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ADHD and Technology Research – Investigated by Neurodivergent Readers

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ABSTRACT

Technology research for neurodivergent conditions is largely shaped by research aims which privilege neuro-normative outcomes. As such, there is an epistemic imbalance in meaning making about these technologies. We conducted a critical literature review of technologies designed for people with ADHD, focusing on how ADHD is framed, the research aims and approaches, the role of people with ADHD within the research process, and the types of systems being developed within Computing and HCI. Our analysis and review is conducted explicitly from an insider perspective, bringing our perspectives as neurodivergent researchers to the topic of technologies in the context of ADHD. We found that 1) technologies are largely used to 'mitigate' the experiences of ADHD which are perceived as disruptive to neurotypical standards of behaviour; 2) little HCI research in the area invites this population to co-construct the technologies or to leverage neurodivergent experiences in the construction of research aims; and 3) participant resistance to deficit frames can be read within the researchers' own accounts of participant actions. We discuss the implications of this status quo for disabled people and technology researchers alike, and close with a set of recommendations for future work in this area.

CCS CONCEPTS

• **Social and professional topics** → **People with disabilities**; Assistive technologies; • **Human-centered computing** → **Accessibility theory, concepts and paradigms**; *Accessibility design and evaluation methods.*

KEYWORDS

ADHD, literature review, critical theory, neurodiversity, neurodivergence, disability studies, cripping, methodology

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1 INTRODUCTION

The term neurodiversity refers to the diversity of neurological make-ups across populations, emphasizing the diversity of cognitive processing or cognitive styles. It originated through self-advocacy and rejects the labelling of neurotypes as deficit or impairment [133]. Dalton's discussion of the potential of the concept of neurodiversity for technological design and research [32] first introduced this to HCI, calling on HCI researchers to collaborate with neurodivergent populations, and to identify and support the abilities of neurodivergent people. In this context, the term neurodivergence refers to the experience of significant difference from what is understood as the norm of cognitive functioning and expression (neurotypical), [133], (which includes medical labels such as, for example, autism, dyslexia, and attention deficit hyperactivity disorder (ADHD)) [153]. Similarly, Mankoff et al. called for research on assistive technology to be informed by the perspective of disability studies and to actively engage with disability communities [108].

Subsequently, recent trends in Computer Science and Human-Computer Interaction (HCI) have seen an increase in research on neurodivergent populations with the understanding of terminology similarly following suit as a result of analyses by neurodivergent scholars (e.g. [153, 173]). With respect to ADHD (Attention Deficit Hyperactivity Disorder[1]) specifically, initial suggestions for the design of technologies exist, albeit largely from a medically informed perspective [147]. Recently, Cibrian et al. provided an overview of technologies designed to support self-regulation for children with ADHD [26]. What has been missing to date is a critical investigation which focuses on how technological research operates in the context of ADHD – particularly from a perspective *explicitly* shaped by people with ADHD.

While modern HCI research in the realm of technologies and disabilities is increasingly informed by theories and practices from

[1]We use the abbreviation of the medical term for lack of an empowering self-determined, non-deficit oriented reference. However, in line with existing literature on neurodiversity [133], we understand ADHD as a variance that does not comprise a 'disorder'.

disability studies, e.g. [32, 108, 154], the first-person perspective of disabled people (be they researchers or not) is crucial to understanding how these technologies operate [108]. These perspectives have historically been less prominent [178], although the field has seen a recent influx of autoethnographic studies [76, 86] and research oriented on agency and self-determination [12, 172].

To this growing body of work, we add a critical literature review of HCI and computer science research broadly concerned with ADHD. This is in line with previous analyses of technologies and neurodivergence or disabilities more generally, including the review on technologies for autistic children by Spiel et al. [152], the survey on accessibility research by Mack et al. [106], investigations on wearables in the context of autism intervention [173] and investigations into research pertaining to neurodivergence and play [153]. Our work additionally responds to and augments previous suggestions for understanding potential design strategies regarding technologies for people with ADHD [147]. What our review adds to a description of the current state of research in ADHD, is precisely an account of our reading as people with ADHD, i.e. that our work is specifically informed by our perspectives and experiences as neurodivergent technology researchers. We deem it particularly relevant to explicitly take on this subjective perspective, given that neurodivergent people are largely excluded from the research about them [152]. However, our personal involvement comes with implications for our reading, analysis and interpretation of the corpus material. Subsequently, our writing is, in parts, inseparably tied to our affective responses as to how our colleagues describe us, our communities and our loved ones.

To set the scene for our work, we now provide background on our understanding of ADHD, delineate prior work in the context of HCI and neurodivergence further and introduce our theoretical backing from Critical Disability Studies and particularly Crip Technoscience. We then provide insights into our overall approach. Our analysis and the subsequent findings illustrate how current research predominantly presents ADHD as a problem space for technology design as a result of solutionist [15] and paternalistic attitudes towards the target population. From these findings, we derive suggestions for the technical research community, speculate on alternatives, reflect on the implications of reading works with personal affect but also line out potentials for future work.

2 BACKGROUND

We briefly define ADHD before attending to existing work in the realm of HCI and neurodivergence, before our presentation of relevant theories drawing on Critical Disability Studies and particularly the concept of 'crip technoscience'.

2.1 ADHD

Within medical contexts, ADHD is officially characterised by hyperactivity, impulsivity and inattention [44]. Diagnosis is often conducted along different presentations: predominantly inattentive, predominantly hyperactive-impulsive, or combined [ibid.]. ADHD, or hyperkinetic behaviour syndrome as it was known previously, was originally characterised as a childhood disorder [101]. On the one hand, this early characterisation did not cover the 'inattentive' (daydreamer) type (which long resulted in the belief that ADHD mainly affects boys) and on the other hand, defining it as a childhood disorder meant that adults who sought a diagnosis were ignored [65, 96]. The belief that ADHD was something that one 'grows out of' persisted, with research suggesting that the prevalence of ADHD in the general population declines steadily across age groups [74]. This belief continues to persist [104], although there is increasing recognition that the fundamental neurological differences that characterise ADHD remain throughout life. ADHD might be less apparent in adults due to a lack of comparability in living conditions (occupation status, family life, etc, whereas in most countries children all go to school) and the development of a range of contextual masking strategies over time, leading to the assessment that it is not well recognised is and subsequently heavily under-diagnosed in adults [87]. Additionally, the presentation of characteristics is tied to conventional norms along gender [48] and race [7], leading to misdiagnoses of depression or oppositional defiance disorder[2] respectively.

People who are diagnosed with ADHD have, in recent years, helped to increase our collective understanding of what the condition feels like and how it operates in daily lives (e.g. Dani Donovan[3], the ADDitude Mag[4], or Pina (ADHD Alien)[5]). These accounts are augmented by critical and appreciative approaches in research [111] and people with ADHD openly entering into research on ADHD [65]. Here, advocacy is largely oriented around providing counterarguments for common harmful assumptions and societal stigma [64], which is often internalised [131]. Such advocacy work within and alongside research has helped to identify the strengths that are part of ADHD, such as cognitive dynamism, courage, energy, humanity, resilience or transcendence (hyperfocus) [135] and to propose appreciative approaches in attending to these [29].

2.2 HCI & Neurodivergence

When proponents in HCI state that they conduct accessibility research, what they specifically mean is not always clear or shared. In a survey of self-identified accessibility research papers published between 1994 and 2019, Mack et al. note that neurodivergent populations (including autistic populations) are of concern in only about 5% of papers [106]. A recent review by Spiel and Gerling on HCI games research and neurodivergent populations similarly identified a significant focus on autistic populations over other conditions, with ADHD being relevant in 11% of the papers in their corpus [153]. Subsequently, many existing reviews in this space are concerned with autism [173], especially autistic children [152]. To date, two reviews provide implications for technological research specifically in the context of ADHD, albeit one driven predominantly by a medical and deficit oriented perspective [147] and the other with a focus specifically on children with ADHD [26].

We provide here a brief overview of existing recent work expressly addressing neurodivergence in technological design. This research includes situations in which neurodivergent individuals

[2]We encourage readers to engage directly with Ballentine's text on the matter, which illustrates that access to diagnosis and adequately respectful recognition of differences is itself fraught with politics and privilege [7].
[3]https://www.adhddd.com
[4]https://www.additudemag.com
[5]http://adhd-alien.com

were involved in the design of data visualisations due to nonstandard processing of visual information [177] or the creation of shared spaces in which neurotypical and neurodivergent people can meet, for example, as kids during play [53] or as adults in work environments [63]. Rarely do we find published work resulting from self-determined design experiments, such as an artistic exploration of the specifics of neurodivergent embodiments by Damiani [33]. We deem these to be important instances of what research and design can look like when driven by neurodivergent people, and it indicates a similar potential for research and design concerning people with ADHD.

Recognising an overbearing load of externally driven research in the context of autism, Parsons et al. illustrate the knowledge- as well as human-rights-based implications of including autistic people in research about them [123] following a proverb in disability activism more generally, which claims "Nothing about us without us." [154]. Closer to HCI, Ymous et al. illustrated how disabled perspectives generally, and neurodivergent perspectives more specifically, are not only given less credibility in research, but also in the broader circumstances in which research activities takes place [178]. One case they present concretely illustrates how the disclosure of an ADHD diagnosis led to one author no longer being considered for a job posting they were otherwise qualified for [ibid]. Including neurodivergent populations in research as neurodivergent researchers further brings implications for mutually negotiating a disabled (or nondisabled) identity [20]. Overall, though, what self-determined and participatory research might look like in the context of ADHD has garnered little attention, and a number of researchers with ADHD have decided not to disclose ADHD publicly [178][6]. Hence, our work adds to existing investigations on neurodivergence and technology design and development by providing an analysis dedicated to the context of ADHD, conducted by authors who explicitly do so as an affected party.

