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DOI
10.1080/07370024.2023.2251969

Publication date
2023

Document Version
Final published version

Published in
Human-Computer Interaction

Citation (APA)
Mauro, N., Cena, F., Putnam, C., Pera, M. S., & Roldán Álvarez, D. (2023). Introduction to this special issue on intelligent systems for people with diverse cognitive abilities. *Human-Computer Interaction*, *39*(1-2), 1-7. https://doi.org/10.1080/07370024.2023.2251969

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HUMAN–COMPUTER INTERACTION

Human–Computer Interaction

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/hhci20

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To cite this article: Noemi Mauro, Federica Cena, Cynthia Putnam, Maria Soledad Pera & David Roldán Álvarez (2023): Introduction to this special issue on intelligent systems for people with diverse cognitive abilities, Human–Computer Interaction, DOI: 10.1080/07370024.2023.2251969

To link to this article: https://doi.org/10.1080/07370024.2023.2251969

Published online: 06 Sep 2023.

HUMAN–COMPUTER INTERACTION
https://doi.org/10.1080/07370024.2023.2251969

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Introduction to this special issue on intelligent systems for people with diverse cognitive abilities

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ABSTRACT

This special issue highlights state-of-the-art research in intelligent systems and technology for people with diverse abilities. To control scope, we pay particular attention to cognitive diversity, including but not limited to, neurodevelopmental disorders and autism, cognitive and learningdisabilities, and dementia. We introduce the papers in this special issue by contextualizing them according to different research areas. By curating leading-edge contributions in this area, we aim to raise awareness about research challenges and requirements inherent in the development and assessment of systems designed for these categories of users.

ARTICLE HISTORY
Received 15 August 2023
Revised 16 August 2023
Accepted 17 August 2023

KEYWORDS
Cognitive Disabilities; Neurodevelopmental Disorders; Autism; Dementia; Intelligent Systems; Human-computer Interaction

1. Introduction

This special issue highlights state-of-the-art research in intelligent systems and technology for people with diverse abilities. To control scope, we pay particular attention to cognitive diversity, including but not limited to, neurodevelopmental disorders and autism, cognitive and learning disabilities, and dementia. By curating leading-edge contributions in this area, we seek to raise awareness about research challenges and requirements inherent in the development and assessment of systems designed for these categories of users.

The inclusion of people with disabilities is extremely important, since, as of 2023, about 27% of US citizens have some form of disability (Centers for Disease Control and Prevention, 2023). This statistic is reflected worldwide, with 16% of the population experiencing some form of disability (World Health Organization, 2023). Prior research has resulted in numerous technologies that support people with physical (e.g., mobility) impairments, and sensory disabilities (e.g., blindness and deafness), but there has been much less attention paid to those with cognitive disabilities. However, according to the Centers for Disease Control and Prevention (2023), the most widespread form of disability regards cognition (close to 13%). Cognitive disabilities pose distinct challenges from the perspectives of: (1) intelligent systems (e.g., which user data to consider, how to design novel efficient algorithms, which information to present, etc.), (2) interaction design (e.g., how to present information, in which format) and (3) technology (e.g., development and principled assessment of new algorithms and technologies). The lack of work in this area can be explained by the difficulty in managing the extreme subjectivity of this condition, in contrast to more objective problems like physical ones.

As a result, prior research efforts dedicated to developing intelligent systems to support people with cognitive disabilities are limited. Among the Human-Computer Interaction (HCI) community,

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technology has begun to support people with cognitive disabilities in managing specific problems targeting specific categories of users, such as social interaction for people with autism (Boyd et al., 2016; Grynszpan et al., 2014; Martin et al., 2019; Putnam et al., 2019; Simm et al., 2016) designs to support people with learning disabilities (Bryant et al., 2014) and communication and job training for people with cognitive impairments (Roldán-Álvarez et al., 2021; Samuelsson & Ekström, 2019; Smith et al., 2011).

