifically emotionally driven involvement, was associated with increased cognitive dysfunction, including impairments in memory, attention, and executive control across all user profiles, proposing that emotionally driven and impulsive interplay with generative AI diminishes executive control and heightens cognitive load. In contrast, ethical reflection indicated a mild protective effect against cognitive dysfunction. Moreover, females exhibited higher cognitive vulnerability than males, while males reported greater ChatGPT engagement and susceptibility to its cognitive effects as compared to females.

Conclusions: The results explain two diverse cognitive stress pathways: (1) emotional compulsive engagement, described by affect-laden and impulsive AI use, and (2) reflective cognitive overload, where ethical contemplation paradoxically develops metacognitive load. These novel results improve the concept of cognitive debt, proposing that both over reflective and overreliant AI interactions could impair cognitive efficacy. The research highlights the urgency of establishing evidence-based digital ethical-use and literacy approaches to promote cognitively sustainable AI usage.

Keywords: Cognitive Debt, ChatGPT, Generative AI, Cognitive Dysfunction, Attention, Memory, Emotional Regulation, Digital Literacy

1. *MS Scholar, Department of Behavioural Sciences, National University of Sciences and Technology, Islamabad, Pakistan*
2. *M.Phil Scholar, Department of Psychology, Foundation University Islamabad, Pakistan*
3. *Ph.D. Scholar, Department of Psychology, Preston University, Islamabad, Pakistan*

Correspondence concerning this article should be addressed to Kiran Shehzadi, Department of Behavioural Sciences, National University of Sciences and Technology (NUST), Islamabad, Pakistan. Email: capt.kiran20@gmail.com.

Background

The development of generative artificial intelligence (AI) techniques, particularly ChatGPT is transforming the nature of human involvement in cognitive and emotional tasks across educational, commercial, and emotional fields (Adeshola & Adepoju, 2024; Arman & Lamiya, 2023; Phang et al., 2025), while raising concerns about increased latent cognitive erosion (Jose et al., 2025) and cognitive flexibility (Chauncey & McKenna, 2024; Szymkiewicz et al.). Many previous studies indicated that students regularly utilise ChatGPT for brainstorming that progressively influences changes in executive and emotional functioning (Rezai et al., 2024). Although generative AI assists are claimed to improve cerebral productivity (Masic, 2024; Yamamura & Hayashi, 2024), there are still concerns about dependency (Zhang et al., 2024)and superficial cognitive processing (Baltezarević & Battista, 2025), as well as decreased cognitive effort (Felin & Holweg, 2024; Shanmugasundaram & Tamilarasu, 2023; Zhao et al., 2022).

A previous EEG study indicated that people who used AI tools such as ChatGPT found lower brain activity in brain regions involved with higher-order thought processes (Pedro, 2023; Yi et al., 2023), demonstrating that AI may reduce neural involvement during advanced thinking activities (Michael Gerlich, 2025; Wei, 2024). These problems resonate in the context of Pakistan, where educational achievement is frequently focused on rote memorisation (Grove, 2025) instead of fostering critical thinking, highlighting potential risks of artificial intelligence-driven cognitive offloading (Michael Gerlich, 2025; M Gerlich, 2025; Iqbal et al., 2025). Additionally, human-AI interaction, like ChatGPT use, could boost self-expression (Chadha, 2024; Lee et al., 2023) and emotional confidence (Chong et al., 2023; Li et al., 2025a) while reducing interpersonal sensitivity (Li et al., 2023; Ojo & Afolaranmi, 2024)and social engagement (Ahmed et al., 2024; Flavián & Casaló, 2021).

According to Asian and African literature guides, moderate usage of artificial intelligence promotes reflective and critical thinking (Hao et al., 2024; Kunnath & Botes, 2025; Zou et al., 2024), whereas overreliance may adversely affect self-regulated learning and long-term memory (Bauer et al., 2025; Li; Zhai et al., 2024). These diverse findings highlight the importance of cultural interpretations of AI's cognitive implications, especially in Pakistan's majority-populated emerging adults (M. Y. Ali et al., 2025; Z. Ali et al., 2025; Yasin & Safdar, 2025).

Several previous researches reveal diverse outcomes for AI's cognitive effect. For example, (González Tigrero, 2024) observed that teenagers utilising ChatGPT for homework reported changes in academic performance and executive functioning. Furthermore, (Baradari et al., 2025) showed using brainwave recordings that AI-assisted reasoning results in lesser brain activation, implying decreased neural involvement. (Li et al., 2025b) also found that users of AI experienced emotional and self-confidence but a reduction in independent thinking (Farahmand & Farahmand, 2025). In the examination-focused system of Pakistan, these kinds of changes could either help educational survival or impede cognitive liberty (Harry, 2023; Holmes & Tuomi, 2022; Selwyn, 2022).

Furthermore, studies in Turkey and Ghana found that moderate AI use can improve reflection and critical thinking (Dağdemir, 2024; İçen, 2022; Malcalm et al., 2024), whereas other researchers warn about AI-induced skill degradation and lower brain activities (Vela et al., 2022; Yadav, 2025). In a collectivist society such as Pakistan and India, where decision-making frequently involves peer and family influence (Ahuja et al., 2021; Saeed & Naqvi, 2022), the individual-level implications of AI on cognitive capacity require further exploration (Del Giudice et al., 2023; Peeters et al., 2021; Rainey, 2023).

The present research is grounded in both Extended Mind Theory (Choi, 2021; Paul, 2021) and Cognitive Load Theory (Evans et al., 2024; Sweller, 2023) that provide a strong framework for comprehending how relying on advanced AI technologies affects cognitive and emotional performance (Gkintoni et al., 2025; Jacobs et al., 2024). In line with Cognitive Load Theory, the limitations of working memory hinder human cognitive architecture, particularly during problem solving and learning (Nikolin et al., 2021; Trapp et al., 2021). ChatGPT is used for simplifying complex cognitive processes (e.g., concept organisation, paraphrasing, and content generation)(Filippi, 2023; Hashemi & Kashefi, 2025) and can minimise extraneous and internal cognitive load, releasing up cognitive resources (Chauncey & McKenna, 2024; Masic, 2024; Szymkiewicz et al.). Nonetheless, this simplifying may be at the expense of relevant load that is required for critical thinking and deep learning (Islam & Islam, 2023). Persistent reliance on artificial intelligence that generates could trigger cognitive offloading (Georgiou, 2025), minimising mental effort (Ahn, 2025) and impeding the improvement of metacognitive methods (Exintaris et al., 2023; Ihsani & Siswono, 2024; Teng, 2025).

In addition to cognitive load theory, expanded theory of mind (Clark & Chalmers, 1998; Oliveira, 2025) proposed that advanced technologies, such as calculators, notebooks, and now AI, may evolve into improvements of human cognition when utilised consistently and frequently (Anna & Bruno, 2025; Tripathi). In the setting of ChatGPT, emerging adults may integrate AI into their daily thinking patterns, potentially improving their long-term memory and reasoning capability (Michael Gerlich, 2025; Lawasi et al., 2024). Nevertheless, EMT raises important concerns: does prolonged use improve cognitive capacities, or does it externalise and perhaps replace internal cognitive functions?(Hernández-Orallo, 2025; Yıldız, 2025). The issue is still open for further debate, especially pertinent in countries such as Pakistan, where formal schooling may not explicitly promote self-regulated learning as well as crucial digital literacy (Ilomäki et al., 2023; Majeed et al., 2025; Peng & Yu, 2022).

The rapid usage of generative AI, like ChatGPT, has influenced human and technology interaction (Magliocca et al., 2025; Olugbade et al., 2023); however, its cognitive repercussions are still unexplained in South Asian contexts, especially in Pakistan (Rana & Khalid, 2025; Zhai et al., 2024). Prior studies reflect just Western concepts, overlooking educational and cultural variation that could shape cognitive affect (Bai et al., 2023). The present study addresses this unique gap by investigating how ChatGPT use

influences memory, attention, metacognition, and executive functioning across four user groups: functional-reactive, passive-compulsive, cognitively engaged, and reflective-ethical people in Pakistan (Arciniegas et al., 2021; Goyal, 2025; Riley et al., 2025).

This study portrays ChatGPT as a facilitator of cognitive enhancement and a possible source of cognitive overload that is grounded in cognitive load theory and the extended mind theory. It explores how many different dimensions of ChatGPT usage frequency and dependency, emotional–behavioural impact, and cognitive influence, as well as ethical reflection, relate to cognitive dysfunction's aspects, such as false triggering, forgetfulness, and distractibility. The study aims to advance understanding of digital cognition by integrating these theoretical perspectives within Pakistan's unique cultural and educational context. It will also provide insights for developing culturally informed educational strategies, mental health frameworks, and digital literacy policies that promote healthy and effective AI engagement.

