

Towards Cognitively Aware Intelligent Systems: A Survey of Human Memory’s Role in Shaping Adaptation Mechanisms

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1 Introduction

- Diverse **systems** and **artificial intelligence** are progressively integrated into daily life
- Necessity of **personalizing** these systems to the user and tackling the **one-size-fits-all** approach
- For more accurate profiling, systems have started integrating not only **basic information** such as background, interests and goals, but **individual traits** such as **cognitive styles**, extracted from specially designed psychological tests
- **Human memory** consists of multiple systems with distinct operating principles and neuroanatomical structures that **function in parallel** to support behavior. It plays a critical role in **learning, decision-making, and adapting to new environments**
- **Motivation:** while technologies are integarting the memory factor into play, it is still unclear what are the current mechanisms and guidelins for measuring and using this data are



2 Research Questions

- **RQ-1:** What forms of information related to this type of process has Human Collaborative AI (HCAI) research used for adaptation of intelligent systems?
- **RQ-2:** For what objectives has this information been used?
- **RQ-3a:** How has this information been used?
- **RQ-3b:** Are there any trends or patterns observable in this usage?
- **RQ-4:** In which application domains?
- **RQ-5a:** Are there any trends or patterns observable in recent developments?
- **RQ-5b:** What challenges and trends exist in recent developments?

6 Conclusion

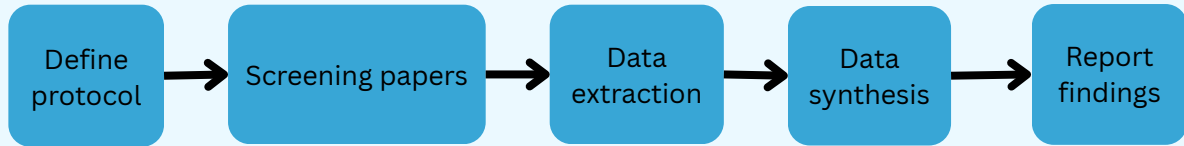
- Correlation between **cognitive load decrease** and **lower performance and efficiency** in users
- Users that have used this systems have shown **improved memory skills**
- Approach used in **games**: difficulty level adjustment
- Approach used in **web** or **AR based environments**: restructuring and modification of content displayed
- Expand survey by **removing feasibility constraints** and **broadening the memory scope**

5 Discussion

- Given the dynamic and fallible nature of the human memory, it becomes necessary to make use of external measures such as **psychometric tests, brain activity monitoring tools** and **temporal indicators** to assess the cognitive load
- Predominance in game-like scenarios: 7 papers are characterized as **serious games**
- 13 papers have only **conceptualized** the adaptation and user profiling step of their systems
- Main audience is not patients of cognitive impairment, but **specialized workers** or **pilots**
- Only **a single paper** designed a tool for children

3 Methodology

- A **Systematic Literature Review**, following the 2020 PRISMA guidelines is conducted to answer the research questions
- Steps of a Systematic Literature Review



- **Query Key Concepts:** Human, Memory, Adaptive, Intelligent Systems
- **Literature Databases:** Scopus, Web of Science, ACM Digital Library
- **Inclusion Criteria:** systems that adapt based on the user’s memory, systems that introduce a conceptual adaptation based on the user’s memory
- **Exclusion Criteria:** non-English papers, computer-related memory, systems that mimic human memory, surveys, reviews, non-adaptable technologies, retracted publications, Wizard-of-Oz approaches, tools designed to assess characteristics
- **Feasibility Criteria:** restricted range of human memory, Computer Science field

