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Assistive technology for developmental conditions: A scientometric analysis

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ABSTRACT

Assistive technology plays a pivotal role in supporting individuals with developmental conditions by fostering independence and addressing needs across physical, cognitive, and communicative domains. Despite its benefits, widespread adoption remains limited due to high costs, usability challenges, and limited real-world applicability. This study offers a comprehensive overview of assistive technology's role in the context of developmental conditions by outlining key research areas and influential publications. Using a scientometric approach, we examined 1322 documents from Scopus and their 44,699 references. Co-citation analysis revealed three main thematic clusters and identified four particularly impactful publications, with the most influential authored by Lancioni and Singh (2014). A qualitative analysis of the clusters highlighted three recurrent research themes: (1) communication and mobility in individuals with profound developmental conditions; (2) cognitive functions and autonomy in individuals with developmental and intellectual conditions; and (3) communication and social cognition in autism. These areas reflect the increasing integration of assistive technologies into therapeutic, educational, and daily life contexts, enhancing quality of life, autonomy, and social participation. Emerging research also underscores the ethical need to design technologies that respect the preferences and lived experiences of individuals with developmental conditions, avoiding the imposition of neurotypical norms. Co-participation in design is gaining prominence, promoting more personalized, inclusive, and neurodiversity-oriented approaches.

Abbreviations: DCA, Document Co-citation Analysis; LLR, Log-likelihood ratio; GCS, Global Citing Score; PRISMA, Preferred Reporting Items for Systematic Reviews.

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1. Introduction

Assistive technology encompasses a wide range of devices, equipment, and systems designed to enhance the functional abilities of individuals with conditions (Lin & Gold, 2018). Children with developmental conditions, in particular, may experience physical, learning, behavioral, and communication challenges that significantly impact their psychosocial and educational development (Gleason et al., 2016). As a result, they often require specialized equipment or personal assistance to carry out daily activities (Lin & Gold, 2018). Interventions aimed at addressing these challenges have increasingly incorporated assistive technology (Pontikas et al., 2022). Examples include mobility aids (Yusif et al., 2016), communication tools (Spitale et al., 2023), and durable medical equipment (Yusif et al., 2016), all of which promote greater independence and accessibility. By fostering learning in more secure, stable, and engaging environments, assistive technology contributes to improved educational outcomes, enhanced autonomy, and better communication skills (Huijnen et al., 2016; Lin & Gold, 2018; Pontikas et al., 2022; Van der Meer et al., 2012). The effectiveness of assistive technology in supporting children with developmental conditions has been demonstrated in a variety of contexts. For example, research has shown that children with Angelman syndrome and other developmental conditions benefit from assistive technology in therapy sessions (Stasolla et al., 2021), while some autistic children experience improvements in social skills through the use of robotics (Syriopoulou-Delli & Gkiolnta, 2022). Similarly, access to assistive technology has been associated with higher levels of engagement and academic success in autistic students (Barnard-Brak et al., 2014), and greater mobility independence in children with cerebral palsy who use manual and powered wheelchairs (Rodby-Bousquet & Hägglund, 2010).

Different types of assistive technology are used based on their specific functions, addressing a wide range of needs across various developmental domains. For instance, mobility aids, such as myoelectric arm prostheses and powered mobility devices (e.g., wheelchairs), support physical independence (Yusif et al., 2016), while cognitive assistive technology, including text-to-speech systems and memory aids, helps individuals with learning and memory difficulties (Widehammar et al., 2019). Additionally, assistive technology caters to sensory impairments, with personal amplification systems and devices that convert speech into text for hearing support (Hermawati and Pieri, 2020), as well as magnifiers and Braille displays for vision assistance (Yusif et al., 2016). Communication aids, such as speech output software and symbol-making programs, are essential for individuals with speech and language impairments/delays (Kbar et al., 2017), while assistive devices for daily living, including reachers and dressing aids, facilitate everyday activities and promote self-sufficiency (Matter et al., 2017). By addressing these various needs, assistive technology improves the person's quality of life and fosters greater participation in social, educational, and professional settings.

Although assistive technology offers significant benefits for individuals with developmental conditions, it is important to acknowledge its limitations in terms of both application and effectiveness. Several challenges hinder its widespread implementation, including high costs, complex designs, and the rapid pace of technological advancement, which frequently exceeds the ability of users and providers to adapt effectively and efficiently (Clifford Simplican et al., 2018; Rasouli et al., 2023). A key concern raised by Rasouli et al. (2023) is the potential for assistive technology to excessively replace face-to-face interactions, which may have negative implications for human relationships and social development. While technology can offer valuable support, it is crucial to consider its role in maintaining personal connections and ensuring that it does not lead to social isolation (Bennett et al., 2018; Owuor et al., 2018). Another limitation is the "human" element involved in engaging with assistive technology, which heavily depends on the provider, such as a professional, teacher, or parent, and the degree of customization tailored to an individual's needs (Pontikas et al., 2022). Many studies on assistive technology are conducted in controlled environments, which may not accurately reflect the real-world complexities and dynamics of therapeutic practice (Huijnen et al., 2016). These interventions tend to be more general and may not effectively address the unique requirements of each individual, limiting their real-world applicability (Huijnen et al., 2016). This limitation is compounded by the fact that most devices, such as robots designed for autistic individuals, face significant constraints in both their range of motion and their ability to resemble human appearance (Puglisi et al., 2022). These challenges underscore the importance of continuous adaptation, customization, and careful consideration of the broader social context when implementing assistive technologies (Shukla et al., 2019).

