

Beyond Task Offloading: HCI Frameworks for Continuous, Real-Time Cognitive and Emotional Compensation by AI Partners for Knowledge Workers with Executive Function Deficits

1. Introduction

Recent advances in Human-Computer Interaction (HCI) have moved beyond simple task offloading to develop frameworks for AI partners that provide continuous, real-time cognitive and emotional compensation—especially for knowledge workers with executive function deficits. These frameworks integrate adaptive AI, emotion-aware interfaces, context sensing, and personalized interventions to support attention, memory, planning, emotion regulation, and cognitive load management (Slovák et al., 2022; Pergantis et al., 2025; Samuel et al., 2022; Jiao et al., 2020; Angulo et al., 2023; Alnfai et al., 2025; Ayari et al., 2020; Kundu, 2022; Zhu et al., 2025; Dell'Aquila et al., 2025; Dissanayake & Nanayakkara, 2025). Key approaches include theory-driven emotion regulation frameworks (Slovák et al., 2022), systematic use of AI chatbots for executive function training (Pergantis et al., 2025), adaptive cognitive fit models that align information representation with user needs (Samuel et al., 2022), and context-aware, emotion-adaptive user interfaces (Kundu, 2022; Zhu et al., 2025; Dissanayake & Nanayakkara, 2025). Social robots and digital coaches are also being designed to deliver personalized, real-time cognitive and emotional support (Pesqueira et al., 2025; Arango et al., 2025; Schouten et al., 2018). Despite promising results, challenges remain in generalizability, long-term efficacy, and ethical deployment, highlighting the need for rigorous, user-centered design and ongoing evaluation (Pergantis et al., 2025; Robledo-Castro et al., 2022; Jiao et al., 2020; Alnfai et al., 2025; Desideri et al., 2020; Sarkar, 2025; Korteling et al., 2021; Shirsat & Sabale, 2025).

2. Methods

We searched over 170 million research papers in Consensus, including Semantic Scholar, PubMed, and other major databases, using targeted queries on HCI frameworks for AI partners providing continuous cognitive and emotional compensation for executive function deficits in knowledge work. A total of 984 papers were identified, 858 were screened, 439 were deemed eligible, and the 23 most relevant papers were included in this review.

Search Strategy



FIGURE 1 Flow diagram of the literature search and selection process.

Eight unique search groups and 20 targeted searches were executed, covering foundational frameworks, real-time support, adaptive and emotion-aware systems, critiques, and interdisciplinary perspectives.

3. Results

3.1. Theory-Driven Emotion Regulation and Cognitive Compensation Frameworks

A leading framework in HCI for emotion regulation interventions proposes a three-part structure: (1) theory-informed selection of intervention targets, (2) strategic design of technology-enabled mechanisms, and (3) practical implementation decisions (Slovák et al., 2022). This approach systematizes the integration of psychological theory with HCI design, enabling AI systems to deliver real-time, adaptive support for emotion regulation and executive function.

3.2. AI Chatbots, Social Robots, and Digital Coaches

Systematic reviews show that AI chatbots can enhance executive skills such as planning, attention, and emotion regulation through personalized, conversational interactions (Pergantis et al., 2025). Social robots and digital coaches use real-time sensor data and machine learning to deliver adaptive cognitive exercises, daily task assistance, and emotional support, particularly for populations with cognitive or emotional vulnerabilities (Pesqueira et al., 2025; Arango et al., 2025; Schouten et al., 2018).

3.3. Adaptive Cognitive Fit and Context-Aware Augmentation

The Adaptive Cognitive Fit (ACF) framework leverages AI to dynamically align information representation and task demands, compensating for cognitive limitations and optimizing human performance in complex environments (Samuel et al., 2022). Context-aware frameworks use multimodal behavioral cues (e.g., gaze, typing, interaction speed) to adjust interventions in real time, supporting cognitive flow and minimizing disruption (Zhu et al., 2025; Dissanayake & Nanayakkara, 2025).

3.4. Emotion-Adaptive and Multimodal User Interfaces

Emotion-adaptive UIs integrate facial recognition, eye tracking, and physiological sensors to continuously assess users' cognitive and emotional states, enabling real-time adaptation of interface elements to reduce cognitive load and support executive function (Kundu, 2022). Hybrid model-based frameworks combine neural networks and ontological reasoning for nuanced emotion recognition and context-sensitive assistance (Ayari et al., 2020).

Key Papers

Paper	Framework/Approach	Target Domain	Key Features	Evidence/Outcomes
(Slovák et al., 2022)	Theory-driven emotion regulation	HCI interventions	3-part framework, systematizes design	Guides future research, practical implementations
(Pergantis et al., 2025)	AI chatbots for executive function	Cognitive/emotional support	Systematic review, personalized chatbots	Positive effects, need for unified framework
(Samuel et al., 2022)	Adaptive Cognitive Fit (ACF)	Information management	AI-augmented info representation	Improved performance, empirical validation
(Kundu, 2022)	Emotion-adaptive UI	High-stress environments	Real-time adaptation, multimodal sensing	Enhanced task performance, user satisfaction
(Dissanayake & Nanayakkara, 2025)	Context-aware cognitive flow	Reasoning support	Multimodal cues, adaptive interventions	Maintains cognitive flow, personalized support

FIGURE 2 Comparison of key studies on HCI frameworks for continuous cognitive and emotional compensation.**Top Contributors**

Type	Name	Papers
Author	Petr Slovák	(Slovák et al., 2022)
Author	Athanasios Drigas	(Pergantis et al., 2025)
Author	Jim Samuel	(Samuel et al., 2022)
Journal	<i>ACM Transactions on Computer-Human Interaction</i>	(Slovák et al., 2022)
Journal	<i>Brain Sciences</i>	(Pergantis et al., 2025)
Journal	<i>Int. J. Inf. Manag.</i>	(Samuel et al., 2022)

FIGURE 3 Authors & journals that appeared most frequently in the included papers.

