The Purpose of Play: How HCI Games Research Fails Neurodivergent Populations

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Play presents a popular pastime for all humans, though not all humans play alike. Subsequently, Human-Computer Interaction (HCI) Games research is increasingly concerned with the development of games that serve neurodivergent[1] players. In a critical review of 66 publications informed by Disability Studies and Self-Determination Theory, we analyse which *populations*, *research* methods, kinds of *play* and overall *purpose* goals existing games address. We find that games are largely developed for children, predominantly in a top-down approach. They tend to focus on educational and medical settings and are driven by factors extrinsic to neurodivergent interests. Existing work predominantly follows a medical model of disability, which fails to support self-determination of neurodivergent players and marginalises their opportunities for immersion. Our contribution comprises a large scale investigation into a budding area of research gaining traction with the intent to capture a status quo and identify opportunities for future work attending to differences without articulating them as deficit.

CCS Concepts: • **Social and professional topics** → **People with disabilities**; • **Applied computing** → **Computer games**; • **Human-centered computing** → *HCI theory, concepts and models*; *Interaction design theory, concepts and paradigms*; • **Software and its engineering** → Interactive games.

Additional Key Words and Phrases: games, play, neurodiversity, neurodivergence, critical review, disability, children, adults, research priorities

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1 INTRODUCTION

Digital games are widely played across society as a form of leisure, offering a pleasurable engagement with assumed beneficial consequences for the well-being of players (among others, [51, 94, 99]). However, because of their minority bodies [11], disabled players still face barriers when trying to access digital play and associated benefits, despite many organisations - including the United Nations [128] - widely recognising an individual's right to play. The Human-Computer Interaction (HCI) games research community has broadly addressed this issue from two perspectives:

[1] In line with recent research [64, 102, 112, 167] and activism [3, 163], we opt for identity first language around disability in this piece.

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(1) **Increasing Accessibility of Games More Generally**
There is a body of work that seeks to reduce barriers to commercially available games, and generally focuses on producing insights with respect to game accessibility and play experiences of disabled players. Here, we see development of specialised interaction paradigms (e.g., [82]) or input devices (e.g., experimental systems such as [72] and industry efforts such as Microsoft's Xbox Adaptive Controller[2] and Logitech's G Adaptive Gaming Kit[3]). Additionally, there is a range of projects that develop case studies that can help us understand how disabled people interact with certain kinds of games, providing implications for design (e.g., work by Yuan and Folmer [186] creating accessible versions of commercially available tangible games, and Gerling et al. [81] investigating challenges and opportunities of VR gaming for wheelchair users). Generally, there is a strong focus on physical disability within this sub-field. However, *neurodivergence often only receives superficial attention throughout implementation* (i.e., guidelines provide detailed insights [74], but implementation remains low [135]).

(2) **Efficacy of Games for Neurodivergent Populations**
We similarly find an increased interest in games for neurodivergent people within our research communities. Previous reviews have analysed the efficacy of serious games for medical and diagnostic process in neuropsychology [174], their usefulness for diagnosing and monitoring people with ADHD (Attention Deficit Hyperactivity Disorder) [46] and which non-touch motion-based games exist for autistic children [12]. More generally, recent work has also looked at games explicitly addressing 'social play', which are largely developed in a context of autistic children [156], and investigated how agency is articulated in technology for autistic children [168]. These works are augmented by more contextual deliberations around the design of games for neurodivergent populations, e.g., in museums [48] or ambient environments [95], as well as conceptual work around how we might broaden the inclusion in games and technology design [16, 20]. Hence, even though medically driven reviews and (participatory) design considerations for games catering to neurodivergent players are increasingly available, *an analysis of existing games as discursive artefacts without a lens on a specific use case from a decidedly neurodivergent perspective* complements existing works.

While game accessibility research has previously been synthesised through literature reviews (e.g., Yuan et al. [187]) and large-scale surveys among disabled players (e.g., Cairns et al. [35]), the research landscape of games that specifically target disabled players remains fragmented. There have been some efforts to summarise existing work, for example in the context of rehabilitation of physical disability [139]; however, research efforts focusing on games for neurodivergent players in particular remain under-explored. As a result, current gaps and challenges in research are unclear, and there is a lack of critical reflection on and across ongoing work and trends.

As a first step toward better understanding the body of research addressing neurodivergence, games, and play, this paper presents a structured review of games and playful systems developed by the HCI research community that specifically target neurodivergent players.

In our work, we adopt a critical, reflective perspective seeking to understand how existing work conceptualises neurodivergence, and how this affects the kinds of games that are presented along with design choices throughout system design, development, and evaluation. Here, we leverage Self-Determination Theory (SDT) [58, 151] as lens for analysis, allowing us to explore to which extent currently available games for neurodivergent populations fulfil basic psychological needs by allowing players to experience *autonomy*, *relatedness*, and *competence* [59].