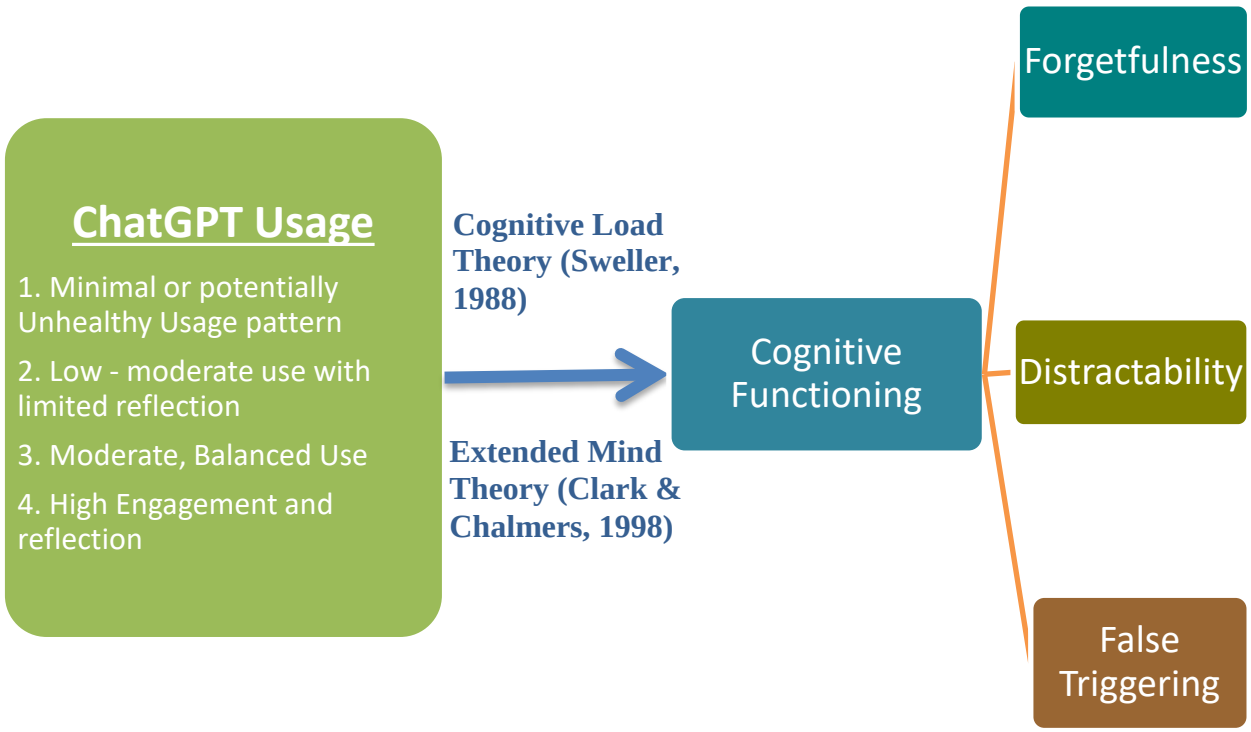
Conceptual Framework of the Study

The conceptual framework illustrates the hypothesized relationships among the key variables investigated in the present study. It provides a structural representation that guides the research process by clarifying how the independent, mediating, and dependent variables are conceptually and theoretically linked.

As shown in Figure 1, the framework is grounded in theoretical assumptions and prior empirical evidence explaining the causal pathways among the study variables. Specifically, it demonstrates how the independent variable(s) influence the dependent variable(s), either directly or through mediating and moderating mechanisms. This framework serves as the foundation for developing the study's hypotheses and analytical model.

Figure 1

Conceptual Framework of the Study



Method

Research Design

This study employed a web-based cross-sectional research design to investigate the impact of ChatGPT usage on cognitive dysfunction among emerging adults in Pakistan.

Objectives and Hypotheses

This study examines the relationship between ChatGPT usage subscales (usage frequency & dependence, cognitive effects, emotional/behavioural impact, and ethical awareness or reflection) and cognitive dysfunction subscales (forgetfulness, distractibility, and false triggering) across emerging adults and four user groups: functional–reactive, passive–compulsive, cognitively engaged, and reflective ethical. This study further investigates the impact of ChatGPT usage on cognitive dysfunction along their subscales in emerging adults across four user groups. Furthermore, it seeks to explore group and gender differences in ChatGPT usage and cognitive dysfunction along their subscales across these user groups. The study tests the following hypotheses, H1: ChatGPT usage will be statistically positively linked to cognitive dysfunction across four user groups: passive compulsive, functional reactive, cognitively engaged, and reflective ethical. Additionally, H2: it explores group-wise differences in ChatGPT usage and cognitive dysfunction across males and females. H3: The emotional/behavioural impact of ChatGPT usage will enhance cognitive dysfunction in emerging adults. H3: higher ethical awareness will mitigate cognitive dysfunction. H4: reflective–ethical users will show elevated ChatGPT usage and cognitive dysfunction as compared to other user groups. H5: Female emerging adults will show higher cognitive dysfunction as compared to male emerging adults.

Sample

A purposive sampling technique was employed to recruit approximately 300 participants, aged 18–25, who were currently enrolled in undergraduate or postgraduate academic programs. Data collection was conducted between June 25 and July 12, 2025, using an online survey administered through Google Forms and distributed through different digital platforms such as WhatsApp, Facebook, and official email. Inclusion criteria were set as participants of 18-25 years, males and females, from urban and rural backgrounds, with at least proficiency in both English and Urdu languages, and who voluntarily provided written informed consent to participate prior to participating in this survey. Exclusion criteria included participants with a history of cognitive deficit and mental health disorders, those who are unable to comprehend English and Urdu languages at an intermediate level, and those who refuse to participate voluntarily in the study.

Instruments

This study used two standardized psychological instruments to examine ChatGPT usage and cognitive dysfunction in emerging adults. ChatGPT usage questionnaires were assessed across four subscales: cognitive effects, ethical awareness/reflection, emotional/behavioural consequences, usage frequency and dependence. Moreover, cognitive dysfunction was measured across three subscales: false triggering, forgetfulness, and distractibility.

ChatGPT Usage Questionnaire (C-UQ). It was developed by Nemat-Allah et al. (2024) and designed to measure user engagement across four dimensions: usage frequency & dependence; cognitive effects; emotional/behavioral impact; and ethical awareness & reflection (Nemat-Allah et al., 2024). Participants were categorized into four user groups showing the depth and intensity of involvement based on total ChatGPT usage scores: (1). Minimal/unhealthy usage group (score < 40): Participants use ChatGPT infrequently or in a passive, compulsive, or non-reflective manner. Their usage may lack intentionality and meaningful cognitive, emotional, or ethical engagement. (2). Low–moderate use with limited reflection group (score 41–60): Participants use ChatGPT more regularly but with limited critical thinking or reflection, with less awareness of emotional or ethical implications. (3). Moderate balanced use group (score 61–80): Participants demonstrate a cognitively engaged pattern with purpose and balance, reflecting moderate levels of frequency, cognitive processing, and awareness. (4). High engagement with ethical reflection group (score 81–100): Participants extensively use ChatGPT, combining information-seeking with deeper reflection. They demonstrate strong emotional involvement and thoughtful consideration of the ethical use of AI tools. The scale reflected good validity and internal consistency in the present study ($\alpha = .85$).

Cognitive Assessment Questionnaire (CAQ). It was developed by Broadbent et al. (1982) and designed to assess cognitive dysfunction across three subscales: (1), Forgetfulness**:** reveals the tendency to forget known information or planned or known actions. (2) Distractibility: Captures susceptibility or absentmindedness to disturbance in focused attention, mainly in social settings. (3), False Triggering: Measures disturbed functioning of motor and cognitive action sequences, demonstrating difficulties in task and attention continuity. The CAQ provides a standardised psychological assessment of cognitive performance for emerging adults. The scale reflected good validity and internal consistency in the present study ($\alpha = .92$).

Procedure

This study was approved by the Ethical Review Board of the Department of Psychology, National University of Sciences & Technology (NUST), Islamabad, Pakistan, and performed in accordance with guidelines of the American Psychological Association (APA). 300 participants were recruited through online platform platforms using Google Forms between June 25 and July 12, 2025. Written informed consent was obtained from participants prior to completing the study. Two standardized psychological instruments were administered to assess participants' ChatGPT usage experiences and their cognitive dysfunction. Participants were assured of the confidentiality of their personal information, which would be kept confidential and used solely for research purposes. The survey link was distributed via social media platforms such as Facebook, WhatsApp and official email, ensuring voluntary participation, informed consent, and the responses to uphold ethical standards and confidentiality.