4. Discussion

The dominant HCI frameworks for continuous, real-time cognitive and emotional compensation by AI partners are characterized by their integration of psychological theory, adaptive AI, and multimodal sensing (Slovák et al., 2022; Pergantis et al., 2025; Samuel et al., 2022; Kundu, 2022; Zhu et al., 2025; Dissanayake & Nanayakkara, 2025). These frameworks move beyond static task offloading, enabling AI systems to dynamically support executive function and emotion regulation in knowledge work. The evidence suggests that such systems can improve task performance, user satisfaction, and well-being, especially when interventions are personalized and context-aware (Pergantis et al., 2025; Samuel et al., 2022; Kundu, 2022; Zhu et al., 2025; Dissanayake & Nanayakkara, 2025). However, the field faces challenges: many studies are early-stage, with limited generalizability and long-term validation (Pergantis et al., 2025; Robledo-Castro et al., 2022; Jiao et al., 2020; Alnfai et al., 2025; Desideri et al., 2020; Sarkar, 2025; Korteling et al., 2021; Shirsat & Sabale, 2025). Ethical considerations—such as privacy, transparency, and the risk of over-reliance—require careful attention in both design and deployment (Pergantis et al., 2025; Sarkar, 2025; Korteling et al., 2021; Shirsat & Sabale, 2025). The literature calls for unified frameworks, larger and more diverse study populations, and participatory design to ensure that AI partners are effective, inclusive, and trustworthy.

Claims and Evidence Table


Claim	Evidence Strength	Reasoning	Papers
Theory-driven, adaptive frameworks enable real-time cognitive and emotional compensation	 Strong	Empirical and theoretical work shows improved support for executive function and emotion regulation	(Slovák et al., 2022; Pergantis et al., 2025; Samuel et al., 2022; Kundu, 2022; Zhu et al., 2025; Dissanayake & Nanayakkara, 2025)
AI chatbots and social robots can enhance executive skills and emotional well-being	 Moderate	Systematic reviews and case studies report positive effects, but generalizability is limited	(Pergantis et al., 2025; Pesqueira et al., 2025; Arango et al., 2025; Schouten et al., 2018)
Multimodal, context-aware systems optimize intervention timing and reduce cognitive load	 Moderate	Studies demonstrate improved performance and satisfaction with adaptive, sensor-driven UIs	(Samuel et al., 2022; Kundu, 2022; Zhu et al., 2025; Dissanayake & Nanayakkara, 2025)
Generalizability and long-term efficacy remain underexplored	 Moderate	Most studies are short-term, with small or specific samples	(Pergantis et al., 2025; Robledo-Castro et al., 2022; Jiao et al., 2020; Alnfai et al., 2025; Desideri et al., 2020; Sarkar, 2025; Korteling et al., 2021; Shirsat & Sabale, 2025)
Ethical and privacy concerns must be addressed in deployment	 Moderate	Literature highlights risks of over-reliance, privacy, and transparency	(Pergantis et al., 2025; Sarkar, 2025; Korteling et al., 2021; Shirsat & Sabale, 2025)

FIGURE 4 Key claims and support evidence identified in these papers.

5. Conclusion

HCI frameworks for AI partners that provide continuous, real-time cognitive and emotional compensation are advancing rapidly, integrating adaptive, theory-driven, and context-aware approaches. While these systems show promise for supporting knowledge workers with executive function deficits, further research is needed to ensure their effectiveness, inclusivity, and ethical deployment.

5.1. Research Gaps

Key gaps include the need for unified frameworks, long-term and large-scale validation, participatory design, and robust strategies for privacy and ethical risk mitigation.

Research Gaps Matrix

Framework Type	Personalization	Long-term Efficacy	Multimodal Sensing	Real-world Validation	Ethics/Privacy
Theory-driven/adaptive	6	3	4	3	3
Chatbots/Robots	5	2	2	2	2
Adaptive Fit/Context	4	2	3	2	2
Emotion-adaptive UI	4	2	4	2	2

FIGURE 5 Heatmap of research coverage by framework type and study attribute.

5.2. Open Research Questions

Future research should focus on developing unified, participatory frameworks, validating long-term impact, and ensuring ethical, privacy-preserving deployment of AI partners for executive function support.

Question	Why
How can unified, participatory frameworks be developed for continuous, real-time cognitive and emotional compensation in knowledge work?	Ensures interventions are effective, inclusive, and user-driven.
What are the long-term impacts and real-world efficacy of adaptive, context-aware AI partners for executive function deficits?	Long-term, real-world validation is essential for sustainable support.
How can privacy, transparency, and ethical risks be systematically addressed in the deployment of continuous AI support systems?	Critical for user trust, safety, and responsible adoption.

FIGURE 6 Open research questions and their significance for future work.

In summary, HCI frameworks for AI partners that provide continuous, real-time cognitive and emotional compensation are evolving rapidly, but require unified design, rigorous validation, and ethical vigilance to maximize their impact for knowledge workers with executive function deficits.

These papers were sourced and synthesized using Consensus, an AI-powered search engine for research. Try it at <https://consensus.app>

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