Designing for Care Ecosystems: a Literature Review of Technologies for Children with ADHD

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ABSTRACT

This paper presents a systematic review of HCI literature focusing on children with ADHD, the prevailing mental health diagnosis in children. Its aim is to (i) chart the state-of-the-art in this domain (e.g. methods used), (ii) identify the ways the HCI community has addressed the needs of children with ADHD (e.g. technologies deployed), and (iii) describe the involvement of the various stakeholders playing a role in their everyday experiences (i.e. their care ecosystem). Our findings show limited engagement of the care ecosystem in the design, development and user studies of current technologies, and shortcomings in designing for multiple ecosystem stakeholders, despite their crucial role. We also find that most HCI contributions are systems aiming to address ADHD-related symptoms. Based on our findings, we provide suggestions for further research and design considerations for future systems that empower and promote the well-being of children with ADHD, while considering their care ecosystem.

CCS CONCEPTS

• **Human-centered computing → Interactive systems and tools**; **HCI theory, concepts and models**; **Human computer interaction (HCI)**.

KEYWORDS

ADHD; Literature Review; Neurodiversity; Neurodivergence; Children; Assistive Technologies; CCI

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1 INTRODUCTION

Attention deficit hyperactivity disorder (ADHD) [45] is the most prevalent mental health diagnosis in children [54, 74]. ADHD has an occurrence of approximately 5% worldwide [52], a number which exhibits significant variability. Children with ADHD exhibit symptoms across two broad areas: inattention and hyperactivity/impulsivity [1]. Various systems and guidelines have been developed within the research community aiming to assist and support individuals with ADHD. For example, ParentGuardian by Pina et al. [50] provides guidelines to parents of children with ADHD when it detects stress, such as "Take a deep breath", via a wearable physiological sensor. Sonne et al. [62] aimed to support families of children with ADHD to establish effective morning and bedtime routines. Zuckerman et al. [77] developed a tablet-based app that measures selective and sustained attention, and a social robotic device for students with ADHD, providing immediate feedback for inattention or impulsivity events in the form of gestures. Here, the question arises to what extent aspects that go beyond specific artefacts designed for children with ADHD or their parents should be considered in HCI research.

From a broader perspective, children have increasingly taken the role of the target users of technology over the last decades [4], resulting in an increased need to understand how to design technologies for them. The rise of research fields such as Child-Computer Interaction (CCI) has contributed to that endeavour [4]. In particular with regard to interventions and technologies for children with ADHD, it is essential to consider not only the child as a sole actor, but the entire care ecosystem [13]. The care ecosystem encompasses all actors who play a role in children's lives, such as parents, siblings, extended family, friends, educators, school teachers and potential therapists or specialists.

The term care ecosystem has already been broadly used in scientific literature. For instance, Cigarini et al. [16] explored the role of different groups of a mental health care ecosystem, including professionals of the health and social sector, formal and informal caregivers, relatives, and friends. Formal caregivers refer to professional, paid personnel, while informal care refers to unpaid care provided by family, close relatives, friends, and neighbors [34]. Weisz et al. [71] also sketched out the mental health ecosystem for clinically referred youths to include multiple layers, such as their families, caregivers and practitioners. Amir et al. [2] already referred to the term "care ecosystem" with regards to the diverse

team of caregivers for children with complex health conditions, including multiple types of medical professionals, parents and community support organisations. The term has also been used within autism spectrum disorder research, e.g. in clinical contexts [32]. To the best of our knowledge, the term "care ecosystem" has not been explicitly used with regards to children with ADHD, but the condition still falls under the broader spectrum of mental health, where the term is present [16, 71]. Nevertheless, variations can be found in ADHD literature; for instance, Cibrian et al. [13] refer to the social actors surrounding the child as its "caregivers".

Exploring the role of these different social actors involved in their everyday experiences could provide a more comprehensive overview and valuable insights to consider when designing for children with ADHD. Along similar lines, HCI research has already pointed out the importance of considering the entire "use ecology" in which technologies are deployed [57], referring to the inclusion of the sociality and spatiality of the environment where technologies are integrated [57]. The importance of considering all stakeholders rather than a single user was also discussed by Forlizzi [20], who argues for a shift from a user-centred design to a stakeholder-centred one. It is crucial to understand how the technologies for children with ADHD could be used in collaboration with the whole spectrum of children's support systems, who can offer motivational and emotional scaffolding [13], and who strongly influence quality of life, social activity, and success in school environments [26, 49].