Data Analysis

Data were initially screened for missing values that were handled by the imputation method. Further, Pearson Correlation Analysis was performed to examine the relationship between ChatGPT usage and cognitive dysfunction along their subscales in emerging adults. One-way ANOVA was employed to examine group differences in ChatGPT usage and cognitive dysfunction across user groups (functional reactive, passive compulsive, cognitively engaged, and reflective–ethical). Multiple regression analysis was conducted to predict cognitive dysfunction (forgetfulness, distractibility and false triggering) based on ChatGPT usage subscales (usage frequency & dependence, cognitive effects, emotional/behavioural impact, and ethical awareness & reflection). Additionally, an independent sample ***t***-test was employed to explore gender differences in cognitive dysfunction and ChatGPT usage across emerging female and male adults.

Results

Table 1 presents the Cronbach's alpha reliability (internal consistency coefficients), mean, standard deviations, and Pearson correlation coefficients in ChatGPT usage along their subscales, including usage frequency & dependence, emotional/behavioral impact, cognitive effects, or ethical awareness & reflection, as well as cognitive functioning along their dimensions such as distractibility, forgetfulness, and false triggering in emerging adults.

This present study reveals both ChatGPT usage and cognitive functioning along their subscales show acceptable to excellent Cronbach's alpha reliability (internal consistency), with Cronbach's alpha reliability values ranging between cognitive effects ($\alpha = .52$) and cognitive functioning ($\alpha = .92$) for a sample of emerging adults. Notably, the overall ChatGPT Usage scale displays high Cronbach's alpha reliability ($\alpha = .85$), which validates the internal coherence of the ChatGPT Usage construct.

This study's Pearson correlation analysis shows that the overall scores of the ChatGPT Usage scale were statistically positively and significantly related to cognitive dysfunction ($r = .27$, $p < .01$) and its subscales: distractibility ($r = .29$, $p < .01$), false triggering ($r = .21$, $p < .01$), and forgetfulness ($r = .23$, $p < .01$). These results recommend that more usage of ChatGPT, specifically when considered by dependence, frequency, and limited reflective commitment, is correlated with higher cognitive problems in emerging adults.Moreover, among the subscales, usage frequency & dependence is strongly positively associated with emotional/behavioral impact ($r = .71$, $p < .01$) and cognitive effects ($r = .65$, $p < .01$), and demonstrates a statistically moderate but significant association with false triggering ($r = .15$, $p < .01$), distractibility ($r = .20$, $p < .01$), and forgetfulness ($r = .15$, $p < .01$), as well as reflecting that greater frequency and dependence on ChatGPT usage are associated with memory processes and impaired attention in emerging adults.

Emotional/behavioral impact and cognitive effects dimensions are also positively significantly associated with all cognitive functioning outcomes. For example, behavioral/emotional impact had the highest association with distractibility ($r = .31$, $p < .01$), after that false triggering ($r = .27$, $p < .01$) and forgetfulness ($r = .23$, $p < .01$) in emerging adults. These findings recommend that impulsive engagement & emotionally driven ChatGPT usage may interrupt memory stability and attentional control.

In contrast, ethical reflection & awareness that captures responsible and deliberate use of ChatGPT reveals a negligible to weak association with cognitive dysfunction, e.g., with forgetfulness ($r = .13$, $p < .05$; $r = .08$) but is non-significant with distractibility ($r = .04$, $p = ns$) and false triggering. This pattern suggests that, ethically, reflective grounded commitment may alleviate the negative cognitive outcomes linked to ChatGPT usage. Furthermore, strong inter-correlations are noted in the cognitive functioning subscales: distractibility, forgetfulness & false triggering are all strongly interrelated, ranging between $r = .71$ to $.81$, $p < .001$, that is demonstrating a coherent construct of cognitive dysfunction in emerging adults.

In Table 2, the findings of a one-way ANOVA exhibit statistically significant differences in cognitive functioning and ChatGPT usage patterns across four user profiles, including unhealthy/minimal use, moderate balanced use, low–moderate use with limited reflection, and high engagement with ethical reflection, which is categorized by the overall ChatGPT usage scores. The results reveal that participants exhibit significantly higher engagement with overall ChatGPT usage and all its subscales: cognitive effects ($F = 139.05$, $p < .001$, $\eta^2_p = .58$), usage frequency & dependence ($F = 130.55$, $p < .001$, $\eta^2_p = .57$), ethical awareness & reflection ($F = 27.59$, $p < .001$, $\eta^2_p = .21$), and emotional/behavioral impact ($F = 99.24$, $p < .001$, $\eta^2_p = .50$), with a greater effect for overall ChatGPT usage ($F = 348.52$, $p < .001$, $\eta^2_p = .77$).

Moreover, this study's findings exhibit significant group differences that are found in cognitive functioning, with overall cognitive dysfunction growing gradually across the usage groups ($F = 4.56$, $p = .01$, $\eta^2_p = .04$). Moreover, the results exhibit that the strongest effect appeared for distractibility ($F = 7.55$, $p < .001$, $\eta^2_p = .07$), after that forgetfulness ($F = 2.91$, $p = .04$, $\eta^2_p = .02$), whereas false triggering has non-significance effect ($F = 2.38$, $p = .07$). Remarkably, ChatGPT users in the High Engagement group exhibit the greater mean scores for cognitive dysfunction and cognitive engagement, for example, distractibility ($M = 19.38$) and forgetfulness ($M = 14.59$). These results recommend that while ethically and deeper reflective ChatGPT use is linked to increased emotional and cognitive involvement. Moreover, it may contribute to memory- and attention-related problems, possibly because of enhanced metacognitive sensitivity and cognitive load to mental gaps.

In Table 3, a multiple regression analyses is conducted to investigate how various aspects of ChatGPT usage including usage frequency & dependence (UFD), cognitive awareness (CA), emotional/behavioral impact

(EBI), and ethical awareness & reflection (EAR) predict cognitive functioning outcomes such as forgetfulness, distractibility, and false triggering. The analysis is performed both for the overall sample and across four usage profiles including minimal/unhealthy use, low–moderate use with limited reflection, moderate balanced use, and high engagement with ethical reflection.

Model 1: Combined Emerging Adults Sample

In model 1, this study's findings demonstrate emotional/behavioral impact (EBI) emerged as a strong and reliable predictor of cognitive dysfunction in the emerging adult sample. The findings reveal that a higher level of EBI significantly predicted cognitive functioning ($\beta = .32$, $p < .001$), forgetfulness ($\beta = .25$, $p < .01$), distractibility ($\beta = .31$, $p < .001$), and false triggering ($\beta = .33$, $p < .001$), which demonstrates that behavioral reliance and emotional involvement in ChatGPT usage are linked to greater memory and attention-related deficiencies. Moreover, cognitive awareness (CA) is fairly significantly predicted to distractibility ($\beta = .15$, $p < .05$), which suggests greater metacognitive involvement may enhance users' awareness of attentional lapses in emerging adults. On the contrary, ethical awareness & reflection (EAR) and usage frequency & dependence (UFD) are non-significant predictors of any cognitive results, which shows their restricted explanatory power in association with cognitive functioning in an emerging adult sample.

Model 2: Minimal/Unhealthy Usage Group

In model 2, this study's results reveal that both CA and UFD exhibit a strong and reliable predictor for all cognitive functioning along their subscales, while EBI has a statistically negative predictor for cognitive dysfunction in the minimal/unhealthy usage group. For instance, EBI is also negatively predicting distractibility ($\beta = –1.69$), recommending that among low-frequency users, emotional/behavioral effects are negatively predicting cognitive functioning.

Model 3: Low–Moderate Use with Limited Reflection

In model 3, this study reveals statistically non-significant predictors, but all ChatGPT usage subscales exhibit weak predictors to cognitive functioning in low–moderate use with the limited reflection group. These findings recommend that people who use ChatGPT at a moderate level without ethical engagement or reflection may not face strong cognitive outcomes, either positive or negative.

Model 4: Moderate, Balanced Use

In model 4, this study's results reveal that EBI is considered a stronger predictor for cognitive dysfunction in the moderate, balanced use group. Moreover, EBI significantly predicted the overall cognitive functioning scores ($\beta = .35$, $p < .001$) and forgetfulness ($\beta = .32$, $p < .001$) in the moderate, balanced use group. These results also support the idea that emotional and behavioral engagement, as compared to frequency alone, plays a central role in predicting cognitive functioning in this group. This study also exhibits that UFD, CA, and EAR are non-significant predictors of cognitive functioning in this group.

Model 5: High Engagement and Ethical Reflection

In model 5, this study's results exhibit that cognitive awareness (CA) is statistically significantly predicting distractibility ($\beta = .50$, $p < .01$) in individuals who are involved in a group with strong ethical reflection. This recommends that those users who analytically reflect on their use of ChatGPT could experience being more attuned to variations in their attentional and memory processes. Conversely, UFD, EBI, or EAR are non-significant predictors of cognitive functioning and, along with their subscales, probably demonstrate a more adaptive or regulated form of ChatGPT involvement in this group.