With recent advances in Artificial Intelligence (AI), the study of intelligent systems to support people with cognitive disabilities has become more relevant, since AI can be used to increase the accessibility of services (Costa et al., 2017; Hong et al., 2012; Mauro et al., 2022; Pera & Ng, 2014). There is a growing number of examples showing how AI is being used by people with different disabilities. For instance, applications that use image and facial recognition for people with visual impairments (e.g., (Kianpisheh et al., 2019)), automatic lip-reading for people with hearing impairments (e.g., (Mattos & Oliveira, 2018)), conversational interaction for people with cognitive impairments (e.g., (Yaghoubzadeh & Kopp, 2015)) and real-time captioning and translations for people with hearing impairments and second language learners (e.g., (Martinez, 2021)). Ethical issues are also a concern (Lillywhite & Wolbring, 2021), and these are compounded by the challenges of making AI itself more inclusive toward these users, to ensure AI fairness for people with disabilities (Guo et al., 2020; Trewin et al., 2019). Other issues concern the implications of designing intelligent systems for people with cognitive disabilities (Lewis, 2020). Moreover, it is necessary to consider the risks of AI for this target population, for example, discrimination against people with disabilities, lack of awareness of AI, and increased unquestioning trust of AI (Smith & Smith, 2021).

2. Review process

For this special issue, we sought to improve awareness of the state-of-the-art in this important area. In response to our call, we received 23 proposals from researchers and practitioners in diverse fields of study. We reviewed these and invited 12 to submit a full research article. After two review iterations, involving experts in computer science and human-computer interaction, nine articles were accepted for this special issue.

3. Articles in this special issue

Our special issue allows us to spotlight state-of-the-art research in this area that explores multiple perspectives and applications, including, but not limited to HCI, Information Retrieval, Recommender Systems, Machine Learning, AI, User Modeling, User Behavior, Interaction, and development of new algorithms and (web) applications.

We organized the articles into four areas: Diagnostics and Enhancement, Vocational and Cultural Deployments, Conceptual Frameworks, and User Studies.

3.1. *Diagnostics and enhancement*

The articles in the first part of the special issue focus on novel intelligent systems that diagnose disabilities and can also enhance cognitive impairments of people with diverse cognitive abilities.

Research into intelligent systems and their use by people with diverse cognitive abilities is varied. Not only is attention paid to how intelligent systems are used for training skills or for diagnosing, but also to how people with diverse abilities can help contribute to the design of such systems. Studies such as the one carried out by Beccaluva et al. (2023), demonstrate how intelligent systems can be used to predict Developmental Language Disorder (DLD). Their web application, MARS, collects data from users while they engage in rhythmic babbling exercises and analyzes these

recordings using machine learning algorithms. This novel approach demonstrates that participants' rhythmic vocal productions can be used in the early diagnosis of DLD.

Paternò et al. (2023) examine Attention Deficit/Hyperactivity Disorder (ADHD) in young children. They introduce PlayToPickUp, a web-based game created using a participatory approach aimed at enhancing cognitive functions such as divided/selective attention and error monitoring in children. This design is the result of a collaboration among a multidisciplinary team of experts and caregivers. Specifically, the team conducted two trials to identify the challenges and opportunities for designing effective intelligent solutions to support children with ADHD in real-world settings.

Gaspari et al. (2023) focus on Multiple Sclerosis (MS), which is the second-most common cause of neurological disability among young adults, causing cognitive impairment in many cognitive domains, including executive-function disorders. Brain games, initially available in paper-and-pen format, have been designed to improve planning abilities. Current computerized cognitive training tools also include this kind of exercise; however, such commercial tools have several limitations, which can be overcome by automated planning. The authors test the usability of two computerized cognitive training exercises for executive functions based on automated planning, which includes new features and interaction mechanisms. The results show that multidomain cognitive training addressing individuals affected by MSwho experience the exercise perform better in the test. The study reveals the benefits of new designs of executive-function exercises based on automated planning, showing that they can be successfully used in multidomain cognitive training by participants affected by MS.

3.2. *Vocational and cultural deployments*

The second set of papers presents work that aims to support people with diverse cognitive abilities in their working life, as well as in their free time, such as when they are visiting a museum.

Estival et al. (2023) address the problem of high unemployment among adults with autism. It is common for people with autism to have deficits in social skills, so the authors' tablet-based intervention, called "Social Handy", aimed to teach work-related social skills through scenarios. The authors worked with: (a) professionals from organizations that offer employment for people with disabilities and (b) adults with autism. Using a participatory design approach, through a two-part study, the authors created 66 social scenarios illustrating 28 social skills (e.g., handling sensitive interactions) for their Social Handy app.