2.3 Critical Disability Studies & Crip Technoscience

In 2010, Mankoff et al. introduced Disability Studies as a productive theoretical background to HCI researchers [108]. In particular, the self-determined foundation of Disability Studies [154] offers a critical opposition to how technologies for disabled people are conventionally conceptualised: as tools focused on upholding a corporeal standard [21] more so than supporting disabled individuals in their unique strategies of navigating environments fundamentally not made with them in mind [28]. Shew coined the term *technoableism* to describe this tendency in technological development and research [139]. Contemporary Disability Studies has built on traditions of Feminist Theories, Queer Theories, and other critical disciplines to explore alternative ways of knowing about what it means to be disabled. Such alternative ways of being are often referred to as 'crip', reflecting disabled activists' reclamation of a common slur (akin to 'queer') [114]. Within HCI, perspectives from disability studies are increasingly taken up in form of e.g., workshops [154], active debates [174] or as analytic lenses [12].

Relevant to understanding our work, our positionality and our analysis is the concept of different models of disability. Although many more concepts exist, the most popular distinction made is the one between a medical (or deficit oriented) model of disability, focused on the individual, and the social (or access oriented) model of disability, focused on environmental barriers [109]. The differentiation across models here is difficult to translate to the context to ADHD, though the notion of neurodiversity [133] offers a non-deficit focused concept of understanding different neurotypes without attributing a qualitative value to that difference; rather, it is constructed as a *mere* difference (akin to [8]).

Nonetheless, the experience of living with an ADHD neurotype is characterised by a mismatch between external expectations and differences in processing external input and information. In conjunction with the prevalent stigma associated with disclosing ADHD and asking for accommodations [115], disabling experiences become integral to our lives. As a result, we have decided to use the term 'disability' in solidarity with other people who make these experiences as one seeking crip kinship [91] and one describing parts of our self-determined identity [136]. Taking on this identity as disabled is subsequently a political act [128], that we engage with deliberately, given that not doing so or operating from a medical perspective on disabilities is a similar political act, in that any presumption of a default status is inherently political.

Within an understanding of disability – and in consequence, the technologies that operate in the space of disabled people's lives – as political, Hamraie and Fritsch offer a set of alternatives for understanding such technologies [66]. Their concept of *crip technoscience* is oriented on centring disabled people as well as making commitments to access, interdependence[7] and disability justice [125]. While the concept of neurodiversity has already been introduced to HCI [32], crip technoscience has not previously been analysed in its applicability to neurodivergent groups.

3 METHODOLOGY

The project of this literature review spanned two and a half years, starting in early 2019. We illustrate our process starting with the specific positionality from which we conducted our reading and which also fundamentally motivated this research. Additionally, we delineate how we constructed and analysed the overall corpus.

The project is motivated by all authors' professional reading of technology research in the context of ADHD. The first author contacted neurodivergent peers to discuss the issues they saw in the descriptions of others about themselves. We met at a conference in early 2019 so that everyone would get to know each other and to kickstart the project. At that time, we also defined early points of interest and distributed reading lenses among each other. In part, our motivation of showing how this work resonates with people with ADHD lies in the hope that we "might support the creation of 'safer' spaces for marginalised academics and students" [124], here specifically neurodivergent peers.

In conducting this work over the span of two and a half years, we made explicit space for different temporalities in this project, following Kafer in taking up crip time, which "bends the clock to meet disabled bodies and minds" [90] instead of vice versa. We

[6] Also verified in private correspondence.

[7] Interdependence describes how individuals interact with and rely on other people and objects in their daily lives, which is a particularly pronounced experience made by disabled people [11].

further need to acknowledge that we had to incorporate grief time (akin to [134]) into this crip time, as we lost peers and friends or had to deal with the ramifications of a global pandemic, including individual illness, ourselves.

3.1 Positionality

We explicitly position ourselves in our work due to our commitment to feminist methodologies [70]. For one, such positioning operates from a point of solidarity with other marginalised researchers and the population researched in the papers analysed (e.g., [45]). Hence, we dissolve the traditional split between subjects and objects in research that characterises so much of (post)positivist research [69]. This is in line with standpoint theory, which conceptualises knowledge production as led by marginalised researchers (arguably including openly neurodivergent ones) as fundamental to a holistic understanding of a topic area [71]. This is particularly relevant in ethnographic work [78], but similarly in synthesising and analysing multiple works in an area, given that personal experiences and implications shape the reading, analysis and interpretation thereof [150]. However, it remains necessary to curate the disclosure of personal information according to comfort and safety [103]. Hence, we report some aspects of ourselves as an aggregate without individual specificities, to ensure that the broad epistemological commitments and contextual positions are clear as a matter of transparency, whilst avoiding making ourselves unnecessarily vulnerable.

That said, we are a group of four HCI researchers: two of us are non-binary, two are women. Two people have tenure and two do not. We are all neurodivergent, with three having been formally diagnosed with ADHD. Our work operates in the contexts of gender, disability, neurodivergence and children, with technologies spanning games, wearables, tangibles and virtual reality. The research we conduct is informed by emancipatory approaches, feminist theories, and, as it relates to disability, grounded by Critical Disability Studies and the neurodiversity paradigm [162].

From the start, our intention was to develop this review from an explicitly reflected positionality, taking on the perspectives of the neurodivergent populations addressed in the research we analysed. This included reflecting on whose perspectives are present and engaged with, who the research aims to empower (and how), and what power relations are implicit in the situations and scenarios addressed. While conducting the survey, it became impossible for us to remain detached - reading often affected us emotionally. Imagining ourselves or people we love in the position of study participants affected us, particularly when it came to children. Even though reading any of the papers on their own might have led to unease, reading the corpus as a whole left us with a sense of disquiet, pain, and even fear, resulting in the need to step back from the analysis at points. This perspective influences our writing style, but it constitutes a vital part of our analysis. Epistemologically, we follow here Jaggar who states that "[i]t is easy to see the ideological function of the myth of the dispassionate investigator. It functions, obviously, to bolster the epistemic authority of the currently dominant groups (...)" [85]. Subsequently, abstracting away the anger and hurt that we felt when reading would undermine the very project we attempt here – which is to highlight the implicit–albeit largely unintended–violence at the heart of such neuronormative projects so that we as a field can do better. Our aim was to ensure that these emotions would be present but not override our analysis while further being used as an analytical tool. The extended time frame of our data analysis and subsequent write-up served to distance ourselves from first reactions. Moreover, we iteratively discussed among the collective of authors how and where these emotions were relevant to include and consider (see also, Section 3.3).

3.2 Corpus Construction

We constructed two corpora, the core corpus and a further extension. Our combined corpus consists of conference/journal publications reporting on conducted research (full/long papers, short papers, Work-in-Progress and Posters, Demonstrations, journal articles), thus not including workshop descriptions, panels, or proposals for special interest group gatherings. For the initial, core corpus, we conducted a search using the terms *ADHD* and *ADD* in the title, abstract or keywords of publications within the ACM Digital Library Guide to Computing Literature[8] as well as the hcibib[9] indexing platform (although the latter stopped indexing content in 2018) on February 19th, 2019. Our analysis is thus intentionally limited to Computing and HCI literature. This resulted in 56 papers. We inspected all abstracts and identified four papers unrelated to our inquiry[10], which we subsequently removed from the corpus, leaving us with 52 papers for our core analysis. We did not further reduce the corpus, allowing us to analyse the differences between longer and shorter publications as well as to cover ongoing developments. Relying on only these two sources means that we have not explicitly looked at technical publications from more clinical or medical journals. However, our focus lies on how ADHD and the technologies in that context are specifically constructed within computing, and especially in HCI-oriented literature.

This core corpus was later extended through a survey of more recent publications, using the same source, from ca. mid 2018 to end 2020, with the aim of determining whether the trends we had identified persisted in these new publications, and/or whether new trends became apparent. We discarded anything unrelated to our inquiry that came up in this search (one workshop and one paper in a language none of the authors confidently comprehend, as well as online versions of full PhD theses). This yielded another 48 publications (after a removal of duplicates), which we refer to as the 'extended corpus'. We then performed a high level analysis of the papers in this extended corpus with the goal of challenging our initial analysis in light of an increased number of publications around neurodivergence within HCI more generally.

3.3 Analysis

For the core corpus, all four authors closely read the material [110], each with a specific focus, namely either *participants* (i.e., who was included or addressed in the research and how did potential participants act), *disability* (i.e., how did authors conceptualise and explain ADHD), *researchers* (i.e., the larger research framing and disciplinary origin of the work) and *technology* (i.e., the design

[8]https://dl.acm.org Please note that this means we sourced publications from several publishers and did not exclusively rely on ACM publications.
[9]https://hcibib.org
[10]Two of those consisted of abstracts only and two additional ones referred to patents.

and development processes, including the artifacts and their purpose), to diversify the initial reading. The definition of separate reading lenses was done to a) accommodate chunky reading in a structured fashion and b) allow for potentially diverging reading of the same papers to appropriately account for different strengths in the research we surveyed. We then procedurally coded along subcategories of these foci individually before contrasting and contextualising our analyses across individual contributors. The author team read each other's comments and codes, and a number of papers were discussed that had been evaluated divergently. The intent here was not to homogenise the diverging assessments but rather to use them productively to better understand both the strengths and weaknesses of a given paper. In addition, papers were categorised for the descriptive analysis in Section 4.1, which provides a general overview of the corpus.

For our theoretical analysis, we started by conceptually mapping out the papers in the corpus [6]. We then drew on theories from Critical Disability Studies (among them, [13, 66, 108, 168]) to analyse the implications of the papers from the perspective of neurodivergent readers. In so doing, we were guided by Boyatzis' approach to thematic analysis, which allows for inductive and deductive coding by multiple coders, whilst acknowledging the situatedness and subjective quality criteria of appropriate coding [17]. We deliberately opted against a more quantitatively oriented codebook approach to favour multiple perspectives in our analysis, and strengthen our results through negotiating divergence among us.

The extended corpus was similarly analysed by two out of the four initial coders to identify trends in current research compared to our initial results. This analysis was based on the codes already established, with new codes only added if a novel trend could be identified. Findings that differ from the initial ones are discussed in separate paragraphs along the topical sections. In a number of cases, papers from this extended corpus provide a good example for a particular trend found in the overall corpus, and are labelled as belonging to the 'extended corpus'.

It is important to note that we make no assumptions as to the neurotype of the individuals involved in conducting the research described in our corpus. Indeed, we are acutely aware of the potential negative repercussions associated with disclosure [178]. Instead, our analysis focusses solely on the discursively relevant aspects of the presented research approach and positioning.