Overall, the multiple regression results recommend that emotional/behavioral impact is one of the most important and strong predictors for cognitive dysfunction, specifically in memory and attention, which is highlighted by emotionally intensive ChatGPT involvement, as compared to usage frequency, and it is also more strongly predictive of cognitive functioning, particularly in both moderate and highly reflective users.

In Table 4, the findings of independent samples *t*-tests show that non-significant gender differences are found in the overall score of ChatGPT usage along its subscales, such as emotional/behavioral impact, cognitive effects, usage frequency & dependence, and ethical awareness & reflection in emerging adults. Moreover, both female and male emerging adults displayed similar involvement levels with ChatGPT usage and its subscales.

On the other hand, the findings of the present study reveal that significant gender differences are found in cognitive functioning along its sub dimensions. The results reveal that female emerging adults exhibit significantly greater levels of cognitive dysfunction in comparison to male emerging adults across all subscales: false triggering ($t = 3.63$, $p = .001$, $d = 0.56$), distractibility ($t = 3.92$, $p = .001$, $d = 0.60$), and forgetfulness ($t = 3.85$, $p = .001$, $d = 0.58$). The overall cognitive dysfunction scores are further significantly greater in female emerging adults ($t = 4.19$, $p = .001$, $d = 0.63$) as compared to males, reflecting a moderate to large effect. Furthermore, these results recommend that ChatGPT usage patterns are comparable across genders, while female emerging adults may face higher cognitive deficiencies, specifically in memory- and attention-related fields.

Discussion

The present study aimed to examine the relationship between ChatGPT usage subscales (usage frequency & dependence, cognitive effects, emotional/behavioural impact, and ethical awareness or reflection) and cognitive dysfunction subscales (forgetfulness, distractibility, and false triggering) across emerging adults and four user groups: functional reactive, passive compulsive, cognitively engaged, and reflective ethical. This study was grounded in cognitive load theory, theory of mind, and digital media use frameworks. The results explain adaptive and maladaptive cognitive effects of generative AI involvement across different ChatGPT user profiles and genders. The findings are interpreted in light of the study's objectives and hypotheses.

The first aim was to examine the relationship between ChatGPT usage subscales (usage frequency & dependence, cognitive effects, emotional/behavioural impact, and ethical awareness or reflection) and cognitive dysfunction subscales (forgetfulness, distractibility, and false triggering) across emerging adults and four user groups. Moreover, H1: ChatGPT usage will be statistically positively linked to cognitive dysfunction across four user groups: passive compulsive, functional reactive, cognitively engaged, and reflective ethical. The results of this study

Table 1

Alpha Coefficients, mean, standard deviations, and correlation matrix among Cognitive Functioning (Forgetfulness, Distractibility and False Triggering) and ChatGPT Usage (Usage Frequency & Dependence, Cognitive Effects, Emotional/Behavioral Impact, and Ethical Awareness & Reflection) in emerging adults (N = 300)

Variables	M	SD	α	1	2	3	4	5	6	7	8	9
1. ChatGPT Usage (Total)	67.26	10.43	.85	-	.87**	.84**	.82**	.50**	.27**	.23**	.29**	.21**
2. Usage Frequency & Dependence	16.67	3.84	.76		-	.65**	.71**	.23**	.18**	.15**	.20**	.15**
3. Cognitive Effects	17.21	3.17	.52			-	.60**	.33**	.22**	.18**	.26**	.17**
4. Emotional/Behavioral Impact	15.14	3.59	.75				-	.10	.30**	.23**	.31**	.27**
5. Ethical Awareness & Reflection	18.23	2.96	.59					-	.09	.13*	.08	.04
6. Cognitive Functioning (Total)	38.96	15.99	.92						-	.92**	.91**	.92**
7. Forgetfulness	12.84	5.48	.74							-	.73**	.81**
8. Distractibility	14.81	6.44	.81								-	.71**
9. False Triggering	11.31	5.60	.77									-

Note. $^{*}p < .01$, $^{**}p < .00$, $^{***}p < .000$.

Table 2

Mean wise differences among four different groups of ChatGPT Usage (Minimal /Unhealthy Usage, Moderate Use with Limited Reflection, Moderate, Balanced Use, and Engagement and Ethical Reflection) among Cognitive Functioning (Forgetfulness, Distractibility and False Triggering) and ChatGPT Usage (Usage Frequency & Dependence, Cognitive Effects, Emotional/Behavioral Impact, and Ethical Awareness & Reflection) in emerging adults (N = 300)

	Minimal / Unhealthy Usage (n = 56)		Low–Moderate Use with Limited Reflection (n = 65)		Moderate, Balanced Use (n = 150)		High Engagement and Ethical Reflection (n = 29)				
Variable	M	SD	M	SD	M	SD	M	SD	F	p	η^2_p
ChatGPT Usage (Total)	31.00	11.49	55.95	4.28	69.61	5.01	83.97	3.61	348.52	.001	.77
Usage Frequency & Dependence	6.33	1.63	12.85	2.55	17.47	2.61	21.90	2.01	130.55	.001	.57
Cognitive Effects	7.50	2.66	14.11	2.29	17.94	1.99	21.21	1.80	139.05	.001	.58
Emotional/Behavioral Impact	5.33	0.82	12.08	2.29	15.74	2.74	19.97	1.78	99.24	.001	.50
Ethical Awareness & Reflection	11.83	7.14	16.92	2.96	18.47	2.44	20.90	1.35	27.59	.001	.21
Cognitive Functioning (Total)	27.83	24.05	35.23	14.97	39.41	15.49	46.59	17.00	4.56	.01	.04
Forgetfulness	8.17	6.85	12.11	5.04	12.97	5.43	14.59	6.02	2.91	.04	.02
Distractibility	11.67	9.89	12.98	5.75	14.84	6.24	19.38	6.49	7.55	.001	.07
False Triggering	8.00	7.64	10.14	5.31	11.60	5.49	12.62	6.25	2.38	.07	-

Note. $p < .01$, $p < .00$, $p < .000$.

Table 3

A multiple regression analysis of ChatGPT Usage dimensions predicting Cognitive Functioning in emerging adults with varying usage profile: Minimal /Unhealthy Use, Moderate Use with Limited Reflection, Moderate Balanced Use, and Engagement and Ethical Reflection (N = 300).

Variables	***Cognitive Functioning (Total)***			***Forgetfulness***			***Distractibility***			***False Triggering***		
	B	*SE*	*β*	*B*	*SE*	*β*	*B*	*SE*	*β*	*B*	*SE*	*B*
Model 1. Combine Sample (N = 300)												
(Constant)	11.80	6.54	-	4.04	2.29	-	3.47	2.62		4.29	2.33	
UFD	-.48	.35	-.12	-.12	.13	-.09	-.20	.14	-.12	-.16	.13	-.11
CA	.45	.39	.09	.09	.14	.05	.30	.16	.15*	.06	.14	.03
EBI	1.44	.36	.32***	.38	.13	.25**	.55	.15	.31***	.51	.13	.33***
EAR	.30	.31	.05	.19	.11	.10	.06	.13	.03	.05	.11	.03
Model 2. Minimal / Unhealthy Usage / Passive Compulsive User (N = 56)												
(Constant)	134.286	.000	-	37.14	.000		59.64	.01	-	37.50	.01	-
UFD	20.071	.01	1.363	5.53	.02	1.31	7.28	.03	1.20	7.25	.04	1.54
CA	10.5	.01	1..62	10.71	.05	1.61	1.26	.01	1.03	2.22	.01	1.01
EBI	-49.50	.03	-1.68	-13.75	.06	-1.63	-20.50	.05	-1.69	-15.25	.01	-1.62
EAR	2.57	.06	.763	.78	.01	.81	1.28	.06	.92	.50	.05	.46
Model 3. Low–Moderate Use with Limited Reflection / Functional Reactive User (N = 65)												
(Constant)	12.46	25.90	-	3.75	8.81	-	4.71	9.72	-	3.99	9.23	-
UFD	-.51	.75	-.08	-.01	.25	-.01	-.35	.28	-.16	-.14	.26	-.06
CA	.12	.84	.01	.05	.28	.02	.09	.31	.04	-.02	.30	-.01
EBI	1.28	.93	.19	.22	.31	.10	.65	.35	.26	.40	.33	.17
EAR	.71	.73	.14	.29	.24	.17	.21	.27	.10	.20	.26	.11
Model 4. Moderate, Balanced Use / Cognitively Engaged User (N = 150)												
(Constant)	-1.83	16.35	-	-3.21	5.80	-	3.42	6.70	-	-2.04	5.76	-
UFD	-.52	.47	-.08	-.13	.16	-.06	-.19	.19	-.08	-.19	.16	-.09
CA	.65	.53	.08	.18	.19	.06	.28	.22	.09	.19	.19	.06
EBI	2.02	.46	.35***	.64	.16	.32***	.63	.19	.27	.75	.16	.37
EAR	.36	.47	.05	.27	.16	.12	-.01	.19	-.01	.09	.16	.04
Model 5. High Engagement and Ethical Reflection / Reflective Ethical User (N = 29)												
(Constant)	21.71	78.93	-	20.73	28.69	-	-10.84	27.61		11.82	30.17	
UFD	-.38	1.67	-.04	-.21	.61	-.07	.10	.58	.03	-.28	.64	-.09
CA	2.88	1.80	.30	.67	.65	.20	1.80	.63	.50**	.40	.69	.11
EBI	-1.98	1.80	-.20	-.68	.65	-.20	-.54	.63	-.14	-.75	.69	-.21
EAR	.55	2.53	.04	-.09	.92	-.02	.02	.88	.01	.63	.96	.13