The present review aims to provide a comprehensive understanding of the role of assistive technology in supporting individuals with developmental conditions by exploring key research domains within this field. While prior literature has addressed specific technologies or target populations, there is a lack of a unified, data-driven synthesis that maps the broader research landscape. This review addresses this gap by analyzing the most recurring themes and identifying the most influential works, thereby providing a systematic overview of the field's evolution and the impact of assistive technology on individuals with developmental conditions. Using a scientometric approach that combines bibliometric analysis with scientific mapping techniques, this study offers novel insights into the structure, dynamics, and intellectual foundations of assistive technology research in the context of developmental conditions. This method allows for a large-scale, data-driven examination of the structure and dynamics of the research landscape, offering valuable insights into the literature of interest (e.g., Carollo et al., 2021; Cavallaro et al., 2025; Fong et al., 2023; Lim et al., 2023).

2. Methods

2.1. Data collection from scopus

As in previous scientometric studies in the field of developmental conditions (e.g., Carollo et al., 2021; Cavallaro et al., 2025; Fong et al., 2023; Lim et al., 2023), all data for the present review were collected from Scopus, which was selected for its extensive coverage of indexed journals (Falagas et al., 2008).

Data were collected on October 16, 2024, using the following search string: "TITLE-ABS(("developmental disabilit*" OR "intellectual disabilit*" OR "cognitive disabilit*" OR "developmental disorder*" OR "neurodevelopmental disorder*" OR "intellectual impairment" OR "neurodevelopmental disabilit*" OR "developmental delay" OR "autism" OR "autistic" OR "ADHD" OR "attention deficit hyperactivity disorder" OR "dyslexi*" OR "dyscalculi*" OR "dyspraxi*" OR "down syndrome" OR "cerebral palsy") AND ("assistive technolog*" OR "assistive device*" OR "technical assistance" OR "cognitive technolog*" OR "rehabilitative technolog*" OR "technological assistance"))". The search aimed to identify documents at the intersection of developmental conditions and assistive technology. Therefore, studies that were solely about developmental conditions without a clear link to assistive technology were not included. To ensure both sensitivity and specificity in our search, we constructed a comprehensive search string that included a range of keywords and synonyms related to both developmental conditions and assistive technologies. We included examples of specific conditions and different categories of assistive technologies (i.e., cognitive aids) to capture a broad scope of relevant literature. Keywords related to developmental conditions included terms such as intellectual disabilities, autism spectrum disorder, attention deficit hyperactivity disorder (ADHD), specific learning disorders (e.g., dyslexia, dyscalculia, dyspraxia), and conditions like Down syndrome and cerebral palsy. The assistive technology keywords encompassed tools and devices designed to improve functionality and enhance the quality of life for individuals with conditions. To further evaluate the effectiveness of the search, we performed a qualitative review of the titles and abstracts of the retrieved articles. The refinement process was concluded once saturation was reached, when no new relevant study appeared, and the gathered data consistently aligned with the aim of our study. No *a priori* time window of interest was defined in order to cover the whole literature in the field. A total of 1322 documents published between 1962 and 2025 were retrieved, which will henceforth be referred to as the "citing documents". The dataset included 652 articles, 23 books, 109 book chapters, 379 conference papers, 45 conference reviews, 8 editorials, 3 errata, 2 notes, 1 retracted, 96 reviews, and 4 short surveys.

The sample of citing documents was first analyzed using the *bibliometrix* package for R (Aria & Cuccurullo, 2017) to identify the most influential countries, scientific journals, authors, documents, and frequent keywords in the literature on developmental conditions and assistive technology.

2.2. Data import in CiteSpace

To conduct the scientometric analysis, the citing documents were imported into CiteSpace (version 6.1.R6 64-bit Advanced) (Chen, 2006). A total of 44,699 cited references were identified, of which 42,623 (95.36 %) were valid. When importing data into CiteSpace, the software considers only references that contain all the essential bibliometric elements in the correct format – including author, year of publication, title, source, volume, pages, and DOI – as valid (Chen, 2014).

2.3. Document co-citation analysis

A document co-citation analysis (DCA) was conducted to identify the main research trends and the most influential documents. DCA is based on the frequency with which two or more publications are cited together in other works (Small, 1980; Trujillo & Long, 2018). The underlying assumption is that documents frequently co-cited are likely to cover the same thematic area in the literature. DCA applies network theory principles, where individual documents are represented as a network's nodes, co-citations as links, and the

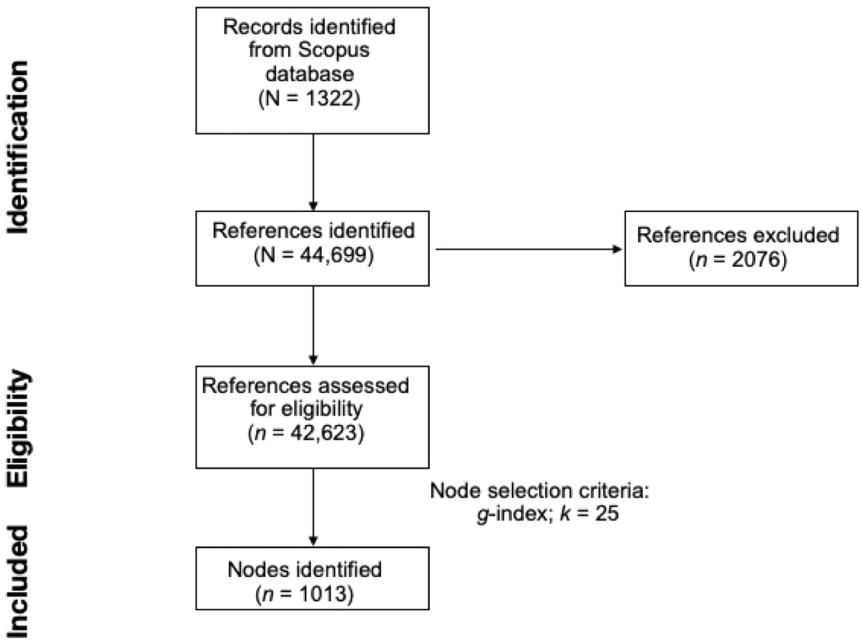

Fig. 1. Preferred reporting items for systematic reviews (PRISMA) flowchart for literature search and references eligibility.

frequency of co-citations as the weight of those links. In this context, each node corresponds to a unique cited document that meets the node selection criteria defined during the network generation process (see paragraph below). Although 42,623 cited documents were initially identified in the dataset, not all of them are retained in the final DCA network; only those meeting the selection thresholds are included. The following step involved defining these selection thresholds and generating the co-citation network.