Overall, the quality and rigour of our analysis stems from 1) our theoretical immersion in Critical Disability Studies, 2) the situated but multiple perspectives of the neurodivergent authors as members of the population of interest who are intended as recipients of the technologies described within this corpus, and who also are all experienced HCI researchers, 3) the collaborative processes in coding and theming our reading, and 4) the extension of our corpus as a response to the interrupted and prolonged analysis process. Our goal is not to establish generalities from our reading, but rather to contribute to an increased understanding of the specificities of different interpretations and knowledges; or, to say it with Haraway, to take the "privilege of [our] partial perspective[s]" seriously [69].

4 RESULTS

In presenting our results, we start by providing readers with a descriptive summary of the corpus before considering individual works to illustrate how knowledge related to technological design and development is created in the context of ADHD. We then dive deeper into the technological aspects of the works in the corpus, specifically by focusing on what these technologies communicate through their material and algorithmic make-up. Finally, we analyse how these papers configure their population of interest as one that provides tech researchers with problems in need of solutions.

4.1 Corpus Description

Due to the inconsistent classification of paper types across venues, we decided to categorise our corpus according to the length of text, as this tends to provide some indication of the size of the contribution and amount of work involved. We distinguish here between long, medium-length and short papers. Paper length denotes total length, including references. Given that formatting has a significant effect on length, we took this into account, based partially on our own experience of reformatting texts, e.g. between the ACM double-column format and the Extended Abstract format that is frequently required for Work in Progress or Posters, or for the common layout for Springer book-style publications.

Our 'long' category corresponds in length to what is currently common for full papers at ACM conferences, and includes journal articles. Our 'short' category combines papers in the format common for ACM Extended Abstract publications and those up to half the length of long papers, including formats from different publishers (e.g., Springer) with an equivalent word count.

As described above, our core corpus consisted of a total of 52 papers: of these, 31 were short papers [11], while 15 were medium length[12]. Only six papers in our corpus could be considered to be long/full papers, with five conference papers in ACM double-column format ranging from 10-13 pages, and one journal paper in IEEE double-column format (see Figure 1).

We then categorised the research and development aims, distinguishing between 1) technical work (e.g. signal processing) or work on systems/methods for diagnosing ADHD (labelled 'diagnosis'), 2) development or evaluation of behavioural therapy tools/devices and other interventions aimed at treating ADHD symptoms, supporting therapy or generally supporting everyday life of people with ADHD, as well as work deriving requirements for such systems (all labelled as 'intervention'), and 3) other work mentioning and discussing ADHD but not aimed at ADHD people as users/recipients, e.g. framework papers (labelled 'other').[13]

[11] Nine in ACM's EA landscape format, three 2-pagers, nine 4-pagers as well as two 5-pagers in ACM double-column format, five of 4-6 page length in Springer format, two of 7-10 page length and one of 11 page length.

[12] Six of 6-7 pages ACM style, another five were 8-9 pages long, two were 12-15 pages in Springer format, and two were 5 pages in IEEE double column format.

[13] To provide an idea of typical publication venues (for simplicity sake for the entire corpus): interventions/tool papers usually appear at SigCHI and SigACCESS conferences, such as CHI, ASSETS, IDC, OzCHI, CHIPlay, TEI, UbiComp, at health-related conferences such as PervasiveHealth, the REHAB workshop, or E-Education related conferences, occasionally within a Computer Graphics context. For Non-ACM HCI conferences, Interact and HCI International are frequent. Papers on ADHD diagnosis appear at non-HCI conferences, such as the Int. Conf on Multimedia, ICMI, the ETRA eye-tracking symposion, in Bioinformatics, IEEE communications magazine, Frontiers in Technology, with only one CHI paper among these.

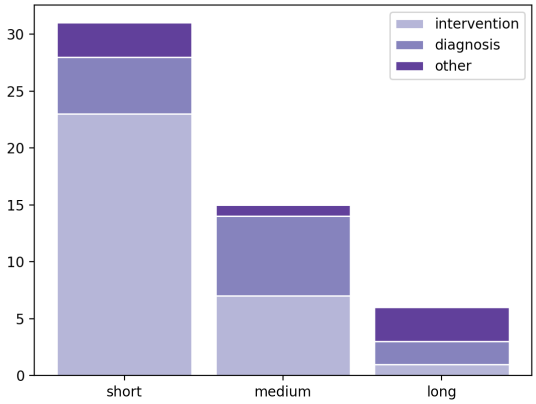

Figure 1: Length of papers within the core corpus and representation of the three topical areas.

When comparing the distribution of papers across both paper length and the type of work (see Figure 1), the balance (distribution) of topic areas almost reverses with increasing paper length. The majority of shorter papers and WiP format publications describe work on interventions and behavioural therapy tools, while almost none of the long papers focus on these topics. In contrast, more technical work on diagnosis of ADHD is dominant in long papers. Of the 31 short papers, only five deal with the diagnosis of ADHD and similar technical work (not related to interventions), while 23 propose and/or test behavioural therapy devices or other tools for ADHD people. Of the 15 medium-length papers, seven deal with diagnosis of ADHD and similar technical work (including experiments), and another seven propose and/or test behavioural therapy devices or suggest other kinds of tools or approaches. Of the six long papers, two focus on diagnosis methods/algorithms (including one journal publication [9]), while another one measures inattention in the general population. Only one proposes behavioural interventions or tools, while another two are more abstract/general (e.g. providing a framework). We also found four papers (of variable length) that employ ADHD as a narrative or potential frame without necessarily addressing the condition or people with it (for a general overview of the papers in the corpus in terms of topic and length, see Table 1).

Thus, publications that discuss e.g. sensor data analysis for diagnosis of ADHD are more likely to be long or medium-length papers, whereas work that investigates behavioural therapy interventions or that collaborates with ADHD people and their environment (e.g. parents and teachers) to develop technology concepts tends to be published as work in progress, poster or demo, and in shorter formats. In many of those shorter papers, a prototype was developed, and sometimes tested with a small number of users, and then often appears to 'disappear' [14].

4.1.1 Low Degree of Clusters. In our set of 52 papers, we only found five clusters of publications that build upon each other (indicating a longer-term research effort), of which two of the clusters are part of the same PhD student's work on *Chillfish* and *Mobero* [144–146, 148, 149]. Another cluster deals with diagnosis and activity measuring [31, 179]. The remaining two clusters comprise short/extended abstract (EA) format publications, both of which focus on designing interventions for emotional regulation [49, 50] and planning skills [165, 180, 181], respectively. This indicates that only a few systems have been deeply evaluated (or iterated upon) from an HCI perspective and then published within HCI (or computing). While there are various reasons why this might be the case (e.g. submissions might get rejected), this is in stark contrast to the amount of highly-visible and long HCI publications of work related to autism. Thus, within HCI, there is a deficit regarding detailed studies of design and user experience and in consequence, little accumulation of design knowledge of how to design for ADHD, more generally.

4.1.2 Gender and Age. Of the papers in the core corpus, almost a quarter (23.1%, or twelve papers) did not involve any participants in the research. Of the remaining papers, 25 (48.1% of all papers) did not report participants' gender. Of the 15 papers that did (28.8% of all papers), a total of 235 men/boys (74.8%) and 78 (24.8%) women/girls were involved, with one participant not disclosing their gender. It should be noted that for the work of Morris et al. [118], we inferred gender of the ADHD population by the percentage of overall gender representation across the 38 participants who identified as having ADHD. While ADHD is approximately two times more likely to be diagnosed in boys than in girls, for adults the (binary) ratio is almost identical, indicating a tendency for women to be diagnosed later in life [48][15]. This suggests that future research on technology to support people with ADHD should ensure that the gender representation of participants is more representative of the overall ADHD population.

Additionally, papers were predominantly concerned with children (32, 61.5%), with seven (13.5%) explicitly focusing on youth (i.e., teenagers). However, in some cases, authors referred to similar age groups either as children or as youth. Finally, ten papers (19.2%) considered adult populations with the remaining three (5.8%) not referencing any specific age group. This shows a fundamental skew towards younger populations in technology research.

We can only speculate on reasons for this skew. It might be based on the the popular belief frequently still conveyed in the media that ADHD is a condition one "grows out of" and thus requires intervention in childhood so it can be ameliorated or erased in adulthood see Section 2.1. There is also the common assumption that children need the most support or would benefit most from early intervention [169]. In addition, behavioural and special needs education is often already located at schools, creating a convenient institutional frame for inquiry. Yet, given we know that ADHD is present throughout one's lifespan, this collective body of research is effectively ignoring a significant part of the population that it purports to address, focusing on childhood intervention rather than life-long assistive technology applications.

Description of the extended corpus: The extended corpus (publications from mid 2018 to end 2020) consists of an additional 48 papers, showing an increase in the rate of publications on ADHD,

[14]For a few prototypes that we found interesting we did actively search for follow-up work by the authors or mentioning the prototype name on their website and via Google Scholar.

[15]Please note that the source for this information only operated on binary notions of gender.

Topic	Length	Papers	n
Diagnosis	short	[3, 24, 73, 105, 163]	5
	medium	[2, 31, 47, 75, 97, 117, 179]	7
	long	[9, 80]	2
			14
Intervention/Therapy	short	[1, 4, 10, 39, 46, 49, 55, 67, 72, 92, 102, 143, 164]	
		[50, 61, 120, 132, 145, 146, 149, 165, 180–182]	23
	medium	[42, 59, 81, 113, 126, 144]	7
	long	[148]	1
			31
ADHD as narrative	short	[166]	1
	medium	[60, 158]	2
	long	[99]	1
			4
Abstract/General	medium	[119]	1
	long	[118, 147]	2
			3

Table 1: Research approaches in papers in the core corpus along size with references

given that these papers were published within a much shorter time frame than the core corpus). The trend for research on ADHD interventions to be 'short' papers (rather than longer) persisted (20 out of a total of 27), but we now also found a larger proportion of short papers on ADHD diagnosis (seven out of a total of 15). The proportion of long 'intervention' publications appears to increase slightly (six out of the total of 48 - on par with seven long diagnosis papers). Again, most appear to be 'one-offs', continuing the trend noted in analysis of the core corpus. The one clear cluster of papers from this period include work on co-regulation of behaviour and emotion of children with ADHD with their caregivers [27, 40, 157] and work developing inclusive play spaces for neurodiverse children [18, 19]. Overall, we observe a sharp rise in the number of publications, though a slower trend towards longer papers.