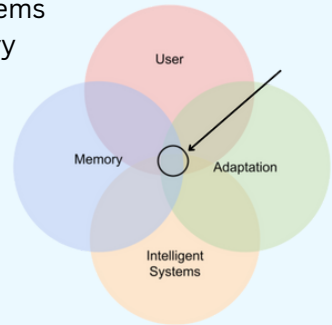


Figure 1. Key concepts of the topic

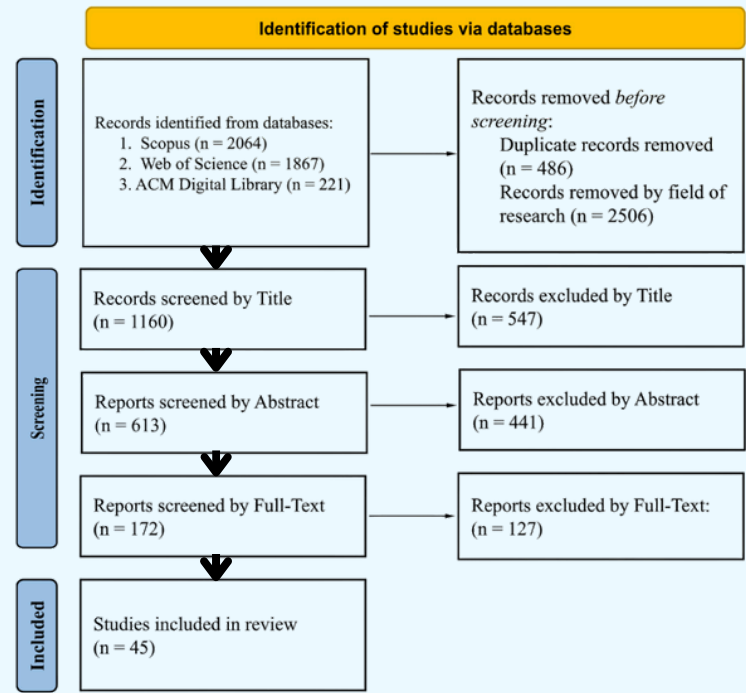


Figure 2. PRISMA flow diagram

- A total of 4152 papers were retrieved, filtered and screened based on the steps showed in figure 2.
- Result: **45 papers included in the study**
- Data extraction was performed on the remaining papers in order to answer the research questions

4 Results

4.1. Memory-related Input Data and Measurements

- 9 types of inputs

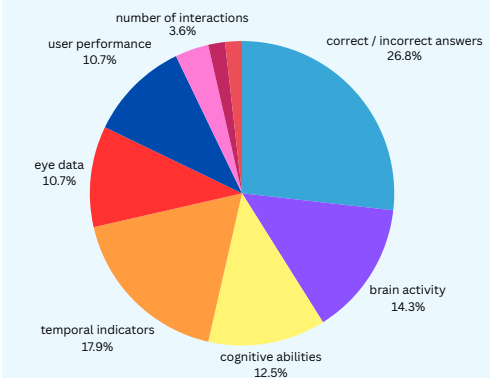


Figure 3. Overview of inputs found in literature



Figure 4. functional near-infrared spectroscopy (fNIRS)

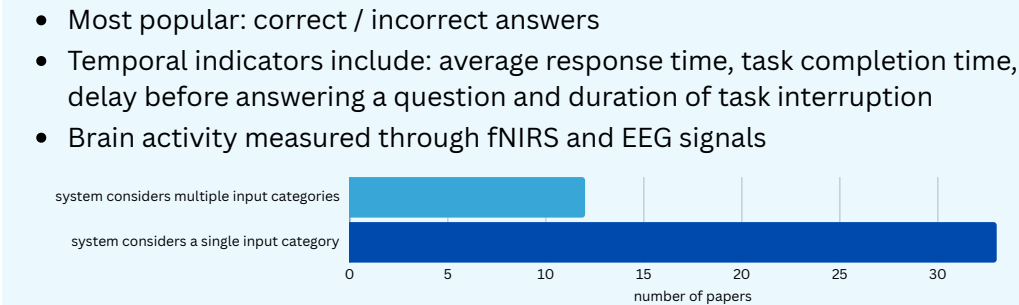


Figure 5. Comparison between systems that consider multimodal input categories and ones that don't

4.2. Adaptation Mechanisms

- Most implemented adaptation: modification of complexity and structure of provided information
- Other common approaches: adjust type of content provided, change difficulty level and add or remove reinforcement strategies
- Cognitive training and rehabilitation: from post brain injury recovery to memory enhancement programs
- Educational support: teaching children basic shapes, learning a foreign language, learning to play the piano
- Daily life assistance: making sure the user has eaten, improve multi-tasking, password generation, decrease sense of isolation

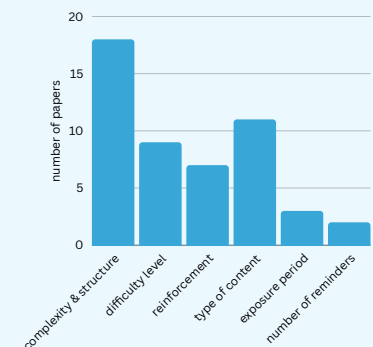


Figure 6. Overview of adaptation strategies

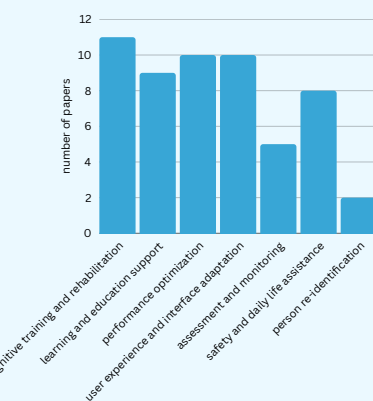


Figure 7. Overview of adaptation objectives

4.3. Application Domains

- 13 out of 45 papers do not mention the intended application domain of their system
- Most popular: Education
- Other domains: Manufacturing, Healthcare and Aviation
- Most papers in aviation and manufacturing presented systems developed using AR or VR

4.4. Challenges and Trends in Recent Developments

- Developed systems are still in their early stages
- Most have not yet made use of multimodal profiling, only considering the perceived human memory, ignoring additional factors
- Systems are focused on enhancing learning efficiency and sustaining productive performance over extended periods of time.