To generate the DCA network and to control its size, we used CiteSpace, a popular tool for mapping scientific knowledge through citation analysis. CiteSpace offers several options to select which publications are included in the network based on how often they are cited, helping to highlight the most influential studies within specific time periods. The main node selection methods available are the *g*-index, TOP *N*, and TOP *N%*. The *g*-index is a bibliometric indicator that builds upon the *h*-index by giving more weight to highly cited documents. Specifically, a set of documents has a *g*-index of *g* if the top *g* publications together have received at least g^2 citations in total (Chen, 2006; Egghe, 2006). This means that the *g*-index not only considers how many documents have been cited at least a certain number of times (as in the *h*-index), but also takes into account the cumulative impact of the most cited documents. In practical terms, higher citation counts among top documents increase the *g*-index value, allowing for a more inclusive and representative selection of influential works. For example, if $g = 10$, the top 10 publications must have at least 100 citations in total.

In contrast, TOP *N* and TOP *N*% methods identify the *N* or *N*% most frequently cited documents within a specific time frame, which in this study was consistently set to one year.

The selection of nodes is influenced by a scaling factor that determines how many documents are included per time slice. To obtain a network of optimal size, we compared the DCA networks generated using different parameter settings: the *g*-index with *k* values of 25 and 50, TOP *N* with *N* set to 50, and TOP *N%* with *N* set to 10. The scale factor values were determined by starting from the default

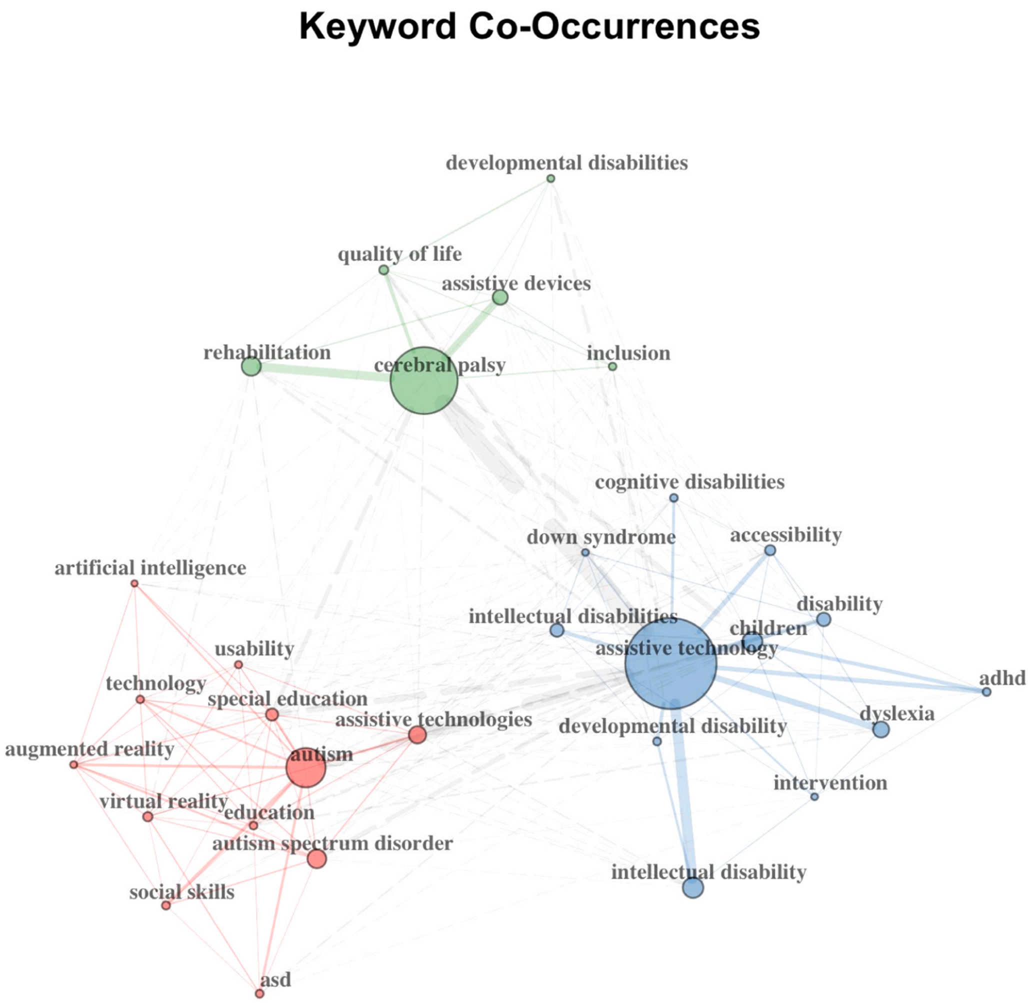

Fig. 2. Keyword co-occurrence analysis in the literature on developmental conditions and assistive technologies. In the resulting network, keywords are represented as individual nodes, with their size corresponding to their degree. Co-occurrences between keywords are shown through solid links (for co-occurrences within the same cluster) and dashed links (for co-occurrences between clusters). The width of these links reflects the frequency of co-occurrence. Based on these co-occurrence patterns, three keyword clusters were automatically identified using the *bibliometrix* package for R (Aria & Cuccurullo, 2017), and they are visualized in the figure with red, blue, and green colors.

value and adjusting it to optimize the network's metrics. All the generated DCA were compared in terms of their structural metrics (i.e., modularity, weighted mean silhouette, number of major clusters). The most suitable DCA network was obtained using the *g*-index with *k* set to 25, which provided the best balance between network complexity and informativeness.