Note. UFD=Usage Frequency & Dependence; CA = Cognitive Awareness; EBI=Emotional/Behavioral Impact; EAR=Ethical Awareness & Reflection, $^{*}p < .01$, $^{**}p < .00$, $^{***}p < .000$.

Table 4

Gender wise differences among Cognitive Functioning (Forgetfulness, Distractibility and False Triggering) and ChatGPT Usage (Usage Frequency & Dependence, Cognitive Effects, Emotional/Behavioral Impact, and Ethical Awareness & Reflection) across emerging female and male adults (N = 300)

Variable	Female (n = 246)		Male (n = 54)					
	M	SD	M	SD	t(df)	p	95% CI (LL, UL)	Cohen's d
ChatGPT Usage (Total)	67.26	9.82	67.28	13.00	-0.01 (298)	.993	-3.11, 3.08	-
Usage Frequency & Dependence	16.56	3.78	17.20	4.08	-1.12 (298)	.263	-1.78, 0.49	-
Cognitive Awareness	17.18	3.08	17.35	3.60	-0.35 (298)	.724	-1.11, 0.77	-
Emotional/Behavioral Impact	15.15	3.50	15.09	4.02	0.11 (298)	.909	-1.00, 1.13	-
Ethical Awareness & Reflection	18.37	2.69	17.63	3.94	1.67 (298)	.097	-0.13, 1.61	-
Cognitive Functioning (Total)	40.73	15.57	30.93	15.56	4.19 (298)	.001	5.20, 14.41	0.63
Forgetfulness	13.40	5.36	10.30	5.37	3.85 (298)	.001	1.52, 4.69	0.58
Distractibility	15.48	6.37	11.78	5.94	3.92 (298)	.001	1.84, 5.56	0.60
False Triggering	11.85	5.57	8.85	5.13	3.63 (298)	.001	1.37, 4.62	0.56

Note. $p < .01$, $p < .00$, $p < .000$.

found that there were significant positive correlations between ChatGPT usage subscales and cognitive dysfunction dimensions across emerging adults. Particularly, emotional/behavioural effect and ChatGPT usage frequency displayed the strongest link with false triggering, forgetfulness, and distractibility. These results are consistent with previous cognitive load theory (Georgiou, 2025; Gkintoni et al., 2025; Schulz et al., 2024), which postulates that cognitively demanding stimuli and excessive task-switching are like AI-mediated interplay among working memory limits, memory consolidation, and impaired attentional control (Obaid et al., 2024; Sikarwar & Zhang, 2023; Yang et al., 2025). Additionally, the association between memory dysfunction and usage dependence supports the idea of digital cognitive offloading (Gilbert, 2024), in which dependence on external AI systems weakens self-monitoring and active memory encoding (Bai et al., 2023; Cheng et al., 2022; Hoskins, 2024).

The second aim focused on evaluating the impact of ChatGPT usage on cognitive dysfunction along their subscales in emerging adults across four user groups. Supporting H2, the emotional/behavioral effect emerged as the most consistent and significant predictor among the cognitive dysfunction subscales. These findings are consistent and support self-regulation theory (Inzlicht et al., 2021; Mithaug, 1993), recommending that emotionally or impulsively reactive usage undermines cognitive control and results in enhanced memory failures and attentional lapses. On the other hand, H3 was just partially supported and aligned with previous studies' results. Although ethical awareness and reflection revealed weak negative associations with cognitive and emotional dysfunction, its effect was non-significantly observed. This result challenges the hypothesis that reflective involvement is cognitively protective(Lewis & Sarkadi, 2024). Moreover, it is possible that heightened ethical contemplation and self-awareness experience a metacognitive processing cost (Jaakkola et al., 2022; Purwaningsih, 2024), theoretically enhancing subjective cognitive load in sustained AI use (Felin & Holweg, 2024), specifically when escorted by emotional involvement (Bagozzi et al., 2022; Phang et al., 2025; Zou et al., 2025).

The third aim examined usage and cognitive difference across four diverse ChatGPT user groups, and Hypothesis 5 was partially supported. The results exhibited that participants who were categorised as having high engagement with ethical reflection scored maximum among usage subscales and, surprisingly, revealed higher cognitive dysfunction, specifically distractibility. These contradictory findings recommend that reflective engagement, whereas apparently adaptive, can contribute to cognitive debt and attentional saturation because of constant metacognitive effort as well as informational overload. These findings support and align with emerging conceptualizations in attentional saturation theory and highlight that even deliberate, value-aligned AI usage cannot be cognitively benign (Chen et al., 2024; Zhao et al., 2024). Moreover, these results support and align a dual-pathway model of cognitive and emotional deficiency in AI usage (Gu et al., 2024; Ortega-Ochoa et al., 2024). The first pathway, emotional-compulsive involvement, includes high behavioural and emotional engagement integrated with frequent use, leading to disturbed memory and attention by emotionally and impulsively driven interaction. Additionally, the second, reflective-cognitive involvement, defined through high ethical awareness or deep reflection, can unexpectedly lead to attentional fragmentation and metacognitive overload when usage is sustained. This approach challenges basic notions of unhealthy versus healthy AI use by presenting that both overly and unregulated reflective involvement can create diverse cognitive burdens (Beese et al., 2023; Dalalah & Dalalah, 2023).

The fourth aim explored gender-based differences in cognitive dysfunction and ChatGPT usage along their subscales in emerging adults. Supporting H4, female emerging adults exhibited more cognitive dysfunction and ChatGPT usage along their subscales as compared to male emerging adults. These results support and align with the gendered cognitive vulnerability model, which recommends that female emerging adults are more vulnerable to emotional reactivity and attentional dysregulation in cognitive stress (Baltezarević & Battista, 2025). It is likely that females' higher affective involvement with advanced AI tools strengthens subjective fatigue and cognitive load (Ahn et al., 2022; Joseph et al., 2024).

Limitations and Future Directions

The present study has many limitations. The cross-sectional or correlational design prevents causal inferences. Moreover, self-report instruments could be subject to biases like social desirability. The homogeneity of the sample (emerging adults from a specific area) limits generalizability. Furthermore, the small reliability of the cognitive effects factors may have affected its predictive and concurrent validity. The study further did not account for the context and content of ChatGPT interplays that could affect cognitive outcomes.

Future studies should adopt experimental or qualitative research designs to develop causal inferences and include standardized behavioral and physiological measures (e.g., memory tasks, EEG, MRI, and fMRI) for improving validity. Expanding the population to incorporate diverse clinical populations, age groups, and cross-cultural samples would enhance generalizability. Psychometric enhancement of the cognitive effects dimensions is required, and investigating the specific context and content of ChatGPT usage can offer deeper understandings into its effect on cognitive load. Recognizing protective factors like emotional regulation and digital literacy may guide prevention and interventions to decrease cognitive strain.

Novel Contributions

This research makes many innovative contributions across methodological, theoretical, and practical fields. Theoretically, it presents a dual-pathway approach of cognitive deficiency in AI practice, differentiating between reflective-cognitive overload and emotional-compulsive involvement, and problematizes the simplistic classification of AI use as either normal or unhealthy, highlighting that both over-reflective engagement and impulsiveness can result in cognitive dysfunction. Further, it extends the application of self-regulation theory, cognitive load theory, and the metacognitive cost hypothesis to human-AI connections. Practically, this research identifies exact ChatGPT practice patterns, including high emotional impact

and frequent use, as important risk issues for cognitive dysfunctions such as distractibility, forgetfulness, and false triggering, offering valuable vision for mental health professionals, including educators, clinical psychologists, and digital health experts, to develop prevention and interventions promoting balanced AI involvement. Moreover, it highlights the key of emotional awareness and digital self-regulation in improving cognitive stress. Methodologically, this study designs and validates a multidisciplinary ChatGPT usage tool, categorizes users into four groups, and uses innovative statistical analyses to recognize usage-related cognitive and emotional risks in emerging adults, providing a nuanced approach to understanding the cognitive effect of AI usage.