4.2 Defining (People with) ADHD in Technology Research

In aggregate, the works in the corpus contextualise people with ADHD as comprising some kind of larger problem, not primarily for the individual, but more so for their immediate social environments as well as society at large. Frequently, via the abstract or within the first few lines of introductory text, ADHD is presented as a discrete entity detached from the person diagnosed with it, a source of familial burden or a threat to collective capital, and thus, an urgent problem requiring early intervention. We now analyse different rhetorical strategies employed in our corpus to illustrate how research publications in computing articulate and define (people with) ADHD.

4.2.1 ADHD as Individual Suffering. Authors often used the language of *suffering* to frame ADHD participants. For example: "*... children around the world suffer from ADHD*" [120], ADHD is "*a common cognitive disorder afflicting many children and adults*" [105], and "*the consequences of this impairment... can be devastating*" [102] (also refer to: [1, 3, 80, 97, 113, 119, 126]). Many authors expressly identify ADHD participants as being distinct from "*healthy*" or "*normal*" participants (as in [47, 61, 80, 102, 132, 179]), and ADHD traits and behaviours as being "*undesire[able]*" [164], "*excessive*" [59, 119], and "*invasive*" [9] (also refer to: [3, 102, 118, 120, 145, 163, 182]).

In so doing, authors use two specific rhetorical strategies: 1) framing ADHD as deviant *other* [37], and 2) determining the condition as detached from the individual diagnosed with it. By crystallising specific aspects of ADHD, the condition is framed as an entity distinct from, and invasive to, any person diagnosed with it as well as their adjacent social unit. This is a common discursive practice that has been critiqued in disability studies for decades, specifically for the context of autism [112, 141], but also negates the fundamental way the associated neurology shapes an individuals' perception of their environment as well as their processing of external signals [111]. Furthermore, such a rhetorical strategy runs counter to ACM SIGACCESS accessible writing guidelines [68], which suggest to consider disability as one aspect of a person, that does not define them in total but makes up part of their identity. Assuming that people with ADHD 'suffer' from having a specific neurotype fails to consider that people appreciate the strengths that come with it, and instead frames our existence as undesirable, and the researchers addressing ADHD as altruistically motivated helpers [28].

4.2.2 ADHD as a Burden to Others. ADHD is furthermore frequently described as a burden to others and to society as a whole. In our corpus (core and extended), children with ADHD are often described as being "*at risk*" of underachievement [4, 9, 55, 81]), substance abuse ([1, 144]), and criminality ([1, 9, 145]), due to having ADHD traits. However, there have been numerous developments in critical psychology that acknowledge that ADHD traits do not play a causal role in these outcomes in isolation from societal discrimination and stigma [22, 121, 161].

The papers we surveyed often aimed at reducing the 'burden' of ADHD, but none recognised socio-cultural contexts and disability stigma as producing "suffering" or contributing to "outcomes". While these projects might be well-intentioned, the approaches pursued often reinforce societal behavioural expectations and thereby place the burden on the ADHD person to adjust, constituting a focus on curative rather than on assistive technology [156].

Many authors further emphasised the burden to family, caregivers, teachers, and broader society. For example: "*there is a significant burden on those affected, their families and society*" [148]; "*ADHD can be challenging for a parent or caregiver with an individual who has this disorder*" [1]; "*a big threat for public health*" [97]; and "*can have a huge emotional and economic impact on families*" [ibid] (see also: [55, 80, 126, 145, 147, 148]). Here, these research projects become legitimised by an unsubstantiated assertion that the family unit is suffering as a result of the ADHD person. Other authors appeal to ADHD's disruption to a person's productivity as a risk to individual success (as in: [1, 4, 55, 80, 147]) and imminent threat to national capital (as in: [39, 50]). Following from these implications, ADHD thus becomes an urgent societal problem solved only by intervention on the individual, rather than on the society which problematises their embodiment. This negates how people with ADHD often have strategies and traits that allow them to make substantial contributions to collectives and societies [135, 167].

4.2.3 ADHD as an "interesting argument". We identified four papers utilising ADHD as a keyword, but do not actually address ADHD. ADHD is instead used to motivate the relevance of the research, however studies are run with "healthy" (sic!) participants, misconceptualising ADHD as an illness. This includes a study of interruption effects, motivated by the assumption that smartphones create ADHD symptoms [99], or one on modality effects on attention [166]. What is problematic here (from our perspective), is that these studies are not relevant to ADHD and, in some cases, grounded in faulty assumptions which equate inattention due to interruptions or modality uses to ADHD). Phrased more directly: ADHD is utilized here as a sales pitch and attention grabber, with little interest or regard for the people behind a catchy diagnostic criterion. The principle behind the neurotype gets exploited as an argument lens, to be useful to neurotypical people.

4.3 Shifting in and out of Focus – People with ADHD in Technology Research

Here, we summarise our analysis regarding the methods utilised, in particular regarding the engagement with participants. This is limited to publications presenting or discussing (potential) interventions and leaves out purely technical contributions or work on ADHD diagnosis. For this analysis, we took notes on who the researchers actively engaged with, and what roles these people had; that is, how, beyond being conceptualised as *users*, they were considered as *testers*, or actually able to shape the work, either as *informants* or as *design partners* (akin to the definition of roles by Druin [41]). We categorised publications based on whether they follow a user-centred design (UCD) approach, and whether they engage in co-design (where stakeholders take an active role in idea generation and prototyping).

Eleven of the 31 papers presenting an intervention or a tool for assisting ADHD people do not explicitly mention a UCD process, nor do they provide any evidence of such a process: only the design rationale and features of a given technology are described (e.g., [42, 92, 164, 182]). One paper mentions plans for future UCD work; three papers claim to have followed a UCD process, but provide no further evidence, or keep participant involvement to an absolute minimum (e.g., conducting a passive survey [39]).

4.3.1 User-Centred or Non-User Centred Design? 16 papers originating from twelve different research projects followed a design process that could be considered user-centered in terms of investigating requirements, interviewing stakeholders and conducting iterative development and testing. Out of these 16, six described some form of co-design (four projects), where stakeholders are involved in design workshops. The short definition of UCD stresses that "designers focus on the users and their needs in each phase of the design process" and "involve users throughout the design process"[16]. 'Throughout the design process' implies that relevant stakeholders are not only involved for testing, but that designers engage with representatives of the relevant populations in early stages to understand their needs and perspectives [137]). A full UCD process should consider all stakeholders, especially the intended end users. This is also emphasised in the child-computer interaction literature [79, 129], which discusses how to 'engage with the voices of children with disabilities' [83]. Even in the emerging area of Animal-Computer Interaction, principles of UCD are extended across species barriers [107], considering e.g. dogs as active participants with agency, preferences and feelings. Yet, closer inspection of the corpus reveals that projects rarely include people with ADHD as the core stakeholders and end users in an active role that directly contributes to the development process. Of 52 papers, 19 claim UCD principles. We consider 16 (related to 12 projects) as actually following through with a UCD approach, but only five projects actually include people with ADHD as (primary) informants and/or co-designers. We acknowledge that sometimes institutional ethics review boards might prevent researchers from more directly engaging with ADHD participants, given their common status as a vulnerable population. Nevertheless, publications should at least mention not having had direct input and feedback from ADHD participants as a limitation of the research.

Of the projects which follow a UCD (but not co-design) approach (ten papers, eight projects), none include ADHD people in either pre-design interviews/workshops or interviews post-intervention/experiment. Instead, the work was informed only by discussions and interviews with teachers, parents, or with medical, clinical and

[16]Quotes taken from https://www.interaction-design.org/literature/topics/user-centered-design (September 7th, 2021).

other professional ADHD 'experts'[17] (sometimes solely with the latter) (e.g. [59, 72, 126, 144, 149]). Several projects involve an evaluation study, where the given technology is deployed. However, the people with ADHD who, for instance, are made to wear a wearable device are rarely questioned about their experiences afterwards (with one notable exception [81]). Evaluation findings tend to focus on whether teachers or parents (or therapists) see improvements, thus prioritizing a 'view from the outside', rather than subjective well-being and individual meaning-making. This goes against principles of user-centered design, which is meant to consider all stakeholders, in particular end users, as well as considering trade-offs between those stakeholders. To put it bluntly, by excluding people with ADHD from central participation and testimony, the focus of research in this corpus is not to support people with ADHD in their daily lives, but rather appears to be lying on bringing "relief" to their parasocial environment through the upholding of neurotypical standards of behaviour and expression.

Not involving people with ADHD early on often creates fundamental issues for the validity of designs that are only recognised late in the process, if at all. For instance, in the development of *ChillFish*, a breath-controlled biofeedback game, Sonne and Jensen [144, 145] collaborated with medical/therapeutic professionals for the design and tested it very late with children with ADHD[18], which revealed that the device did not work adequately for them.

Other work by Sonne et al. [146, 148] focuses on 'involving families' in improving morning and bedtime routines of children with ADHD, and includes parents and domain professionals (i.e., clinicians) in the design process. They developed a mobile app that reminds children of a bedtime routine and steps them through it using timers and 'star' rewards. The design was iterated based on parents' feedback and after a two week study, parents were interviewed. Parents were also responsible for defining the routine that the children were then guided through by the app. In this entire process, it is not mentioned that the children were ever consulted about their preferences and experiences: in any case, the publications do not include children's perceptions, comments or feedback. While children with ADHD tend to exist within family units, not explicitly attending to their specific perspectives amplifies the power structures enacting on them in their daily lives. Garcia et al. [59] developed wearable activity monitoring devices coupled with a portable feedback mechanism that rewards children for being still and not moving too much. The mechanism follows a behaviourist script in which a virtual character becomes more and more happy the less the child moves. They observed classes at a specialist school, interviewed teachers, parents and specialists, and brainstormed with teachers. The children played only a passive role in lab tests and in the actual intervention during two days of school by wearing the devices. Only at the very end of the project was a focus group interview held with the children in the class, which is too late in the process to meaningfully enable participants to challenge and contribute to its design.