The literature search and the generation of the DCA network are summarized in Fig. 1.

2.4. DCA network evaluation metrics

To assess the properties of the generated DCA networks, both structural and temporal metrics were employed, following established practices in scientometric research (e.g., Carollo et al., 2021; Cavallaro et al., 2025; Fong et al., 2023; Lim et al., 2023).

Structural metrics include modularity, silhouette, and betweenness centrality. Modularity measures the extent to which a network is divided into distinct clusters or modules (Chen et al., 2010). The modularity index ranges from 0 to 1, with higher values indicating clearer separations between the network's clusters. Silhouette evaluates how well-defined and internally cohesive a cluster is, as well as its distinction from other clusters (Rousseeuw, 1987). The silhouette score spans from −1–1, with a higher score reflecting better internal cohesion and greater separation from other clusters (Chen, 2014). Betweenness centrality, ranging from 0 to 1, measures the role of a node in connecting random nodes within the network (Freeman, 1977). These structural metrics provide a quantitative description of the network's overall structure, including clusters and nodes.

Temporal metrics comprise citation burstness and sigma. Citation burstness identifies abrupt increases in the citation frequency of a publication over time, determined through Kleinberg's algorithm (Kleinberg, 2002). Sigma quantifies the scientific novelty and influence of a publication within the network, calculated as $(centrality + 1)^{burstness}$ (Chen et al., 2010). Both citation burstness and sigma can theoretically range from 0 to infinity. Together, these temporal metrics allow for the evaluation of a publication's evolving impact within the network.

3. Results

3.1. Bibliometric properties of the citing documents

The bibliometric analysis indicated that, on average, the documents were 8.10 years old and received 14.77 citations each. Among the most cited works were Bell et al. (2022) (total citations on Scopus = 306, average citations per year = 102), Frank Lopresti et al. (2004) (total citations on Scopus = 278, average citations per year = 13.24), and Hess et al. (2008) (total citations on Scopus = 251, average citations per year = 14.76).

Based on the analysis of the affiliations of corresponding authors, the majority of publications in the literature on developmental conditions and assistive technology originated from the United States of America ($n = 217$ documents, Single Country Publications (SCP) = 200, Multiple Country Publications (MCP) = 17), Canada ($n = 43$ documents, SCP = 35, MCP = 8), and India ($n = 40$ documents, SCP = 35, MCP = 5).

The main sources for the collected documents were *Lecture Notes in Computer Science* ($n = 75$), *Disability and Rehabilitation: Assistive Technology* ($n = 58$), and *ACM International Conference Proceeding Series* ($n = 34$).

Additionally, the dataset contained a total of 4106 authors, with the most productive contributors being Stasolla F ($n = 25$ documents), Lahiri U ($n = 12$ documents), and Hayes Gr ($n = 10$ documents).

In terms of keyword usage, a total of 2617 authors' keywords were identified within the sample. The ten most common keywords included *assistive technology* ($n = 302$), *cerebral palsy* ($n = 204$), *autism* ($n = 94$), *intellectual disability* ($n = 59$), *children* ($n = 53$), *rehabilitation* ($n = 52$), *assistive technologies* ($n = 46$), *autism spectrum disorder* ($n = 43$), *dyslexia* ($n = 43$), and *special education* ($n = 36$). The co-occurrence patterns among the keywords are illustrated in Fig. 2.

3.2. Network's structural properties

The optimal DCA network consisted of 1013 nodes (i.e., cited references) and 2231 links (i.e., co-citation). Hence, on average, each document was connected to 2.20 other documents in the network. Overall, the network was highly divisible into homogeneous and separated clusters (modularity = 0.969, weighted mean silhouette = 0.990).

In the network, three main thematic research domains were identified (see Table 1). Although the three main clusters included a

Table 1
Details of the three major clusters identified with the document co-citation analysis. The Log-Likelihood Ratio (LLR) label is automatically generated by CiteSpace software.

ID	Size	Silhouette	Mean Year	LLR Label	Title
2	34	1.000	2011	Rett syndrome	Communication and Mobility in Individuals with Profound Developmental Conditions
4	24	0.979	2014	Rett syndrome	Cognitive Functions and Autonomy in Individuals with Developmental and Intellectual Conditions
12	16	0.983	2013	Critical literature review	Communication and Social Cognition in Autism

total of 74 cited documents, this subset represents the most strongly connected and thematically cohesive core of the network. In CiteSpace, clusters are formed based on the strength of co-citation links, which means that only documents with consistent co-citation relationships are grouped together, while more weakly connected items remain outside the clusters. Cluster #2, renamed *"Communication and Mobility in Individuals with Profound Developmental Conditions,"* contained the largest number of documents and was the most homogeneous (size = 34, silhouette = 1.000, mean publication year = 2011). Based on size, Cluster #2 was followed by Cluster #4 and Cluster #12. Cluster #4, renamed *"Cognitive Functions and Autonomy in Individuals with Developmental and Intellectual Conditions,"* included 24 documents (silhouette = 0.979, mean publication year = 2014). Cluster #12, renamed *"Communication and Social Cognition in Autism,"* comprised 16 documents (silhouette = 0.983, mean publication year = 2013). Research clusters were initially labeled automatically using the log-likelihood ratio (LLR) algorithm. However, all documents within the thematic clusters were carefully reviewed, and the labels were manually refined to better reflect their thematic focus.