Conclusion

This study determines that ChatGPT usage substantially affects cognitive processing, specifically in association to distractibility, forgetfulness, and false triggering across emerging adults. This study found two distinct pathways to cognitive stress: (1) emotional-compulsive engagement, described by impulsive and frequent use that disrupts attention and memory, and (2) reflective-cognitive engagement, where sensitive ethical awareness could trigger metacognitive load, resulting in attentional exhaustion. These results challenge the binary organization of AI practice as either unhealthy or healthy, emphasizing that both overly reflective and compulsive engagement can impair cognitive and emotional performance by different mechanisms. Emotional/behavioral influence emerged as the important factor of cognitive dysfunction, whereas ethical reflection offered limited protective impacts. Moreover, gender differences found in cognitive results, despite comparable usage patterns, recommend underlying emotional regulatory and neurocognitive mechanisms. This study provides a nuanced approach for understanding the cognitive outcomes of AI usage and highlights the requirement for future study employing neurocognitive and experimental methodologies to improve frameworks of safe and cognitively sustainable AI involvement in an increasingly digital environment.

Received: August 11, 2025 Accepted: 10 November, 2025: Published online: November 10, 2025

Ethical Consideration

The study was approved by Department of Behavioural Sciences, National University of Sciences and Technology (NUST), Islamabad, Pakistan. Consent Form was taken before taking data and participants were asked to take voluntary participation.

Acknowledgement

The author thanks to Department of Behavioural Sciences, National University of Sciences and Technology (NUST), Islamabad, Pakistan.

Availability of data and materials

The data sets used and analyzed during the current study are available from the corresponding author on reasonable request.

Authors' contributions/Author details

Kiran Shehzadi conducted this study under the supervision of Khalida Khan and Muhammad Imtiaz Chaudhry

Corresponding author

Correspondence to Shehzadi, k.
capt.kiran20@gmail.com

References

Adeshola, I., & Adepoju, A. P. (2024). The opportunities and challenges of ChatGPT in education. *Interactive Learning Environments*, *32*(10), 6159-6172. https://doi.org/10.1080/10494820.2023.2253858

Ahmed, O. O., Islam, S. I. T., Hamdan, S. I., Al-Rajab, M., Alqatawneh, I., Al-Sartawi, A., & Kanan, M. (2024). Quality Pointpal: AI-enhanced redefinition of social networking for sustainable digital usage and genuine human connections. *Operational research in engineering sciences: Theory and Applications*, *7*(1).

Ahn, J., Kim, J., & Sung, Y. (2022). The effect of gender stereotypes on artificial intelligence recommendations. *Journal of Business Research*, *141*, 50-59. https://doi.org/10.1016/j.jbusres.2021.12.007

Ahn, S. (2025). Preserving Critical Thinking in the Age of Large Language Models: The Paradox of Cognitive Load and Efficiency. *The Korean Journal of Medicine*, *100*(5), 197-200.

Ahuja, K. K., Banerjee, D., Chaudhary, K., & Gidwani, C. (2021). Fear, xenophobia and collectivism as predictors of well-being during Coronavirus disease 2019: An empirical study from India. *International Journal of Social Psychiatry*, *67*(1), 46-53. https://doi.org/10.1177/0020764020936323

Ali, M. Y., Naeem, S. B., & Bhatti, R. (2025). Artificial Intelligence (AI) applications and usage among the LIS professionals of Pakistan. *Journal of Librarianship and Information Science*, *57*(3), 787-800.

Ali, Z., Khan, S. A., Anwar, S., Fazal, I., & Ahmad, I. (2025). AI Algorithms and Their Influence on Consumer Trust in Social Media Advertising, Case Study of Pakistani Youth. *Annual Methodological Archive Research Review*, *3*(5), 300-315.

Anna, R., & Bruno, F. (2025). The Extended Mind and the Influence of Cognitive Artifacts on Human Cognition. *Italian Journal of Educational Research*(34), 021-028.

Arciniegas, D. F. T., Amaya, M., Carvajal, A. P., Rodriguez-Marin, P. A., Duque-Muñoz, L., & Martinez-Vargas, J. D. (2021). Students' attention monitoring system in learning environments based on artificial intelligence. *IEEE Latin America Transactions*, *20*(1), 126-132. https://doi.org/10.1109/TLA.2022.9662181

Arman, M., & Lamiya, U. R. (2023). ChatGPT, a Product of AI, and its Influences in the Business World. *Talaa: Journal of Islamic Finance*, *3*(1), 18-37.

Bagozzi, R. P., Brady, M. K., & Huang, M.-H. (2022). AI service and emotion. In (Vol. 25, pp. 499-504): SAGE Publications Sage CA: Los Angeles, CA.

Bai, L., Liu, X., & Su, J. (2023). ChatGPT: The cognitive effects on learning and memory. *Brain-X*, *1*(3), e30.

Baltezarević, B. V., & Battista, D. (2025). Artificial intelligence and cognitive boundaries: a critical examination of intelligence, understanding, and consciousness. *Knowledge-International Journal*, *69*(1), 61-66.

Baradari, D., Kosmyna, N., Petrov, O., Kaplun, R., & Maes, P. (2025). NeuroChat: A Neuroadaptive AI Chatbot for Customizing Learning Experiences. *arXiv preprint arXiv:2503.07599*.

Bauer, E., Greiff, S., Graesser, A. C., Scheiter, K., & Sailer, M. (2025). Looking beyond the hype: Understanding the effects of AI on learning. *Educational Psychology Review*, *37*(2), 45.

Beese, D., Altunbaş, B., Güzeler, G., & Eger, S. (2023). Did AI get more negative recently? *Royal Society Open Science*, *10*(3), 221159.

Chadha, K. (2024). *Imagine Yourself Explorations in Fostering Personal Expression With Generative AI*. Massachusetts Institute of Technology.

Chauncey, S. A., & McKenna, H. P. (2024). Creativity and innovation in civic spaces supported by cognitive flexibility when learning with AI chatbots in smart cities. *Urban Science*, *8*(1), 16.

Chen, A., Evans, R., & Zeng, R. (2024). Coping with an AI-saturated world: psychological dynamics and outcomes of AI-mediated communication. In (Vol. 15, pp. 1479981): Frontiers Media SA.

Cheng, X., Lin, X., Shen, X.-L., Zarifis, A., & Mou, J. (2022). The dark sides of AI. *Electronic Markets*, *32*(1), 11–15. https://doi.org/10.1007/s12525-022-00531-

Choi, G. (2021). *The internet-extended mind: The psychological ramifications and philosophical implications of cognitive offloading* [Senior thesis, Claremont Colleges]. Claremont Colleges Scholarship. https://scholarship.claremont.edu/scripps_theses/1675

Chong, L., Raina, A., Goucher-Lambert, K., Kotovsky, K., & Cagan, J. (2023). The evolution and impact of human confidence in artificial intelligence and in themselves on AI-assisted decision-making in design. *Journal of Mechanical Design*, *145*(3), 031401.

Clark, A., & Chalmers, D. (1998). *The extended mind*. Analysis, 58(1), 7–19. https://doi.org/10.1111/1467-8284.00096

Dağdemir, V. (2024). *The analysis of postgraduate studies on AI in education in Türkiye.* Digital Security & Media, 1(1), 60–77.

Dalalah, D., & Dalalah, O. M. (2023). The false positives and false negatives of generative AI detection tools in education and academic research: The case of ChatGPT. *The International Journal of Management Education*, *21*(2), 100822.

Del Giudice, M., Scuotto, V., Orlando, B., & Mustilli, M. (2023). Toward the human–centered approach. A revised model of individual acceptance of AI. *Human Resource Management Review*, *33*(1), 100856.

Evans, P., Vansteenkiste, M., Parker, P., Kingsford-Smith, A., & Zhou, S. (2024). Cognitive load theory and its relationships with motivation: A self-determination theory perspective. *Educational Psychology Review*, *36*(1), 7.

Exintaris, B., Karunaratne, N., & Yuriev, E. (2023). Metacognition and critical thinking: Using ChatGPT-generated responses as prompts for critique in a problem-solving workshop (SMARTCHEMPer). *Journal of Chemical Education*, *100*(8), 2972-2980.

Farahmand, F., & Farahmand, F. (2025). Thinking fast and slow for artificial intelligence systems design. *Journal of Engineering Design*, 1-14.