In their case study, Lieto et al. (2023) discuss the design and evaluation of an affect-based sensemaking system integrated into an app designed to foster the inclusion and engagement of Deaf individuals in cultural heritage. This endeavor aims to enhance the engagement of deaf museum visitors with artworks. To do this, the researchers collaborated with experts in AI, HCI, museology, and the Gallery of Modern Art in Turin, with support from the Turin Institute for the Deaf. Users of the system can share their personal interpretations of artworks by creating simple stories based on the museum's art collection. The system then utilizes user annotations to explore the collection of stories, highlighting affective similarities and contrasts among them, to foster perspective-taking and empathy.

3.3. *Conceptual frameworks*

The third part of the special issue is dedicated to two articles that review the literature concerning intelligent systems for people with diverse cognitive abilities from two different perspectives.

Chessa et al. (2023) survey innovative research in Information and Communication Technologies used for people with Autism Spectrum Disorder (ASD), classifying prior work based on three different, but strictly crossed axes, namely the triad of impairment (either communication, social

interaction, or social behaviors), research purpose (either diagnosis or therapy) and system activity (either monitoring or intervention).

Hocine and Sehaba (2023) review papers about personalization within e-learning systems, discussing the strengths and weaknesses of current research and describing opportunities to improve research in personalized e-learning systems for people with cognitive disabilities. Many previous literature reviews focus on specific areas of personalized learning, but they do not investigate personalization techniques for autonomous learning of students with cognitive disabilities. Indeed, most e-learning platforms have been initially designed without taking into account users with multiple profiles and impairments. The review suggests that personalized systems can help overcome access barriers in learning for people with disabilities by helping them learn autonomously without the direct intervention of tutors.

3.4. *User studies*

Finally, the fourth part of the special issue presents two articles that describe different user studies that aim to improve the design of intelligent systems for people with diverse cognitive abilities.

Sitbon et al. (2023) investigate how to ensure that the interaction models offered by intelligent systems, and particularly search engines, are both accessible and useful to people with diverse cognitive abilities. The authors use a participatory approach to explore a range of settings to encourage participants to demonstrate "information seeking" behaviors. They observe that seeking information was not seen as a primary goal by participants, nor how they wanted to engage with search engines. Throughout the contextual interviews, the researchers instead observed instances where the search engine was used as a means to connect with the interviewer, sharing life events and interests, and demonstrating abilities, rather than one of accessing knowledge and information. Specifically, researchers observed that browsing itself supports non-verbal conversations, with each step able to scaffold and refine a discourse aimed at the person supporting the activity.

The work by Suijkerbuijk et al. (2023) explores how interviews with people with dementia can be used to enhance intelligent systems. Results show that information exchange with people with dementia can be supported by carefully constructed questions, well designed-probes, and an appropriate length of interview. The authors believe that interviews should be designed as a fulfilling experience, from which both parties can benefit. To create a pleasant atmosphere during the interviews, researchers should be prepared to respond respectfully to negative responses and be able to adapt to different signs of consent, therefore, being able to adapt an intelligent system that caters to their unique challenges and requirements.

4. Concluding remarks

The authors of the articles included in this special issue highlight open challenges and opportunities related to how to best design intelligent systems for people with diverse cognitive abilities. They also focus on the importance of involving target users in the design process in a participatory design approach. The intelligent systems presented in the papers have different aims, from diagnosis to training and support for people's everyday lives. Moreover, the user studies and surveys highlight issues and guidelines that are useful for designing and developing intelligent systems for people with diverse cognitive abilities. Furthermore, as the articles focus on different cognitive abilities, we hope that this special issue will offer a broad perspective in the field. Beyond showcasing open issues and new opportunities for research, we believe this special issue serves as a means to build a community around this important area of study, as research in this area is otherwise disseminated across many different venues.

Acknowledgments

We extend our gratitude to all the authors who submitted proposals to this special issue. Moreover, we are thankful to the reviewers for dedicating their time and effort to provide constructive criticisms and valuable feedback during the review process. Finally, we would like to thank Steve Whittaker and Scott Carter, the current Editor and Administrative Editor, respectively, of the Human-Computer Interaction journal, and Sean Raney, from the Journal Editorial Office, for their guidance and support throughout our curation of this Special Issue.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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