3.3. Impactful documents

In the network, four documents exhibited a sudden surge in citations (see Table 2). These highly influential works were authored by Lancioni and Singh (2014) (citation burstness = 4.687, burst duration = 2 years), Parsons et al. (2004) (citation burstness = 3.692, burst duration = 1 year), Goodwin (2008) (citation burstness = 3.074, burst duration = 1 year), and Wehmeyer and Shogren (2013) (citation burstness = 3.064, burst duration = 1 year).

In particular, Lancioni and Singh (2014) presented a comprehensive review of assistive technologies for individuals with developmental conditions, highlighting their personal and social needs. The study provides an overview of existing devices and evidence-based guidelines for selecting and tailoring assistive technologies. It emphasizes the importance of considering individual needs, preferences, and the feasibility of assistive technology in daily life. Additionally, it underscores the role of a multidisciplinary team in selecting, customizing, training, and supporting users and caregivers, ensuring long-term effectiveness. Expanding on technology-assisted interventions, Parsons et al. (2004) explored virtual environments as tools for teaching social skills to autistic children. The study found that desktop-based training simulations improved social interactions and adaptive behaviors, as children quickly learned to navigate virtual settings and interpret social cues. These findings suggest that structured virtual environments can support social skills practice and help compensate for executive function difficulties. Similarly, Goodwin (2008) examined the benefits and challenges of computer-based interventions for autistic individuals, emphasizing how technology enhances communication, learning, and social engagement while addressing accessibility and customization barriers. Finally, Wehmeyer and Shogren (2013) introduced the field of applied cognitive technologies for individuals with developmental conditions. The article explored how digital assistive systems and smart technologies promote learning, independence, and quality of life. As for the authors, these tools, to be effective, must be accessible, customizable, and integrated into everyday technology, such as smartphones. Moreover, they play a crucial role in fostering autonomy and community participation through personalized support.

4. Discussion

This study examined the knowledge structure in the field of assistive technology for individuals with developmental conditions. Through a document co-citation analysis of 1322 publications and 44,699 references, we identified key research themes and the most influential contributions in the literature. Unlike previous narrative or topic-specific reviews, our study provides a comprehensive, data-driven overview of the role of assistive technology in developmental conditions. While prior literature has often focused on specific technologies or populations, a broader, unified mapping of the field has been lacking. Our scientometric approach addresses this gap by outlining the structural patterns and evolution of assistive technology research in developmental conditions. In doing so, it identifies dominant and emerging themes, influential works, and underexplored areas. The findings revealed three major thematic domains and highlighted four impactful publications. Among them, Lancioni and Singh (2014) emerged as the most influential, offering a comprehensive review of assistive technologies for individuals with developmental conditions.

To further contextualize these findings, the following section presents a qualitative review of the major research clusters, arranged chronologically from the earliest to the most recent based on their mean publication year. For each citing document in the cluster, we report its coverage (i.e., the number of documents cited by papers within the cluster) and its global citation score (GCS), which represents the total number of citations a publication has received in Scopus.

4.1. Cluster #2: communication and mobility in individuals with profound developmental conditions

The earliest thematic domain of research focuses on enhancing communication and mobility skills for individuals with severe

Table 2
Describing metrics of the four documents with a citation burst.

Reference	Citation Burstness	Publication Year	Burst Begin	Burst End	Duration (Years)	Sigma	Centrality
Lancioni and Singh (2014)	4.687	2014	2015	2017	2	1.01	0.00
Parsons et al. (2004)	3.692	2004	2011	2012	1	1.00	0.00
Goodwin (2008)	3.074	2008	2011	2012	1	1.00	0.00
Wehmeyer and Shogren (2013)	3.064	2013	2019	2020	1	1.00	0.00

developmental and intellectual conditions. Key citing documents in this cluster include Stasolla et al. (2015c) (coverage = 19, GCS = 53), Stasolla and Perilli (2015) (coverage = 18, GCS = 5), Stasolla et al. (2015b) (coverage = 11, GCS = 33), and Lancioni et al. (2015) (coverage = 7, GCS = 9).

A significant portion of publications in this cluster is dedicated to Rett syndrome, a neurodevelopmental condition marked by severe impairments in motor skills, communication, and cognition (Rett, 1966). Following an initial typical development phase, individuals with Rett syndrome typically experience stagnation and regression (Didden et al., 2010; Zhang et al., 2019), leading to the loss of adaptive and social functions, such as verbal language and purposeful hand movements (Munde et al., 2016; Zhang & Spruyt, 2024). Other common features include repetitive handwringing (Brunetti & Lumsden, 2020), speech impairment (Foxe et al., 2016; Sigafoos et al., 2023), motor coordination deficits (Romano et al., 2020), seizures (Operto et al., 2019), and breathing abnormalities (Tascini et al., 2022). Within this context, Stasolla et al. (2015c) explored the use of photocells, adaptive interfaces, and personal computers to support decision-making in three girls with Rett syndrome and severe conditions. The intervention reduced stereotypic behaviors, increased independent responses, and enhanced self-determination and happiness, demonstrating the efficacy of assistive technology in improving their quality of life. Similarly, Stasolla et al. (2014a) found that a vocal output communication aid was as effective as a picture exchange communication system in improving communication while reducing stereotypies. Stasolla et al. (2015a) demonstrated that assistive technology enhanced request-making, choice-making, and literacy skills, with benefits maintained post-intervention. Beyond communication, assistive technologies have been employed to improve mobility. Stasolla and Caffo (2013) tested a microswitch-based program integrating optic sensors to foster self-determination and locomotor behavior in children with Rett syndrome. The study reported increased mobility, happiness, and a reduction in stereotypies.