[17] Of course, there is a specific irony in not acknowledging the actual expertise held by people with ADHD, a move also common in research on autism [116].

[18] As indicated by the authors in the presentation of their work during TEI 2016, they were not given permission by their institutional ethics review body to include children with ADHD earlier in the process. These less than ideal circumstances are often outside of authors' control, but affect the quality of the design and research in the ways we describe here.

4.3.2 Participating in Design. Work following a Participatory Design (PD)/CoDesign approach appears to be more likely to engage directly with ADHD children, teenagers or adults as active contributors to the design process and as conversation partners in evaluation (e.g.[46, 50, 67, 165, 180]). We highlight the work by Eriksson et al. [46] who ran future workshops and conducted lo-fi prototyping sessions with students that have ADHD to explore their conceptions of time. The aim was to develop appropriate representations for a tool that enables them to tell the time in a way that fits their individual perception and thinking, helping to develop better time-processing abilities. This addresses the ADHD characteristic of difficulty in telling the time and time perception [14]. Zuckerman et al. [165, 180, 181] similarly actively involved ADHD children to develop Tangiplan, a tool that supports the planning of daily tasks and scaffolds their execution. They interviewed child-parent pairs and encouraged the children to play with the potential interaction using a paper mockup. Moreover, with the tool, children can define their own routines, set their own goals, and decide where to put the Tangiplan hourglass reminders, and, thus, are in full control. This was one of very few projects to give agency to people with ADHD and seek to support their individual strategies. Another example in our core corpus is a project that interviewed adults with ADHD [81] to understand their self-chosen strategies for personal information management, though it appears that there is no follow-up work.

However, even CoDesign processes may ignore the perspectives of those with ADHD. For instance, Pina et al. [126] claim to be 'working with families' to develop a prototype that would provide parents with in-situ cues for behavioural coping strategies. However, read closely, we noticed they only involve parents in interviews and workshops, enquiring about their needs, and later, about their experiences after deploying the tool (which helps parents structure their interactions with children and provides prompts and interventions when parents become stressed), whereas they did not enquire with the children about how this affected them. While it could be argued that this tool enabled parents to deliver parental strategies more effectively, it ignores the nature of their interactions with children, whether these are adequate, and what these mean for the ADHD child. As such, it is possible for maladaptive parenting strategies to persist, and even worsen. Such an approach removes the agency of people with ADHD, not just in design processes but also the resulting interactions with technologies.

4.3.3 Participant Resistance. We found several examples of enacted resistance which can be read as commentary on technology interventions for ADHD [169, 173]. For instance, when tactile feedback was intended to function as a corrective sensation for participants to attend to and adjust their behaviour accordingly [97], ADHD participants instead enjoyed the tactile sensation, and would engage in behaviour that triggered more of it, resulting in paradoxically higher "scores" on the game while rating lower on "performance" in terms of the intervention's behavioural aims.

Given the nature of ADHD, time was a common site of contention within the corpus. In the Mobero study [148], the researchers deployed novel timer devices to "assist the child in becoming independent and lowering the parents' frustration levels." Yet the devices caused some participants stress and frustration. One participant protested the intervention by hiding the timers during meal times.

In another time-based intervention for adults [50], participants rated the intervention as "intrusive", with "one participant withdrawing from the trial after receiving ten false alarms within two hours." By engaging with ADHD participants as design informants, Eriksson et al. [46] were able to recognise how neurodivergence contributes to time perception difficulties, and thus - rather than reinforcing normative patterns - sought to design for "a more useful representation of time." Through participatory practice, they were then able to design for time to be "organized into activities in a certain order as a stretch of time, rather than its relation to specific hours and minutes", illustrating how an appreciative engagement with participants can yield more appropriate technological interventions which marry neurodivergent preferences and neurotypically formed expectations.

Additionally, we have identified a unique literacy of resistance from this ADHD technology corpus: *embodied resistance*. While in previous work [169], resistance came about through participant action, in this study, resistance can often be read within the participants' bodily and autonomic reactions to protocol. ADHD bodies are witnessed resisting detection: "the quality of the ADHD image is worse than that of the control image, probably due to the movement of the children during image acquisition." [2]; "...the data from the user study was unreliable… [because]... the children found it hard not to fiddle with the EDA electrodes" [149]. ADHD children in digital sensor apparata both "out" themselves through hyperactivity while simultaneously concealing the detail of their own biosignals, disrupting the efficacy of algorithmic feature extraction and classification.

Extended Corpus. The ratio of UCD approaches has only marginally increased in the more recent publications of our extended corpus. Of 27 'intervention'-oriented publications, only 14 report on a UCD approach. Of these fourteen, eleven use a classical UCD process. Six of these actively engage with teachers, therapists, or parents, but not with the ADHD people involved as study subjects. Only four publications (all from the same project [25, 27, 40, 157]) engage directly with ADHD children. Unfortunately, even though the researchers here consulted with their core stakeholders, when the children requested design specifications that went against the researchers' agenda – in this case, that the children do not want to share data with parents and teachers as it violates their privacy – this input was ignored. Whilst we recognise the various trade-offs that can occur during the design phase, with some ideas taking priority over others, we nonetheless feel that a discussion of why young people's input into the design was sought, but not necessarily acted upon, is merited [130]. Thus, direct participation is not a guarantee for having one's agency acknowledged and actively included. Further, we found one survey study with ADHD adults [38]. Only Boyd et al. engage in CoDesign activities with families and interview ADHD children [19].

However, the majority of UCD-style projects continue to ignore the perspective of those people whose interests the research supposedly supports and helps. For instance, Spiller et al. [155] aim to implement behaviour management strategies in classrooms, based on a 'token economy'[19] (a reward system for 'good' behavior), and engaged with teaching staff, school psychologists and behaviour analysts. The work resulted in a glanceable classroom display where all children can see each other's status, and which displays warnings in the event of undesirable behaviours. Over a ten month deployment, the classroom teacher and behaviour analyst were repeatedly interviewed. Park et al. [122], in a team involving UX designers, pediatric psychiatrists and developmental disorder therapists, interviewed parents of children diagnosed with ADHD to derive requirements for a mobile voice-bot to assist the children in daily routine tasks, but not the children themselves.

4.3.4 Summarising The Role of People with ADHD as Stakeholders. As we delineated above, ADHD people are involved in experiments and studies, but very rarely are asked about their opinions, needs, desires, and experiences. Experiments often involve rather invasive procedures, such as strapping wearable sensors to participants' bodies, e.g. to detect 'excessive motor activity' or to infer attention loss [1, 59, 143, 163], sometimes for extended time periods, occasionally explicitly without their consent, and providing them with positive or negative feedback on their behaviour, either directly/individually (e.g. vibration alerts) or via contextual interventions (alerts to e.g. teachers or parents, displays visible to the entire class). When reporting on the study, none of these publications provide a rationale or explanation for why ADHD children or teenagers were not interviewed directly. There is little further information on how consent or assent was gained apart from parental consent (whereas the child-computer interaction literature recommends to "actively seek consent from children" [129])[20]. This is not to suggest that child consent was not obtained by any of the studies reported upon, but that this has not been made explicit either.

We assert that, overall, there is a lack of engagement with core stakeholders (the direct end users on the 'receiving end' of any interventions) in this technology space, that is, people with ADHD. Instead, a by-proxy approach is taken, of working with professional ADHD experts, teachers or parents. This ignores not only the subjective perspectives, interests, needs and desires of ADHD people, but also the power-differential between children/teenagers and parents/teachers/medical experts, as well as the inherent conflicts of interest between these stakeholders (e.g. teachers may just want the class to be quiet and well-behaved, whereas a child needs more activity). Moreover, by focusing on children in this context, the power differentials between researchers and their ADHD audience are amplified, further limiting the agency of ADHD adults as well. If people with ADHD are not systematically engaged in designing and making meaning of the technologies that are built to operate in their lives, the resulting artefacts will very likely embody and materialise neurotypical expectations more than self-determined support, which is why we take a closer look at these in the following section. We need to emphasise here again that neurodivergent researchers might also end up creating products that embody neurotypical norms as these are powerfully present in Western societies and often internalised by neurodivergent people as well.

[19]However, as Kohn reminds us, "[a]ttempts to short-circuit [the teaching] process by dangling rewards in front of children are at best ineffective, and at worst counterproductive" [95].

[20]That Child-Computer Interaction researchers emphasize that this should be the standard indicates that it is not always a given. Note that Ethics Boards often only require parental consent, and only require that children cannot be forced to take part. This ignores the impact of family power dynamics on children's ability to decide for themselves.

4.4 Technological Artefacts in the Context of ADHD

When considering technologies designed for intervention, we classified the corpus according to the type of technology that was developed and utilised. We identified four clusters of technologies that occurred most frequently, and in at least two distinct projects within our core corpus (with the number of papers reporting each type of technology shown in parentheses):

- **Wearables** (10x) in different form factors, ranging from a hugging vest for deep touch pressure therapy (e.g. [42]), wristbands combined with e.g. smartphones [49, 50, 126], belts that measure inhalation or acceleration [59, 143], to smartwatches [39] and other wearable devices and sensors;
- **EEG** (4x) ranging from mobile EEG devices for everyday tracking [10], applications for neurofeedback training [113, 132] to the use of EEG as an evaluation tool for media consumption [102];
- **Smartphones** (4x) appear either as general purpose technology [99] or as a platform for time structuring applications [146, 148, 149]; and
- **Augmented and Virtual Reality** (3x) are used as simulation environments to train specific skills [120], time perception [61] or as an interactive frame for another technology (in this case, a Brain Computer Interface (BCI)) [164].

Other technologies appear only once or twice, e.g. eye tracking games [1], a handheld game controller for breathing exercises [144], fidget toys [67], full body games [72], and Tangible Interfaces [165, 181]. Robots were used twice [97, 182].