Felin, T., & Holweg, M. (2024). *Theory is all you need: AI, human cognition, and causal reasoning. Strategy Science*, *9*(4), 346-371. https://doi.org/10.1287/stsc.2024.0189

Filippi, S. (2023). *Measuring the impact of ChatGPT on fostering concept generation in innovative product design. Electronics*, *12*(16), 3535. https://doi.org/10.3390/electronics12163535.

Flavián, C., & Casaló, L. V. (2021). *Artificial intelligence in services: current trends, benefits and challenges. The*

Service Industries Journal, *41*(13-14), 853-859. https://doi.org/10.1080/02642069.2021.1989177

Georgiou, G. P. (2025). ChatGPT produces more" lazy" thinkers: Evidence of cognitive engagement decline. *arXiv preprint arXiv:2507.00181*.

Gerlich, M. (2025). AI tools in society: Impacts on cognitive offloading and the future of critical thinking. *Societies*, *15*(1), 6.

Gerlich, M. (2025). *AI Tools in Society: Impacts on Cognitive Offloading and the Future of Critical Thinking*. Societies, 15(1), 6. https://doi.org/10.3390/soc15010006

Gilbert, S. J. (2024). *Memory Augmentation, Cognitive Offloading, and Digital Technology.* Psychological Inquiry, 35(2), 110-112. https://doi.org/10.1080/1047840X.2024.2384129

Gkintoni, E., Antonopoulou, H., Sortwell, A., & Halkiopoulos, C. (2025). Challenging cognitive load theory: The role of educational neuroscience and artificial intelligence in redefining learning efficacy. *Brain Sciences*, *15*(2), 203.

González Tigrero, R. O. (2024). *Advantages and disadvantages of artificial intelligence in the learning process in teenagers* La Libertad: Universidad Estatal Península de Santa Elena. 2024].

Goyal, A. (2025). AI as a cognitive partner: A systematic review of the influence of AI on metacognition and self-reflection in critical thinking. *International Journal of Innovative Science and Research Technology*, *10*(3), 1231-1238.

Grove, C. N. (2025). Are Learning and Understanding Impaired by Memorization? *draws on my research for three published books*.

Gu, Z., Zhu, Q., He, H., Lan, T., & Yu, Z. (2024). Analysis of Emotional Cognitive Capacity of Artificial Intelligence. 2024 27th International Conference on Computer Supported Cooperative Work in Design (CSCWD),

Hao, Z., Fang, F., & Peng, J.-E. (2024). The integration of AI technology and critical thinking in English major education in China: Opportunities, challenges, and future prospects. *Digital Applied Linguistics*, *1*, 2256-2256.

Harry, A. (2023). *Role of AI in education. Interdisciplinary Journal & Humanity (INJURITY), 2*(3), 260–268. https://doi.org/10.58631/injurity.v2i3.52

Hashemi, N., & Kashefi, H. (2025). *Using ChatGPT in teaching integral concepts: Opportunities and challenges. Mathematics and Society, 9*(4), 1–22. https://doi.org/10.1234/mathsoc.2025.004.

Hernández-Orallo, J. (2025). Enhancement and assessment in the AI age: An extended mind perspective. *Journal of Pacific Rim Psychology*, *19*, 18344909241309376.

Holmes, W., & Tuomi, I. (2022). State of the art and practice in AI in education. *European journal of education*, *57*(4), 542-570.

Hoskins, A. (2024). *AI and memory.* Memory, Mind & Media, 3, e18. https://doi.org/10.1017/mem.2024.16

İçen, M. (2022). *The future of education utilizing artificial intelligence in Turkey.* Humanities & Social Sciences Communications, 9(1), 1–10. https://doi.org/10.1057/s41599-022-01284-4

Ihsani, U. A., & Siswono, T. Y. E. (2024). Student's Metacognition in Solving Mathematical Problem using Chat-GPT. *Journal of Mathematical Pedagogy*, *5*(2), 102-112.

Ilomäki, L., Lakkala, M., Kallunki, V., Mundy, D., Romero, M., Romeu, T., & Gouseti, A. (2023). Critical digital literacies at school level: A systematic review. *Review of Education*, *11*(3), e3425.

Inzlicht, M., Werner, K. M., Briskin, J. L., & Roberts, B. W. (2021). Integrating models of self-regulation. *Annual review of psychology*, *72*(1), 319-345.

Iqbal, J., Hashmi, Z. F., Asghar, M. Z., & Abid, M. N. (2025). Generative AI tool use enhances academic achievement in sustainable education through shared metacognition and cognitive offloading among preservice teachers. *Scientific Reports*, *15*(1), 16610.

Islam, I., & Islam, M. N. (2023). Opportunities and challenges of ChatGPT in academia: A conceptual analysis. *Authorea Preprints.* https://doi.org/10.22541/au.167xxxxxx

Jaakkola, N., Karvinen, M., Hakio, K., Wolff, L.-A., Mattelmäki, T., & Friman, M. (2022). Becoming self-aware—How do self-awareness and transformative learning fit in the sustainability competency discourse? *Frontiers in Education*, *7*, Article 855583. https://doi.org/10.3389/feduc.2022.855583

Jacobs, C., Johnson, H., Rennie, T., Lambert, J., & Joiner, R. (2024). Human-Computer Interaction and Artificial Intelligence: Advancing Care Through Extended Mind Theory. *Cureus*, *16*(12).

Jose, B., Cherian, J., Verghis, A. M., Varghise, S. M., S, M., & Joseph, S. (2025). The cognitive paradox of AI in education: between enhancement and erosion. *Frontiers in Psychology*, *16*, 1550621.

Joseph, O. U., Arikpo, I. M., Victor, O. S., Chidirim, N. E., Mbua, A. P., Ify, U. M., & Diwa, O. B. (2024). Artificial Intelligence (AI) in academic research. A multi-group analysis of students' awareness and perceptions using gender and programme type. *Journal of Applied Learning & Teaching*, *7*(1), 76-92.

Kunnath, A. J., & Botes, W. (2025). Transforming science education with artificial intelligence: Enhancing inquiry-based learning and critical thinking in South African science classrooms. *Eurasia Journal of Mathematics, Science and Technology Education*, *21*(6), em2655.

Lawasi, M. C., Rohman, V. A., & Shoreamanis, M. (2024). The Use of AI in Improving Student's Critical Thinking Skills. *Proceedings Series on Social Sciences & Humanities*, *18*, 366-370.

Lee, Y. K., Park, Y.-H., & Hahn, S. (2023). *A portrait of emotion: Empowering self-expression through AI-generated art. arXiv preprint* arXiv:2304.13324. https://doi.org/10.48550/arXiv.2304.13324.

Lewis, P. R., & Sarkadi, Ş. (2024). *Reflective artificial intelligence. Minds & Machines, 34*(2), Article 14. https://doi.org/10.1007/s11023-024-09664-2.

Li, J., Chu, Y., & Xu, J. (2023). Impression transference from AI to human: The impact of AI's fairness on interpersonal perception in AI-Mediated communication. *International Journal of Human-Computer Studies*, *179*, 103119.

Li, J., Yang, Y., Liao, Q. V., Zhang, J., & Lee, Y.-C. (2025a). As confidence aligns: Exploring the effect of ai confidence on human self-confidence in human-AI decision making. *arXiv preprint arXiv:2501.12868*.

Li, J., Yang, Y., Liao, Q. V., Zhang, J., & Lee, Y.-C. (2025b). As Confidence Aligns: Understanding the Effect of AI Confidence on Human Self-confidence in Human-AI Decision Making. Proceedings of the 2025 CHI Conference on Human Factors in Computing Systems,

Magliocca, P., Canestrino, R., Carayannis, E. G., & Gagliardi, A. R. (2025). Understanding human–technology interaction: evolving boundaries. *European Journal of Innovation Management*, *28*(5), 2006-2028.

Majeed, M. K., Ahmad, T. B. B. T., & Khan, A. S. (2025). Empowering functional skills through digital literacy and ICT self-efficacy: Evidence from rural Islamic secondary schools in Pakistan. *At-Tarbawi: Jurnal Kajian Kependidikan Islam*, *10*(1), 1-15.

Malcalm, E., Boakye, M. I., Hevi, S., Asiedu, E., & Anim, M. E. (2024). Analysis of the effect of artificial intelligence on the academic performance, creativity and innovation of tertiary students in Ghana. *Stakeholder Engagement And Participation*, 129.

Masic, I. (2024). Are There Any, and if Yes, Which are the Possibilities for Intellectual Productivity by Use of Artificial Intelligence? *Int J Biomed Healthc*, *12*(4), 264-272.

Mithaug, D. E. (1993). *Self-regulation theory: How optimal adjustment maximizes gain*. Praeger Publishers/Greenwood Publishing Group.