The research extends beyond Rett syndrome to other neurodevelopmental conditions, emphasizing the role of assistive technology in fostering communication, mobility, and engagement. Stasolla et al. (2015b), Lancioni et al. (2010), Stasolla et al. (2015a), and Lancioni et al. (2015) examined assistive devices in children with motor conditions. Stasolla et al. (2015b) demonstrated that microswitches and laptops improved academic performance in six children with cerebral palsy and severe motor conditions, with gains that were sustained and generalized across contexts. The study also showed that providing these children with tailored, low-cost input devices requiring minimal effort to operate, can foster motivation and selfdetermination, promote independence and learning, and simultaneously reduce passivity and the risk of social isolation. While Lancioni et al. (2010) showed that adapted walker devices enhanced ambulation in children with severe intellectual and motor conditions, as all children showed increased frequencies of step responses during the intervention phase, further supporting the effectiveness of assistive approaches in encouraging and enhancing ambulation. Lancioni et al. (2010) also highlighted three important considerations: *(i)* the crucial role of child motivation in intervention success; *(ii)* the need for further technological improvements and integration with traditional therapies, and *(iii)* the importance of social validation by caregivers and professionals to assess the intervention's impact.

Assistive technology has also proven effective in promoting autonomy and social inclusion. Stasolla et al. (2015a) found that customized input devices improved interaction and leisure activities in three children recovering from post-coma conditions due to traumatic brain injury. Similarly, Lancioni et al. (2015) showed that assistive interventions enhanced occupational engagement, such as independent moving between workstations, as well as mobility, including appropriate interaction with objects in individuals with multiple conditions, including intellectual conditions and blindness.

Additional studies highlight the broader potential of assistive technologies. Stasolla et al. (2014b) reported that a microswitch-cluster program improved object manipulation and reduced self-stimulatory behaviors in autistic children with intellectual conditions. Lancioni et al. (2007) demonstrated that a young adult with severe spastic tetraparesis gained autonomy in managing television use, successfully performing 392 out of 408 tasks like turning the device on/off and selecting channels. Finally, Lancioni et al. (2014) showed that individuals with multiple conditions, including sensory and cognitive impairments, could engage in meaningful independent activities, such as assembling a water pipe, when provided with appropriate technological support.

These studies highlight the multifaceted benefits of assistive technologies for individuals with intellectual and severe developmental conditions. Across interventions targeting communication, literacy, decision-making, and mobility, assistive technologies consistently reduced stereotypic behaviors and increased independent, purposeful responses. Notably, these interventions also promoted self-determination, emotional well-being, and overall quality of life. Taken together, the findings underscore the potential of assistive technologies to support core functional abilities while fostering greater autonomy and engagement in individuals with profound developmental conditions. Promisingly, ongoing research is needed to refine these technologies further and to integrate them seamlessly with traditional therapeutic approaches, maximizing their effectiveness and accessibility.

4.2. Cluster #12: communication and social cognition in autism

The second cluster explores the role of technology in supporting communication and social skills in autistic individuals. This research area is primarily shaped by three key studies: Spiel et al. (2019) (coverage = 8, GCS = 133), Gitlow et al. (2019) (coverage = 4, GCS = 2), and Pham et al. (2019) (coverage = 3, GCS = 6). These works collectively examine how assistive technologies can enhance social interaction, the ethical considerations involved, and the potential for participatory design approaches.

One major focus within this cluster is the evaluation of high-tech interventions designed to improve communication skills among autistic individuals. Pham et al. (2019) provided a comprehensive review of various assistive technologies, including Speech-Generating Devices, which enable users to communicate through symbol selection or text input, and Robot-Mediated Interventions, where social robots facilitate structured interactions to enhance eye contact, social responses, and communication. Additionally, Video-Based Instruction was highlighted as an effective method, using recorded demonstrations to model desired social behaviors, such as greetings and initiating conversations. Pham et al. (2019) emphasized that these interventions must be tailored to individual needs and should involve collaboration among researchers, educators, and policymakers to ensure alignment with educational standards and best practices.

While assistive technologies offer potential benefits, Spiel et al. (2019) critiqued how many existing designs prioritize behavior modification based on neurotypical norms rather than addressing the genuine needs and preferences of autistic individuals. The study advocates for a shift towards active co-creation with autistic children, emphasizing the importance of designing technologies that promote autonomy, self-expression, and well-being instead of enforcing neurotypical social norms. Ethical considerations, such as avoiding surveillance-like implementations and ensuring user empowerment, are central to this perspective. In a similar vein, Frauenberger et al. (2011) explored participatory design methods, including storytelling, sensory engagement, and digital prototyping, to actively involve autistic children in the development of technology-enhanced learning environments. The study underscores that designing for children with special needs requires adaptable and inclusive approaches that foster creativity, engagement, and a sense of ownership over the technology being developed.

Beyond assistive technologies and participatory design, virtual reality has emerged as a promising tool for enhancing social cognition in autistic individuals (Dechsling et al., 2021). Didehbani et al. (2016) investigated the effectiveness of Virtual Reality Social Cognition Training, where children interact with simulated social situations in real time. The study found that this training significantly improved emotion recognition and analogical reasoning skills, as children engaged in decision-making and strategic thinking during their virtual interactions. Similarly, Ip et al. (2018) applied virtual reality across six distinct learning scenarios to enhance emotional and social adaptation in autistic children. After 28 training sessions, participants demonstrated significant improvements in emotional expression, regulation, and social interaction, with skills that transfer to real-life settings. However, no notable gains were observed in emotion recognition tasks, possibly due to limitations in score variability or the static nature of the stimuli used.