The biggest group of projects (10) in our core corpus aim to **train focus, concentration or attention (span)**, usually of children [1, 4, 67, 72, 92, 99, 102, 132, 164, 182], with another two projects aiming to support self-regulation of attention directly [113, 149]. Other projects are concerned with **frustration tolerance** as a related topic [120] or **working memory** [61]. **Hyperactivity** is utilized as an indicator for diagnostic technologies [9, 117, 179], although only a subset of ADHD people are hyperactive.

Another cluster of projects aim to support **self-regulation**, with different foci: emotional and cognitive control, e.g. through breathing exercises [49, 50], self-management of emotion by predicting agitated situations [163] or of "motor excess" [59]. **Impulsive action** is deemed to be in need of suppression, so there are two projects focusing on self-regulating of impulsivity [72] and impulsive speaking [143]. The breathing exercises with Chillfish [144] similarly are aimed at training approaches for calming down. A small cluster focuses on **supporting the perception of time** [46, 59, 61] and two projects support **routines in the home**: morning [146, 148] and evening [180, 181] respectively. Pina et al. [126] share this focus on families by supporting **parenting strategies and interventions**. Only one project looked at **personal information management strategies of adults with ADHD** [81]. A smaller number of projects have aims that do not neatly fit with descriptions of ADHD but are more aligned with research typically focussing on autism, e.g. improving sensory processing via deep touch pressure therapy [42] or helping children to learn how to use touch appropriately and become used to social touch [97].

4.4.1 Specific Purpose: Controlling Body Movements. In our analysis, we found numerous examples where children were equipped with wearable devices in a way that is intrusive, stigmatising, and that frequently employs classical stimuli-response conditioning approaches, as training to suppress certain types of actions or to encourage others. *Blurtline* [143], intended for classroom use, is designed to warn children that they are about to speak impulsively through a belt worn around the chest which detects deep inhaling. Notwithstanding the intrusiveness of such an approach, the design risks false alarms, e.g. if a child attempts to do breathing exercises in order to calm down. Sonne et al. [149] equip children with no less than eight accelerometers on their limbs, a heartrate sensor and an EEG headset to infer loss of attention during school classes, and then alert the child to their lack of attention. In addition to the obvious issue of stigma, there is no consideration of the fact that such alerts might feasibly act as distractors in and of themselves, and may well cause distress to the child[21]. Garcia et al. [59] develop a 'portable companion creature' that provides vibration feedback to children and makes an unhappy face if 'motor excess' is detected, thus motivating children to make the toy smile by sitting still. From such a system, it is possible for children to internalise that their natural bodily movements make other people sad. Similarly, there is a watch which provides feedback on 'performance' in the evening. This follows a classical behaviourist conditioning strategy while ignoring the role that movement might have for a child, e.g. supporting them in finding an outlet for their activity impulse or to calm down, and thereby enabling them to focus [5].

The high frequency of wearables can, subsequently, be traced to attempts to monitor ADHD people (usually children) in daily life, often to provide in-situ interventions or to enable reflection about their day. It should be noted that some of these setups are very extensive and not realistic; in particular they run the risk of further fuelling already prevalent stigma. However, they also fuel internalised oppression by communicating to the wearer that the ways in which they feel comfortable in their body and the ways they like to move are inappropriate and need to be changed to belong to dominant society[22].

4.4.2 Specific Purpose: Diagnosing the Disordered. Research into technologies for diagnosing ADHD is frequently motivated by the need for 'less subjective' and hence more 'objective' measures [105, 117, 179] and, as is implied, more accurate assessments: "Since most ADHD diagnostic procedures are based on subjective assessments, the goal of this study was to develop an objective assessment (...)" [105]). Further, it is often argued that automated diagnoses will reduce the workload for medical and therapeutic professionals to let them have an "accurate, less time consuming and a less tedious job" [3]. In addition to the initial diagnosis, it is envisaged that some methods may further be used in monitoring the outcomes of interventions (e.g. [88]).

Common approaches include fMRI and MRI (6x) [e.g., 2, 47, 80][23], EEG or other brain waves (2x) [e.g., 75], eye tracking (3x), analysis

[21]It is interesting to note that ADHD is already a predictor for anxiety - though not vice versa - in three-year-olds [58].

[22]Expectations on paper length preclude us from discussing this further, but suffice it to say that Foucault [51, 52] would have had a field day with this.

[23]Most MRI and fMRI studies appear to be motivated by the 2011 ADHD-200 Global Competition on identifying ADHD bio-markers from brain imaging data, which states

of touchscreen interaction data or general movement data (6x) [e.g., 9, 117, 179], based on the assumption that ADHD people will fidget or exhibit particular movement patterns, as well as more complex combinations of bio-data (motion data, eye movement, heartrate, body temperature) (2x) [e.g., 163]). Three publications use screen-based computer-led tasks [73, 105, 179]. Others employ machine learning to analyse questionnaire data to predict ADHD, or monitor user performance during task switching [e.g., 73].

Of the twelve publications in our core corpus which focus on diagnostic technologies, the intended audience consists exclusively of medical professionals and clinicians, sometimes additionally involving special education teachers. All of these publications rely on some form of outside observation. Only one considers that diagnostic tools could be helpful for self-diagnosis as a matter of clarity and to identify personal access needs [179]. The focus on diagnosis from measurable behaviour can further be read as a distrust in 'lived experience' as almost none consider the inside perspective of what it is like to undergo diagnosis. Only one recent 2020 CHI paper [88] reports to have interviewed children that took part in a study with diagnostic tasks about their experience. This ties in with a resistance to "subjective" (i.e family and self-reported) diagnostics for something that is deeply experiential, embodied, culturally mediated, and lived [35]. Automating diagnostic procedures further inherently reduces individuals to a set of symptoms (as previously shown in the context of autism [94]), an aspect that none of the publications we surveyed critically grapple with.

Extended Corpus. The updated corpus reveals that the range of areas that are addressed has diversified somewhat in recent years. **Attention and concentration** are still the dominant categories (7x), which includes training the ability to focus a target on a screen or training attention via an eye-gaze game [23] or adaptive learning environments that guide attention via a virtual agent on-screen. Two projects address **time management** (this includes the only paper focusing on adults [38]). Recent more extensive projects focus on self-regulation of behaviour and behaviour management (including [40]). These tend to build on the behaviourist notion of a 'token-based economy' that reinforces 'good behavior' through rewards, such as being allowed to play a favourite game at the end of the day [155]. Two projects aims to train **response inhibition** or **reduce impulsivity** [16, 157]. One project develops a voice bot to support and scaffold **daily task execution, goal setting and planning** [122]. An outlier, following a completely different approach, is the project by Boyd et al. [19] on sensory-inclusive play spaces for neurodiverse children. These support open-ended play and develop ideas for play types from children's sensory preferences and needs.

5 DISCUSSION

Overall, our results show a preponderance of technologies for intervention and diagnosis in the context of ADHD. We further identified the exclusion of people with ADHD from knowledge production of technologies for/about them. This leads to technologies which primarily embody neurotypical expectations rather than neurodivergent needs and desires, as well as a singular framing of the target population as a source of "problems to solve". We now discuss the implications of these findings in terms of understanding who "the user" is for a specific technology in neurodivergent contexts and what technological alternatives might look like based on the concept of crip technoscience [66].

5.1 Defining the Population of Interest

In numerous instances within both of our corpora, the emphasis on diagnosis and intervention means that the research conducted does not focus on **people** with ADHD as the "population of interest", but instead reduces them to a list of symptoms that need to be diagnosed and subsequently addressed, and ignores their perspectives, experiences and wishes. As such, the research conducted embodies a neurotypical perspective that subjects people with ADHD to societal norms. Subsequently, most technologies are not intended to be used by or to be in the control of people with ADHD, but rather by others in their environment, including professionals upholding neurotypical norms (in line with what has been observed for autistic populations previously [152]). In the spirit of "nothing about us without us", we identify a fundamental lack of active involvement of people with ADHD across the corpus, particularly in cases where they are relegated to act as a data source or acting as objects to be tracked in a technological setting. These are precisely the settings in which people with ADHD must be actively involved[24] in the design of technologies from the outset so as to ensure that the resulting technologies avoid amplifying existing power dimensions detrimental to neurodivergent individuals and that they actually benefit people with ADHD. In this light, we now reflect on the lack of meaningful inclusion of people with ADHD within our corpus more generally.

5.2 UCD without the Users?

The development process of most systems described in our corpus does not fulfil the criteria expected in modern day quality standards for user-centred design (UCD) [79, 137]. A few pay lip service to the approach, without the involved methodological and epistemological commitments (i.e., not presupposing needs and desires), while others follow the general process in a rudimentary way, establishing requirements, and then move on to development and an evaluation study, whilst ignoring a key principle, that of focusing on all stakeholders (compare Section 4.3). This is at odds with textbooks on Interaction Design and UCD [77, 137, 140], which stress the importance of involving 'real users' in the design process, consulting them, and taking account of their input, including their reactions to prototypes. End user tasks and goals should drive development: "it is imperative that representative users from the real target group be consulted" [137, p.432].

the aim of understanding the neural basis of ADHD (http://preprocessed-connectomes-project.org/adhd200/) to inform diagnosis of ADHD and guide clinical decision-making for treatment. While the overall goal behind this might be well-intended, it makes us passive objects in a competition that treats our lives and selves essentially as extractable (and, hence, discardable) data sources.

[24]This does not mean that researchers need to have or to publicly disclose ADHD, but refers to a process that actively elicits the perspective and opinions of people with ADHD in both requirements analysis and evaluation, e.g. through interviews and other methods, or through co-design approaches that explicitly make space for their respective agency. It is decidedly not about research identity, but about an epistemological stance oriented on creating spaces for the meaningful collaborative shaping of technologies together and a generally appreciative stance to take on in technology research on ADHD.

As noted above, the 'end users' in many cases are not actually conceptualised as being people with ADHD, which leads to most of these technologies amplifying neurotypically (in)formed positions and perspectives. Basing a design solely on input from medical experts (as done by some of the papers in our corpus) can mean only involving 'proxy users' [137]. Most of the papers we analyzed actively consulted teachers and parents of ADHD individuals and not the individuals themselves. Yet in UCD, the latter (who are required to wear/use/be monitored by these systems) need to be considered direct users or primary stakeholders. This illustrates that in research involving marginalised populations, who is identified as the primary stakeholders is not just a factual or designerly, but a critical and political decision.