Specific guidelines for design sessions with developmentally diverse children in general have often highlighted the need to actively involve caregivers, teachers and therapists [6]. However, designing technologies for children with ADHD considering their entire care ecosystem is an inherently complex process, given the number of social stakeholders and their interwoven role in the child's everyday experiences. To the best of our knowledge, no comprehensive overview of HCI literature on children with ADHD exists, outlining the methods and contributions to-date, and charting the roles of their care ecosystem.

This paper is intended to benefit HCI and CCI researchers, technology designers, and ADHD professionals aiming to support the well-being of children with ADHD and their care ecosystem, by contributing an understanding of factors involved in designing technology for children with ADHD. In particular, this work presents results from a systematic review of 27 HCI papers focused on children with ADHD. The aim is to create a state-of-the-art overview that can serve as a starting point when designing for children with ADHD, while considering the roles of stakeholders of their care ecosystem. In this paper, the term children refers to ages up to 18 years.

With this systematic literature review, we seek to address the following research questions (RQs):

- RQ1: Who are the intended users of technologies for children with ADHD and how are the various stakeholders of their care ecosystem involved by current approaches within the HCI field?
- RQ2: What are the characteristics of current technologies for children with ADHD concerning types of technologies, objectives, and contexts of use?
- RQ3: What are the methodological approaches employed, and how are the developed technologies for children with ADHD evaluated?

We found that the majority of HCI contributions are systems aiming to address and improve ADHD-related symptoms. Our results also show that the most represented group in HCI research on children with ADHD are eight-year-old boys, and that of the 23 systems identified, four are games.

Regarding the context in which technologies are deployed, most papers in our corpus do not specify the physical environment, i.e. the location where their contributions are deployed, but rather the context of use in the form of a situation (e.g. the Chillfish biofeedback breathing game to support relaxation [58]). Moreover, we reveal trends regarding the engagement of the care ecosystem in the design, development and user study phases of the proposed systems. We found that there are shortcomings in the involvement of the various care ecosystem stakeholders in these phases, with only five systems in our corpus considering additional stakeholders beyond children with ADHD as their target group (i.e. entire families or children and their caregivers). This contradicts the known importance and crucial role of the care ecosystem [13, 26, 49]. We also provide an overview of the results that the studies in our corpus report, thus pinpointing areas where future research could focus.

This paper contributes the following: (i) a systematic literature analysis charting the state-of-the-art in HCI literature focusing on children with ADHD, considering the role of their care ecosystem; (ii) identification of current trends and gaps that suggest how the field should move forward; and (iii) considerations for designing future systems that empower and promote the well-being of children with ADHD and their care ecosystem.

2 BACKGROUND & RELATED WORK

This section describes attention deficit hyperactivity disorder (ADHD) in more detail. We then engage with literature reviews in HCI focusing on neurodivergent populations to contextualise our work, and present related work on technology design for individuals with ADHD.

2.1 Attention deficit hyperactivity disorder (ADHD)

ADHD is categorised into three types: predominantly inattentive (ADHD-I), hyperactive-impulsive (ADHD-HI), or combined presentation (ADHD-C) [24], depending on which of these characteristics is prevalent. In the inattentive presentation, the main symptoms relate to difficulties sustaining attention, which often lead to forgetfulness and distractability. In the hyperactive-impulsive presentation, children demonstrate hyperactivity, inability to sit still and restlessness. Additionally, they can have issues with excessive talking and blurting, as well as not waiting their turn in games or conversations. The combined type exhibits symptoms from both of these presentations. Furthermore, ADHD has been associated with academic underachievement, disruptive behaviours, bedtime resistance and poor self-regulation of emotions [19, 63].

To date, standard treatment for ADHD includes mainly psychosocial treatments (behavioural or cognitive-behavioural), medication treatment with stimulants (mostly methylphenidate), and their

combination [51, 66, 68]. For example, psychosocial treatments for ADHD focus on the parents, the teacher, and the child, with variants of (cognitive) behavioural therapy [68], emphasising the crucial role of the care ecosystem. Behavioural therapy utilises techniques such as conditioning and reinforcement to teach desired behaviours, for instance by praising or rewarding good behaviours and eliminating unwanted ones (e.g. by allowing children to experience the logical consequences of negative behaviours [40]). For children with ADHD, this approach can often help improve behaviour and self-control [40].