In addition to interventions targeting autism, assistive technology is also increasingly utilized to support college students managing mental health challenges such as anxiety and depression. Although focused on a different population, Gitlow et al. (2019) offers complementary insights into how everyday technology can help individuals experiencing mental/cognitive challenges. Many students find these tools, such as scheduling apps, routine management, medication tracking, and symptom monitoring, beneficial and are open to learning how to use them. However, Gitlow et al. (2019) report that for some, the use of technology can contribute to stress or exacerbate symptoms. This highlights the need to tailor assistive technologies to individual needs and preferences, considering a *continuum* of low-to high-tech options and integrating user feedback to ensure optimal fit and effectiveness. Future directions may include peer-led education groups and a focus on navigating the dual impact of social networks to better support autonomy and well-being among students with mental health conditions.

These studies explore the use of assistive technologies to support communication and social engagement, primarily in autistic individuals, while also extending to populations experiencing mental health/cognitive challenges. A central focus lies in high-tech interventions, such as speech-generating devices, robot-mediated interactions, and video modeling, which have demonstrated effectiveness in enhancing communication and social behaviors. However, critical perspectives within the cluster challenge the prevailing emphasis on behavior normalization and neurotypical standards. Researchers advocate for a transition toward participatory, co-designed technologies that prioritize user autonomy, foster authentic self-expression, and steer clear of surveillance-oriented approaches. Virtual reality is also presented as a promising tool to foster social cognition, though questions remain about its ecological validity. Finally, studies involving college students with anxiety and depression underscore both the potential and risks of everyday technologies, calling for more individualized, ethically grounded, and context-sensitive approaches that prioritize well-being over conformity.

4.3. Cluster #4: cognitive functions and autonomy in individuals with developmental and intellectual conditions

The most recent cluster focuses on the use of assistive technologies to support cognitive functions and promote independence in individuals with developmental and intellectual conditions. Key citing documents include Desideri et al. (2020) (coverage = 9, GCS = 28), Adolfsson et al. (2015) (coverage = 4, GCS = 18), Damianidou et al. (2020) (coverage = 3, GCS = 2), Wennberg et al. (2021) (coverage = 3, GCS = 7), Wehmeyer et al. (2020) (coverage = 3, GCS = 16), Palmqvist and Danielsson (2020) (coverage = 3, GCS = 4), and Babb et al. (2020) (coverage = 3, GCS = 23). These studies explore how assistive technologies enhance cognitive abilities and foster autonomy in individuals with intellectual and developmental conditions.

Assistive technologies have demonstrated significant potential in improving executive functions in autistic individuals. Desideri et al. (2020) reviewed their role in compensating for atypical executive functions, showing that they enhance self-awareness, self--monitoring, and task completion, while also reducing stereotypies. Furthermore, the authors note that executive functioning remains underexplored in adults, particularly autistic individuals with average intelligent quotient who actively engage in community life. Similarly, Adolfsson et al. (2015) examined electronic planning devices and their effectiveness in aiding individuals with cognitive conditions in managing daily tasks, organizing time, and improving volition. For children with ADHD, assistive technologies address time-processing difficulties, which are crucial for occupational performance. Wennberg et al. (2021) investigated a multimodal, time-based intervention that combined compensatory Temporal Aids for Daily Living with time-management training. The study demonstrated that this integrated approach significantly improved children's ability to achieve occupational performance goals, highlighting the importance of combining technology with skill-building strategies. The findings also underscore the importance of individualizing interventions, as children with developmental conditions experience greater independence and participation when using aids tailored to their specific needs.

Beyond cognitive support, assistive technologies play a critical role in fostering autonomy in daily life. Babb et al. (2020) explored the use of video-based visual scene displays combined with a tablet-based augmentative and alternative communication app to support adolescents with severe conditions, such as autism or Down syndrome, in volunteer activities. The study found that these tools significantly improved both skill acquisition and social interaction, essential for successful participation in such activities. Additionally, Palmqvist and Danielsson (2020) examined the role of assistive technology in daily planning across three groups: children with intellectual conditions or autism, children with ADHD, and neurotypical children. The study found that all three groups utilized assistive technology, typically with the involvement of an intermediary. The authors highlight that the presence of this intermediary might indicate a reliance on ongoing adult support, which may limit the child's independence. On the other hand, this dependency may also reflect a mismatch between the design of assistive technology and the child's specific support needs. Assistive technology may not always be sufficiently customized to the individual strengths and weaknesses of the user. As a result, the authors advocate for more comprehensive guidance when prescribing assistive technology and for selecting or adapting technologies that better support autonomous use. Despite these limitations, the study underscores the potential of assistive technology to support essential cognitive functions such as memory, time management, and higher-order cognitive processes, illustrating its broad applicability. Expanding on this, Damianidou et al. (2020) investigated the relationship between applied cognitive technology features and cognitive functions such as attention, memory, and decision-making in individuals with intellectual and developmental conditions. The study proposed a classification system to improve communication in technology prescription, categorizing assistive technologies based on the cognitive functions they support. Notably, it emphasized the effectiveness of "output" features, such as video prompts, in enhancing cognitive performance. By aligning assistive technology with individual cognitive needs, this approach improves real-world task outcomes and helps clinicians select the most appropriate interventions.

The benefits of cognitive technologies extend beyond developmental conditions. Gillespie et al. (2012) demonstrated their effectiveness in supporting various cognitive functions, including attention, calculation, emotional regulation, self-awareness, planning, time management, and memory. These technologies have proven valuable for individuals with acquired brain injuries, neurodevelopmental disorders, psychiatric conditions, dementia, and intellectual conditions, highlighting their versatility and broad applicability.

Recent technological advancements have significantly expanded opportunities for autonomy among individuals with developmental and intellectual conditions. Wehmeyer et al. (2020) provided a comprehensive overview of innovations that help bridge the gap between individual capabilities and environmental demands. Global positioning system (GPS)-enabled travel assistance and augmented reality support independent navigation by helping individuals move through their surroundings with greater confidence. Video prompting, smart assistants, and remote support technologies facilitate the completion of daily tasks such as cooking and personal care, promoting independent living. Health monitoring tools, including smartwatches and telemedicine services, allow for real-time tracking of health metrics and enable remote medical consultations. In the realm of career development, artificial intelligence-driven career assessments and augmented reality-based job training programs assist individuals in securing employment opportunities. Furthermore, social media platforms and communication apps play a crucial role in enhancing social engagement and interaction, fostering greater inclusion in various social and professional settings.