Only few of the projects took an effort to understand the needs of people with ADHD and the consequences such technological interventions have on their well-being, experiences and overall lives. Indeed, many studies revealed cases of 'resistance', where participants did not behave as expected, rendering the intervention, essentially, useless (see Section 4.3.3). Hence, testing systems on neurotypically presenting people cannot replace user tests with ADHD individuals. In analogy, it is meanwhile well established that interfaces for disabled people cannot be effectively designed or tested by participants temporarily putting themselves into a position emulating a disability, since the lived experiences with disabilities and the strategies involved therein cannot be momentarily experienced and simulated [12].

The number of projects that sought to interview and gain feedback from ADHD individuals only covers roughly 12% of papers in the core corpus. Of other publications, few provided a rationale or explanation for not consulting them, or listed this as a limitation of the research. Yet within HCI, there has been a great amount of discussion of how to design for - and with - vulnerable populations (from homeless people, refugees, people living with dementia, the visually impaired, to breast cancer patients) [159]. Thus, the importance of doing so is known. Moreover, as participants in our corpus skew towards younger populations, it is commonly deemed insufficient in the area of Child Computer Interaction to take account of children's cognitive development as reported by medical and educational experts, but that children need to be directly involved in the design of technologies, and that active involvement is preferred, at minimum as testers (who provide feedback), if not as informants or design partners [41, 79, 84, 129].

5.3 People with ADHD as Study Subjects - But without Subjectivity?

Only a few of the papers we reviewed consider the perspective and the goals of the supposed population of interest. Instead, researchers tend to consult parents, teachers, or medical-therapeutic professionals, thus exaggerating hierarchical power structures and potentially increasing conflicts (see also, [28]). This further raises issues around informed consent: In the case of children with ADHD, can we assume that parents can provide consent for their children or should we acquire explicit consent from children? How can we even acquire genuine consent in the context of power hierarchies in schools and families [151]? In the case of adults with ADHD, can we assume that medical professionals and therapists adequately represent the desires of people with ADHD? Here, we need an awareness of living expertise of people with ADHD akin to rising awareness of the expertise of autistic people [116].

The way that ADHD individuals are treated in some of the work we surveyed relegates us to detached objects involved in collecting data (e.g., by wearing trackers), but not involved in making meaning about said data or ourselves. Ethics and IRB committees appear to approve of such research (possibly because they tend to derive from health research, which primarily discuss potential harms, and where treatment is provided through doctors and other experts, who then also evaluate the outcomes). Moreover, ethics committees consider disabled people and children as vulnerable to exploitation or loss of privacy, where it is deemed relevant to protect them from outsiders in their everyday life. Thus, especially with a prevalent focus on children with ADHD, at least two issues come together that create an incentive to *not* work directly with them, as it is procedurally less complex to rely on teachers and parents to administer and monitor a study, and rely on their feedback. The latter issue extends to user testing of prototypes, frequently conducted with neurotypical individuals, particularly when the concern is with ADHD children. When ethics committees consider children with ADHD as a 'vulnerable population' or 'high risk group', they will only approve evaluation with ADHD people once prototypes have been pre-tested (as is the case with, e.g. [144, 145]). This is presumably meant to spare vulnerable populations from a bad experience when testing unstable and unusable systems, but leads to designs not being critically challenged early on and subsequently the continued development of designs that ultimately turn out to be much less helpful than imagined. The thinking behind this is flawed, assuming that if a system works for neurotypical populations, it will similarly work for people with ADHD.

Thus, institutional regulations can create hurdles for actively involving ADHD individuals. Unfortunately, we found little direct evidence that ethics committees prohibit the active involvement of ADHD people and an inquiry into their experience within technology trials, as none of the papers surveyed provided any rationale for *not* interviewing them. Here, we rely on future work interviewing authors on their experiences with formalised ethics procedures to augment our theoretical inference. As we stated earlier, not having done so should be explicitly highlighted as a research limitation. Nevertheless, researchers could advocate stronger for UCD approaches that involve 'vulnerable' populations.

As it stands, though, the technologies resort to a rhetoric implying their population of interest being people with ADHD, while privileging perspectives that uphold neurotypical norms. This is done by relegating individuals with ADHD to passive roles within the design and development processes of technologies that conceptualise us as passive in their interaction scenarios as well. Further, by focusing on the vulnerability of the population, people with ADHD are systematically kept outside the meaning making of technologies about us as part of the fundamental research design. This is below standards for the involvement of and considerations regarding neurotypical populations more generally, but also falls below HCI and Interaction Design standards for treating children, animals and other neurodivergent populations in research.

5.4 Speculating on Crip Technoscience for ADHD Technology Research

In preparation of our recommendations below, we now speculate on alternatives for technology research in the context of ADHD. We do so by taking inspiration from the Crip Technoscience Manifesto published by Hamraie and Fritsch [66]. By no means, we intend this to represent the desires of neurodivergent people at large or even all people with ADHD. Fundamentally, our speculations do not replace actually involving people with ADHD in (technology) research about ADHD; they are ours alone. The manifesto lines out four different principles we adapt for our specific context.

5.4.1 "Crip technoscience centers the work of disabled people as knowers and makers." [66]
As shown above, people with ADHD are largely not acknowledged in their expertise or being involved in generating designs. To some extent, this is entangled with the tensions identified by Liang et al. in research involving marginalised participants more generally regarding *exploitation*, *membership*, *disclosure*, and *allyship* [103]. We envision ADHD research to orient itself on collaborative partnerships between researchers and participants, while acknowledging that these groups do not have to be and should not necessarily be completely distinct. However, disclosing membership is fraught with power dynamics considering that ADHD is partly understood a learning disability, which, if taken for granted on a surface level, is counter-intuitive to also holding steady employment[25] as a researcher [178]. Hence, even if disclosure as a member is not possible, positioning non-exploitative research from a place of allyship that centers people with ADHD contextually, practically, and materially can comprise a way to conduct future work in this area.

5.4.2 "Crip technoscience is committed to access as friction." [66]
We envision that the involvement of people with ADHD in research and the resulting technologies should not try and orient themselves to removing friction from interactions. Not just the power dimensions inherent in such endeavours, also the diverging ways of perceiving and processing environmental input lead to potential for different interpretations and priorities. Prior research involving groups of neurodiverse children has shown that different attitudes towards design [93] as well as deliberately agonistic strategies [54] have fundamentally productive consequences not just for more collaborative interactions among neurodiverse groups consisting of neurodivergent and neurotypical individuals, but also for the design of technological artefacts. We do not recommend here to actively introduce harmful aspects of friction, but rather sit with emerging ones, questioning why this friction became apparent at a given moment and what underlying dynamics govern it, instead of trying to smooth them over as a reflex.

5.4.3 "Crip technoscience is committed to interdependence as political technology." [66]
We further speculate on research valuing interdependence more, i.e., attending to how everyone depends on others to survive, which is pronounced for disabled people [11]. This "possible orientation" [ibid] – which we, in line with Bennett et al. do not mean as prescriptive, but rather suggest as a commitment to access more generally –; this orientation requires researchers to explicitly understand the resulting technological artifacts and implications as political. Refusing an explicit position does not mean that the resulting artifacts are less political [cf. 175] they might similarly embody specific politics themselves in return [89]. Hence, we recommend reflecting on and communicating the politics shaping research explicitly and hope researchers recognise interdependence as a stance in combination with the last point of the Crip Technoscience Manifesto, the commitment to disability justice.

5.4.4 "Crip technoscience is committed to disability justice." [66]
Even though not all authors of this review understand their experiences with ADHD as disabling, we share with the disability community the fundamental exclusion on meaning making about our own lives and the technologies governing those. However, we further imagine here a commitment to crip kinship [91] in that people with ADHD and researchers in this space think about disabilities and differing needs holistically and with a justice lens. In that, we encourage technology researchers, akin to the Design Justice principles, to "prioritize design's impact on the community over the intentions of the designer" [30]. Technology researchers need to actively attend to the harms they have (often inadvertently but nevertheless) introduced to marginalised communities and to position themselves towards those. This process is likely disruptive and painful, but necessary to establish respectful and equitable partnerships between researchers and marginalised communities.

5.5 Reading Research while Neurodivergent

Through the redefinition of people with ADHD as the explicit population of interest and taking on commitments of Crip Technoscience, we envision future technology research in the context of ADHD to be more equitable and better oriented on the needs and desires of this population. Of course, our perspective is biased. As neurodivergent readers ourselves, what we read are descriptions referring to us and our families, descriptions that are oriented on deficits, study designs that employ drill techniques and behavioral conditioning methods based on reward and punishment approaches. The way in which the participants were described, the things they were asked to do, or discouraged from doing, and the expectations for 'desired behaviours' underlying these interventions frequently showed little consideration for the actual needs and the emotional well-being of neurodivergent participants, even if the intention of the researchers was 'to do good' [108]. Over and over again, we read about study designs that treat our peers as research subjects without any agency, who are seen to depend on being conditioned to behave according to norms set by medical experts and teachers because their lives would otherwise be doomed to failure. This is emotionally difficult, feels offensive and violating, and contradicts our lived experiences as agential beings. Hence, our reading is influenced by this affective, emotional and very personal reaction towards the texts in the corpus. However, precisely because our perspective is marginalised while the perspectives of medico-therapeutic professionals as well as those of researchers and funding bodies at large dominate the discussion of which technologies are relevant to design, develop and assess in the context of ADHD, our interpretation and analysis provides an additional viewpoint to consider. We do not claim that

[25] within the limits of neoliberal academia

our reading stands for all neurodivergent people or for all people with ADHD, but it is an instance of an assessment that compliments and challenges the status quo we found in our corpora.

6 IMPLICATIONS FOR RESEARCH

Understanding existing concepts of 'users', prevalent scripts and the potentials of crip technoscience comprises only the first step for researchers to critically and equitably engage with technology research involving people with ADHD. While other researchers and even other researchers with ADHD might come to differing suggestions, we provide some guidance as to how, from our perspective, technology researchers might conduct work with this population in the future. Our recommendations start suggesting alternative ways of conceptualising ADHD and the people diagnosed with the condition from a disability studies perspective. We then propose some considerations to directly and equitably involve neurodivergent people in technology research concerning them and the exciting space opening up for critically informed technological development in this space more generally.