Nikolin, S., Tan, Y. Y., Schwaab, A., Moffa, A., Loo, C. K., & Martin, D. (2021). An investigation of working memory deficits in depression using the n-back task: A systematic review and meta-analysis. *Journal of affective disorders*, *284*, 1-8.

Obaid, M., Parveen, I., Awan, S. J., & Batool, M. (2024). The Cognitive Frontier: Ai's Role In Shaping Academic Performance and Attention Capacities Of Gen-Z Students. *ASSAJ*, *2*(4), 549-567.

Ojo, S. O., & Afolaranmi, A. O. (2024). The Effects of Artificial Intelligence (AI) on Human Interpersonal Connections. *Lead City Journal of Religions and Intercultural Communication*, *2*(2), 162-174.

Oliveira, D. G. d. S. (2025). Rethinking Human-AI interactions through the maintainability: a new criterion for Trust and Glue in the Extended Mind Thesis. *Trans/Form/Ação*, *48*(6), e025061.

Olugbade, T., He, L., Maiolino, P., Heylen, D., & Bianchi-Berthouze, N. (2023). Touch technology in affective human–, robot–, and virtual–human interactions: A survey. *Proceedings of the IEEE*, *111*(10), 1333-1354.

Ortega-Ochoa, E., Sabaté, J.-M., Arguedas, M., Conesa, J., Daradoumis, T., & Caballé, S. (2024). Exploring the utilization and deficiencies of generative artificial intelligence in students' cognitive and emotional needs: A systematic Mini-Review. *Frontiers in Artificial Intelligence*, *7*, 1493566.

Paul, A. M. (2021). *The extended mind: The power of thinking outside the brain*. Mariner Books.

Pedro, F. (2023). Theoretical analysis of the brain and artificial intelligence. *Journal of Robotics Spectrum, 1*, 024–035. https://doi.org/10.53759/9852/JRS202301003.

Peeters, M. M., Van Diggelen, J., Van Den Bosch, K., Bronkhorst, A., Neerincx, M. A., Schraagen, J. M., & Raaijmakers, S. (2021). Hybrid collective intelligence in a human–AI society. *AI & society*, *36*(1), 217-238.

Peng, D., & Yu, Z. (2022). A literature review of digital literacy over two decades. *Education Research International*, *2022*(1), 2533413.

Phang, J., Lampe, M., Ahmad, L., Agarwal, S., Fang, C. M., Liu, A. R., Danry, V., Lee, E., Chan, S. W., & Pataranutaporn, P. (2025). Investigating affective use and emotional well-being on ChatGPT. *arXiv preprint arXiv:2504.03888*.

Purwaningsih, E. (2024). The role of metacognition in character education: A case study on students' moral and ethical formation strategies. *Society*, *12*(1), 1-13.

Rainey, P. B. (2023). Major evolutionary transitions in individuality between humans and AI. *Philosophical Transactions of the Royal Society B*, *378*(1872), 20210408.

Rana, V., & Khalid, G. (2025). Artificial Intelligence (AI) and South Asian Economies: Navigating opportunities and facing challenges. In *South Asian Economic Development in the Era of Global Turbulence* (pp. 145-157). Routledge. https://doi.org/10.4324/9781032716244-16.

Rezai, A., Soyoof, A., & Reynolds, B. L. (2024). Disclosing the correlation between using ChatGPT and well-being in EFL learners: Considering the mediating role of emotion regulation. *European Journal of Education*, *59*(4), e12752.

Riley, T. F., Jerome-Raja, A., & Chakravarthi, S. (2025). Executive Functioning Skills and Artificial Intelligence. In *Transforming Special Education Through Artificial Intelligence* (pp. 257-278). IGI Global.

Saeed, B., & Naqvi, I. (2022). Understanding of Purposefulness and Meaning in Life in Collectivistic Culture of Pakistan: A Qualitative Approach. *Pakistan Journal of Applied Psychology (PJAP)*, *2*(2), 137-146.

Schulz, T., Knierim, M. T., & Weinhardt, C. (2024). How generative-AI-assistance impacts cognitive load during knowledge work: a study proposal. In *NeuroIS Retreat* (pp. 357-365). Springer.

Selwyn, N. (2022). The future of AI and education: Some cautionary notes. *European journal of education*, *57*(4), 620-631.

Shanmugasundaram, M., & Tamilarasu, A. (2023). The impact of digital technology, social media, and artificial intelligence on cognitive functions: a review. *Frontiers in Cognition*, *2*, 1203077.

Sikarwar, A., & Zhang, M. (2023). Decoding the enigma: benchmarking humans and AIs on the many facets of working memory. *Advances in Neural Information Processing Systems*, *36*, 74039-74076.

Sweller, J. (2023). The development of cognitive load theory: Replication crises and incorporation of other theories can lead to theory expansion. *Educational Psychology Review*, *35*(4), 95.

Szymkiewicz, V., Carvalho, E., & Ford, E. A Correlational Study of the Relationship Between ChatGPT Usage & Cognitive Flexibility.

Teng, M. F. (2025). Metacognitive awareness and EFL learners' perceptions and experiences in utilising ChatGPT for writing feedback. *European Journal of Education*, *60*(1), e12811.

Trapp, S., Parr, T., Friston, K., & Schröger, E. (2021). The predictive brain must have a limitation in short-term memory capacity. *Current Directions in Psychological Science*, *30*(5), 384-390.

Vela, D., Sharp, A., Zhang, R., Nguyen, T., Hoang, A., & Pianykh, O. S. (2022). Temporal quality degradation in AI models. *Scientific reports*, *12*(1), 11654.

Wei, S. (2024). *The AI era: Reshaping how we think and work.* In *Human and the world at a crossroads: Technologies, resources, and social institutions – Practical studies: Proceedings of the 4th International Scientific and Methodological Seminar (May 15–17, 2024), dedicated to*

the memory of Doctor of Philosophy, Professor, and Corresponding Member of the National Academy of Pedagogical Sciences of Ukraine Maria Dmytrivna Kultaieva (pp. 37–38). National Technical University "Kharkiv Polytechnic Institute." https://repository.kpi.kharkov.ua/items/becdd58c-f532-477f-ad32-e4f1b100a952

Yadav, P. (2025). Cognitive Sustainability in the Age of AI: A Philosophical Framework for Understanding Competency Erosion and Cognitive Stratification in Human-AI Systems. *Available at SSRN 5317987*.

Yamamura, E., & Hayashi, R. (2024). AI, ageing and brain-work productivity: Technological change in professional Japanese chess. *Plos one*, *19*(5), e0299889.

Yang, Z., Khairuddin, A. S. B. M., Huang, C. J., Ru, W. W., Noman, H. M. F., Putri, T. W. O., Xu, X., & Haq, M. M. (2025). A Review of Short-Term, Long-Term, and Memory Consolidation Mechanisms in the Hippocampus and Cerebral Cortex. *IEEE Access*.

Yasin, F., & Safdar, G. (2025). Exploring the Utilization and Understanding Level of Artificial Intelligence (AI) Technology among University Students in Pakistan. *Online Media and Society*, *6*(1), 55-69.

Yi, S.-i., Kendall, J. D., Williams, R. S., & Kumar, S. (2023). Activity-difference training of deep neural networks using memristor crossbars. *Nature Electronics*, *6*(1), 45-51.

Yıldız, T. (2025). The minds we make: A philosophical inquiry into theory of mind and artificial intelligence. *Integrative Psychological and Behavioral Science*, *59*(1), 10.

Zhai, C., Wibowo, S., & Li, L. D. (2024). The effects of over-reliance on AI dialogue systems on students' cognitive abilities: a systematic review. *Smart Learning Environments*, *11*(1), 28.

Zhang, S., Zhao, X., Zhou, T., & Kim, J. H. (2024). Do you have AI dependency? The roles of academic self-efficacy, academic stress, and performance expectations on problematic AI usage behavior. *International Journal of Educational Technology in Higher Education*, *21*(1), 34.

Zhao, C., Qu, B., Zhou, J., & Lin, C. (2024). The effect of AI-induced outcome favorability on vigilance performance—an exploration based on attention capacity theory. *Current Psychology*, *43*(13), 11493-11506.

Zhao, G., Li, Y., & Xu, Q. (2022). *From emotion AI to cognitive AI. International Journal of Network Dynamics and Intelligence*, 1(1), 65–72. https://doi.org/10.53941/ijndi0101006

Zou, W., Liu, Z., & Lin, C. (2025). *The influence of individuals' emotional involvement and perceived roles of AI chatbots on emotional self-efficacy. Information, Communication & Society*, 1-21. https://doi.org/10.1080/1369118X.2025.2508394.

Zou, X., Su, P., Li, L., & Fu, P. (2024). AI-generated content tools and students' critical thinking: Insights from a Chinese university. *IFLA journal*, *50*(2), 228-241.

Publisher's Note