These studies highlight the growing importance of assistive technologies in supporting cognitive functions and fostering independence among individuals with developmental and intellectual conditions, such as autism, Down syndrome, and ADHD. The reviewed studies show that these technologies improve executive functioning, self-monitoring, time management, and daily task performance. When combined with training or structured interventions, they lead to meaningful improvements in occupational outcomes, particularly for individuals with attention or planning difficulties. Beyond cognitive support, tools like video-based communication systems, digital planners, and time aids promote autonomy and social participation in both children and adults. By aligning assistive technology features with specific cognitive needs, emerging frameworks have improved the personalization and effectiveness of interventions. These tailored approaches contribute to the broad applicability of assistive tools in various conditions, strengthening their transformative potential. Technological advancements, such as GPS-based navigation aids, video prompting systems, artificial intelligence-driven job training, and telehealth platforms, are further expanding opportunities for independent living, meaningful social participation, and access to employment.

5. Limitations of the study

The scientometric approach of the current study provides valuable insights into the primary thematic areas of research; however, it also has several limitations. One key limitation is that Scopus was the sole data source used in this study, which may have led to the omission of relevant documents not indexed in this database from the citing document sample. While incorporating additional databases, such as Web of Science, would have enhanced the comprehensiveness of the data collection, integrating both Scopus and Web of Science poses considerable computational challenges. These platforms have different formats and a significant overlap in references, which could result in potential duplications and thus require complex harmonization processes that are currently difficult to manage with existing software. Although the initial corpus was derived from articles indexed in Scopus, the DCA was based on the full set of references cited within those articles. This approach helps mitigate Scopus-specific biases by incorporating influential works that may fall outside the Scopus index or lack the specific keywords used in the initial search. Additionally, the selection of keywords during data collection also presents a limitation, as relevant documents using different terminologies might have been inadvertently excluded. For instance, studies focusing exclusively on specific conditions such as “Down syndrome” or “cerebral palsy”, without referencing broader terms like “developmental disability”, may not have been captured. Again, it is important to note that the scientometric analysis, based on co-citation patterns among cited documents, ensures wider coverage by including publications that extend beyond Scopus indexing and the specific search terms, thus reducing the likelihood of missing pertinent studies. Additionally, scientometric methods rely on citation counts and co-citation patterns, which are quantitative indicators that may not reflect the actual quality or impact of individual studies. High-quality research can be underrepresented in citation data, particularly if it originates from less prestigious institutions or from scholars with limited access to high-impact publication venues (Callaham et al., 2002). Finally, it is worth noting that newer publications may appear less influential in citation-based analyses due to limited time for citations to accumulate, a factor that may undervalue emerging research directions. To mitigate these issues, the current review incorporates a qualitative analysis of the research clusters in the Discussion section. This approach helps avoid reinforcing a system that prioritizes quantitative metrics over qualitative analysis. Moreover, our cluster analysis considers both the content of the citing and the cited documents. This strategy reduces biases associated with the quantitative features of documents, as citing documents are included in the clusters based on the citations they make, rather than the number of citations they receive.

6. Conclusion

In this study, we employed a scientometric approach (e.g., Carollo et al., 2021; Cavallaro et al., 2025; Fong et al., 2023; Lim et al., 2023) to map the knowledge structure of the literature on assistive technology in developmental conditions. By analyzing 1322 documents, we identified four impactful documents and three major clusters of research, emphasizing their contributions to communication, mobility, cognitive skills, and social cognition in conditions such as Rett syndrome, autism, intellectual, and profound developmental conditions. Unlike prior reviews focused on specific technologies or populations, our study provides a broad, data-driven synthesis of the field's evolution. This approach revealed the increasing integration of assistive technologies in therapeutic, educational, and daily living contexts, highlighting their potential to enhance quality of life, self-determination, emotional well-being, independence, and social participation, while also reducing stereotypic behaviors, for individuals with developmental conditions. The study also shows the multifaceted benefits of these technologies across domains such as communication, literacy, mobility, decision-making, and executive functioning. However, alongside these advances, our qualitative analysis suggests a growing recognition of ethical considerations in the design of these technologies, particularly the importance of aligning technology designs with the genuine needs and preferences of individuals rather than enforcing behavioral norms based on neurotypical standards. In this regard, co-participation in intervention design emerged as a key factor, though it remains underrepresented in citation trends and keyword evolution. Future research should further explore this aspect, shifting the focus towards valuing disabilities and tailoring technologies to accommodate the unique needs and behaviors of individuals, rather than striving for standardization.

CRediT authorship contribution statement

Anders Nordahl-Hansen: Writing – review & editing, Conceptualization. **Dagmara Dimitriou:** Writing – review & editing, Conceptualization. **Eman Gaad:** Writing – review & editing, Conceptualization. **Alessandro Carollo:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Conceptualization. **Gianluca Esposito:** Writing – review & editing, Supervision, Conceptualization. **Giuseppe Iandolo:** Writing – review & editing, Conceptualization. **Dorina Shermadhi:** Writing – review & editing, Writing – original draft, Investigation, Formal analysis.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Given their roles as Editor-in-Chief (Dagmara Dimitriou), Senior Editor (Gianluca Esposito), Associate Editors (Alessandro Carollo and Anders Nordahl-Hansen), and Guest Editor (Eman Gaad), these authors had no involvement in the peer-review of this article and had no access to information regarding its peer-review. Full responsibility for the editorial process for this article was delegated to another journal editor. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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