6.1 Conceptualising ADHD

We need to fully acknowledge that we already started from the point of view to understand ADHD not along notions of pathology but instead as a neurological variance among many neurotypes (akin to neurodiversity [32]). However, in reviewing our corpus, we find that the fundamentally dominant way in which ADHD is conceptualised is rooted in the notion of a medical deficit model of disability. This is not only a question of values and conceptual differences (albeit it is that as well), but also leads to the proliferation of plain faulty assumptions of what might support people with ADHD and, in some cases, introduces active harms.

As an example, many of the publications we surveyed aim to train the ability to focus attention on a task. The assumption here is that neurotypical modes of 'paying attention' are helpful for people with ADHD in the same way. For one, this seems to only consider distractability without acknowledging periods of intense focus during which people with ADHD find themselves so immersed in a given activity that we might even ignore bodily needs for as long as possible [82]. It is typical for people with ADHD to go into this kind of 'hyperfocus' [65, 96] once they achieve focus on a task that they are genuinely interested in. Attention thus is generally, but in particular for us, highly contextual and a given strategy that works for a specific context (e.g., building prototypes) does not readily transfer to another (e.g., writing a paper). Studies that train attention on random tasks in a lab-setting have the inherent weakness that the skills trained in this way do not transfer to other contexts and situational demand-structures, and ignore the role of motivation and goals.

Moreover, many of the interventionist and 'therapeutic' approaches as well as diagnostic technologies all play together to amplify the harm done to people with ADHD [142]. While debunked in other contexts as not only ineffective [62], but deeply harmful [98], behaviourism is still prevalent in the technologies we surveyed. The consequences thereof include a higher rate of depression among people with ADHD [34] as well as a higher rate of suicidal ideation [56]. Many of the publications surveyed focus solely on which behaviours teachers and parents (or medical experts) want to suppress in children or youth, and which to increase, working with systems of punishment, social ostracism and rewards. There is no investigation into how the objects of such procedures actually feel, how these procedures affect pupils, and what they genuinely need and want.

Essentially, we urge our professional colleagues to take up the responsibility that comes when working with marginalised groups in research. Even if researchers are lured in by the rhetorics of 'helping' and 'supporting' [43], they need to a) acknowledge the potentially harmful implications their work might have [171], b) use appreciative language that is not oriented on a presumed deficit and c) acknowledge that the people behind a supposedly 'other' group might be closer than initially assumed. We are technology researchers as well and we are deeply affected by how the field conceptualises us and our peers.

6.2 Involving Neurodivergent People as Partners in Research

People with ADHD need to be acknowledged as core stakeholders in research. We call for researchers to actively advocate with IRB and ethics committees for user-centered and participatory approaches, which empower participants and meaningfully involve them. Researchers need to provide more extensive argumentation for why ADHD children (and adults) are not at 'higher risk' as participants of a study than neurotypical children and why their active participation is indispensable for ensuring the resulting systems are adequate and improve their quality of life. The research community could contribute to this by collating examples of IRB-approved CoDesign and UCD studies with populations that typically are considered vulnerable. In that, we hope that our indication that this comprises an ethical issue through our review supports authors' arguments within their institutions.

Methodologically, we see an implication for future research in directly including people with ADHD in research about ADHD. Instead of talking about individuals (and inherently conceptualising them as not worth talking with), actively involving them is the basis for respectful and appreciative partnerships. This can, for example, happen in the form of collaborating with other researchers with ADHD, with activist organisations or, within the adequate epistemological commitments, as active participants. Fundamentally, though, and following Walker et al., we urge researchers to consider how their work and actions relate to existing power differentials and might introduce new ones, to conceptualise consent in a meaningful way for all parties involved, and to center people with ADHD in technology research and design, starting with the use of respectful and appreciative language [160]. Some examples in our corpus already started conducting such work (e.g., [27]), though such work mostly occurs in the extended corpus (i.e., in recent years) and is few and far between.

6.3 Attending to Technology

The technologies represented in our corpora largely hail from framing ADHD as a deficitary difference requiring correction and cure [28], a problem requiring a solution [15] – preferably a technical one. What is lacking, however, are technological designs that adequately

account for neurodivergence and ADHD as a mere difference [8], that attend to existing strengths, akin to ability-based design [176] and allow for self-determined engagement with technologies oriented on the populations' needs. The potential of attending to these strengths has been additionally shown by a recent interview study about the positive aspects of ADHD with successful adults with ADHD [135]. We argue, that the development of technologies oriented on supporting agency and choice provides ample research opportunities in this area that remain largely untapped. In the remainder of this section, we illustrate some of these potentials.

While it makes sense to focus on children, simply because due to their on-going development, technological research can be gratifying for researchers and funding bodies alike, we identified a significant lack of technologies for adults with ADHD. These adults include the authors of this paper and might be colleagues and collaborators. Hence, adults with ADHD can and do lead successful work lives, but might require different stimuli to work well in their areas of expertise. Additionally, technologies offering to structure daily life can be useful, but should provide flexible options to account for the individual complexities involving, for example, the care for children and/or other family members or a demanding social and/or work life.

Finally, we strongly recommend moving away from behaviourist interventions that solely aim at disciplining people with ADHD into acting more neurotypically. This has fundamentally negative impacts on their lives largely due to associated stigmas [138] as seen in increased depression [127] as well as suicide rates [57]. Similarly, technologies supporting diagnostic processes could be more humane by being oriented on providing an opportunity for supporting an individual with ADHD compared to identifying and managing them. These technologies could be oriented on the dialogical process involved in diagnosis [35], acknowledge the differences in presentation e.g., along age or gender and include strategies that support the identification and establishment of self-determined management of the condition and its presentation in a neurotypically structured world.

6.4 Gaps in Research

Next to the direct implications for ADHD technology research in general, we also identified a number of gaps that could redefine and further explore the role(s) technologies play in this context. We present only a few as a starting point for conversations about alternative approaches; this is by no means a complete list. However, it shows that beyond language use, the involvement of people with ADHD and a closer look at the discursive and material consequences technologies embody, there are core topical gaps in the knowledge production about ADHD and technologies.

Most of the works we surveyed focused on ADHD in children and even where this was not the case, often opted for young participants (i.e., children or adolescents). One (to us) glaring gap lies in the need for research involving *adults*, including especially older adults with ADHD. As adult life is typically less externally structured compared to children's lives, technologies likely would take on different roles. Additionally, children tend to be more entrenched in power structures and are attributed less agency in deciding about their technological interactions compared to adults. Hence, deliberately engaging with adults has the potential to challenge the dominant paternalistic paradigms governing much of technology research in the context of ADHD currently.

Similarly, we see potential in technologies supporting executive functioning on self-given tasks. In opposition to making people with ADHD adhere to an externally defined task regime, we suggest identifying opportunities for supporting and allowing people to figure out how to get those things done that they want to succeed at intrinsically[26]. Even though we see many strengths in our neurotypes and how they are influenced by ADHD, we also acknowledge that some difficulties could do with support; however, this should be driven by the needs and desires of people with ADHD, instead of using every technological design in this space as an opportunity for externally driven interventions.

Apropos strengths of ADHD: As mentioned above, research in our combined corpora largely configured ADHD as a deficit. Hence, these works did not consider supporting any strengths in ADHD, given these were conceptually absent. Such strengths are expressed individually for every person with ADHD and might lie in enhanced creativity, being able to make connections between on surface different areas, abstracting content or planning (for others). Given that many adults with ADHD have developed a range of strategies for coping with the demands of neurotypically shaped societies, technologies could also have a role in supporting such strategies (similar to [81] in our core corpus).

Finally, we see potential in taking a step back and looking at how people with ADHD already use and appropriate existing technologies. One example could be how they seek and distribute information on social media to create communities oriented on meaning making about themselves. There is similarly no work available trying to understand why many of the strategies working for neurotypical individuals fail ADHD people in structuring their lives (e.g., weekly calendar planning [100]).

The possibilities for such projects, considering ADHD holistically along multiple facets, involving people with lived experiences adequately, understanding technology with the potential for emancipation and attending to questions that remain open from a self-determined perspective, show us that the status quo of how technology research in the context of ADHD can be challenged. Hence, we encourage our colleagues as well as our peers (and those who fall in both categories) to contribute to actualising these possibilities – fully acknowledging that technology researchers need to build up trust first [170]. Here, we hope that our work might contribute to building a foundation to start a productive conversation.

7 CONCLUSION

We presented an analysis of works discussing technologies in the context of ADHD from the perspective of neurodivergent readers. In our results, we delineated how people with ADHD are often kept from co-producing the technologies that are proposed to assist them. We further identified that technological research largely focuses on diagnostic and interventionist approaches, with changing attitudes

[26]The language here is deliberately chosen to echo self-determination theory [36] in the spirit done for autistic people [168] and neurodivergent populations in a different technological context [153].

only appearing very recently. The discussion then illustrated the harms current research introduces by predominantly operating from a deficit model of ADHD traits. We then speculate alternatives leading to a range of recommendations we make for future works in this space. In that, we do encourage researchers to shed their commitment to neurotypical norms and engage with us and other marginalised populations not from a paternalistic but a solidaric and community oriented position.

As any, this work comes with limitations. For one, all authors of this work are white, work in the Global North and, as we indicated above, find ourselves faced with the privilege of access to a diagnosis in the context that the diagnosis also regulates societal access to accommodations. Additionally, given our position as academics, we had luck in our education to even reach this status. Hence, we do not claim to speak for all people with ADHD and can only represent ourselves in our shared analysis. Given, however, that more and more researchers openly disclose their ADHD, also within HCI, and the budding research into self-determined options for technologies in this context, we contribute a close reading of existing works and delineate the future potential such appreciative approaches have. Technologies have a space in all our lives; but if they are largely relegated to categorising and altering the behaviours of isolated groups of people, we – as technology researchers – have a responsibility to provide alternatives.

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