2.2 Literature Reviews in HCI focusing on Neurodiversity

Neurodiversity refers to a divergence from the norms that usually de ne individuals as neurotypical, expressing a variety in the human brain activity [65]. There has been an increasing interest by the HCI community in neurodiversity, particularly in building a systematic understanding of technologies for neurodivergent populations. This interest is re ected in literature reviews on neurodiversity within the HCI domain. Börjesson et al. [6] performed a systematic literature review on the involvement of developmentally diverse children in design. They found that developmentally diverse children are increasingly involved in the design process, especially children with high-functioning autism, and that the role of adults is also more prevalent than when designing with neurotypical children. Their results highlight the importance of active participation of the caregivers, teachers and therapists when designing for neurodivergent children.

Another example is the work by Spiel et al. [64], who reviewed the purposes of HCI technologies for children with autism and how these discursively conceptualise their agency. They identify a focus on autism as a de cit that requires "correction", showing that these technologies do not cater to the needs of children with autism but rather embody the expectations of a neurotypical society. Baykal et al. [4] present a systematic literature review on collaborative technologies for children with special needs, demonstrating how the subject has gained traction and that the most frequently represented group is boys with autism, pointing out the need for more demographically diverse studies. Mack et al. [36] recently published a literature survey of accessibility papers in CHI and ASSETS, underlining areas that have received disproportionate attention and those that are under-served. For instance, cognitive disorders (where ADHD is categorised) account for less than 10% of the papers. These examples demonstrate the increasingly strong interest of the HCI community in understanding and designing for neurodivergent children. In combination with the prevalence of ADHD, the need emerges for an integrated understanding of how HCI has addressed the subject and for charting of possible ways to move forward towards meaningful ways to support the population and its care ecosystem.

2.3 Technology Design for People with ADHD

Sonne et al.'s [61] mapping of assistive technologies for children with ADHD, published in 2016, proposed a design framework comprising two dimensions (technology, ADHD symptom), and a set of practical design strategies. Additionally, they identi ed unexplored opportunities for assistive technologies for the ADHD domain, and illustrated how their design framework could be applied. Altogether, Sonne et al. [61] classi ed nine systems for individuals with ADHD based on i) their use at home or school, ii) their target user group (children and/or parents or adults), and iii) the functionality the assistive technology o ers from a technological, information-providing point of view.

More recently, Cibrian et al. [12] published a book that reviews available technologies for individuals with ADHD, with a focus on how technology has advanced in this domain. Their aim is to provide a resource for product developers to deliver a better user experience to people with ADHD, and to enable individuals with ADHD to be content-creators themselves. Further, they strive to inspire the development of new assessment, diagnostic or therapeutic tools. Cibrian et al. [12] classify interactive technology research based on the role of technology in the following domains: i) diagnosis and assessment of ADHD, ii) training cognition and attention skills, iii) social and emotional skills, iv) supporting behaviour management and self-regulation, v) supporting academic skills, vi) supporting everyday life skills and employment; and vii) improving motor skills, physical access, and physical behaviours.

Additionally, Cibrian et al. [14] recently published a review of technological interventions that speci cally assist in and assess the self-regulation of behaviours and emotions, supporting children with ADHD. They found that such technologies are deployed within the following settings: the family (home), educational (school), and clinical, and that lab-based studies are often necessary in early development stages, e.g. to validate feasibility. They demonstrated how the di erent kinds of technological interventions they identi ed (robots, serious games, virtual reality, sensors, web-based, m-health) can provide opportunities for self-regulation of children with ADHD, o ering a "safe environment" to practice behaviours and receive feedback.

We extend previous work by conducting the rst systematic literature review in HCI with a focus on children with ADHD. In contrast, Sonne et al. [61] and Cibrian et al. [12] explored assistive technologies for individuals with ADHD, without speci cally focusing on children. In our review, we position the child in the centre while considering the role and involvement of the care ecosystem. The role of the care ecosystem has not been addressed by previous work, despite its de ning role [13, 26, 49]. Additionally, Cibrian et al.'s [14] recent review focused on technological interventions speci cally for self-regulation of children with ADHD, while our review is not focused on a speci c aspect that the proposed technologies aim to address.

Based on our analysis, we outline current approaches in HCI with respect to: (i) the intended users of technologies for children with ADHD, (ii) their types and aims, (iii) their contexts of use, (iv) the methodological approaches employed, and (v) how and by which stakeholders they are evaluated. By analysing these aspects and the role of the various actors of the care ecosystem, we not only chart the state-of-the-art in the eld, but also point out shortcomings in current approaches and provide design considerations for designing future technologies that promote the well-being of both children with ADHD and their care ecosystem.