[2]https://www.xbox.com/en-US/xbox-one/accessories/controllers/xbox-adaptive-controller
[3]https://www.logitechg.com/en-us/products/gamepads/adaptive-gaming-kit-accessories.html

Our results show that existing projects predominantly adopt a serious gaming perspective, and relegate play almost exclusively to externally driven purposes. Thus, games are developed to either address specific characteristics or attempt to cure individuals from neurodivergent traits that are perceived and identified as undesirable, with the majority of systems designed to be played in educational or medical settings. Additionally, our results show a strong emphasis on younger players, often children, while only few projects focus on the needs of neurodivergent adults. Likewise, while most projects included neurodivergent people in system evaluation, involvement of the target audience at the design stage remains less common. Generally, our findings show that there are only few examples of projects that seek to facilitate free, i.e., leisurely play for general audiences, the form of play most frequently enjoyed by neurotypical people. Based on these findings, we discuss the role of medicalisation and the lack of self-determination in digital games for neurodivergent audiences, and we reflect on implications for the wider accessibility of immersive play.

Through our work, we contribute a large scale investigation into the current state of the art of HCI games research concerning neurodivergent players. As the field gains traction, our analysis offers reflection across individual works and identifies gaps in existing approaches with the hope to stimulate future work serving this population. With recent work calling for HCI and design research to consider justice [6], socio-political consequences [103] and ethical implications for marginalised populations [180] more explicitly, we intend our work to offer an analytical perspective on how HCI games research serves neurodivergent populations – and how it could do so better in the future.

2 BACKGROUND

Several theories influence our review. We now illustrate our understanding of disability and the concepts we draw from in our work particularly as they relate to neurodivergence before we explore a range of approaches that have aimed to define games and play. Finally, we focus on Self-Determination Theory (SDT), a popular psychological theory employed in games research to understand why humans value play, and how it relates to neurodivergence.

2.1 Modelling Disability

Within Disability Studies, researchers differentiate a range of approaches to defining disability as a concept categorising people and their identities. Marks provided an overview of three models, namely the *medical*, the *psychological* and the *social* model of disability [117]. These (together with other ones following) are presented as an overview in Table 1.

Model	Attribution	Individual	Technologies
Medical	Individual	Pathologised	Assistive/Corrective/Diagnostic
Psychological	Individual	Pathologised	Assistive/Corrective
Social	Environmental	Difference	Accessibility/Awareness
Identity	Complex	Difference	Self-Determination

Table 1. Models of Disability, how disability is attributed, how the individual is understood and how technologies operate within this model.

The "medical model focuses on individual pathology and attempts to find ways of preventing, curing or (failing these) caring for disabled people" [117, p86]. Technologies operating from this model are focused on supporting the appropriate identification of characteristics in an individual leading to diagnosis, correcting medically presumed deficits and assisting with living in an able-normative environment.

"[P]sychology also tends to locate disability within an individual person who has failed to adjust to, and 'overcome', an impairment" [117, p87]. The main difference to the medical model above stems from an assumption that bodies and minds can be thought of as separate[4] and identified limitations within a physical bodies require solely enough 'willpower' to be addressed. Hence, this model combines neoliberal individualism with medical fixatedness [91]. Subsequently, technologies embody similarly assistive and corrective notions, though more focused on a narrative of 'overcoming'.

"In contrast to individualising approaches, the social model locates disability not in an impaired or malfunctioning body, but in an excluding and oppressive social environment" [117, p88]. Embodiments are then seen as differences that need accommodation be they temporary or permanent. Accordingly, technologies aim then at digital accessibility and increasing awareness about the way 'minority bodies' [11] experience environments designed with only majority bodies in mind (see also, [87]). However, this model has been critiqued as erasing the embodied difference as meaningful [42], though others again caution against essentialising this difference [70].

Within the subarea of critical disability studies, the boundaries of dis/ability are systematically troubled and that troubling used as a lens to think through aspects of humanity more generally [86]. Disability can then become part of one's *identity* [159] not just in the form of self-identification, but also in the form of other-identification [30]. Self-identification constitutes a political move [136], even if the category remains unstable [52]. Such a move is often also prohibited by ableism in two forms: (1) external, as a lack of safety and increased vulnerability attached to someone openly assuming an identity largely associated with weakness and failure and (2) internalised as a consequence of repeated exposure to such societal paradigms [36]. Subsequently, many people shy away from actively identifying themselves as disabled [176]. Attribution in this context is seen as a complex interplay between embodied difference and societal exclusion [160]. Technological artefacts under this model would follow a notion of self-determination in identifying needs and desires of disabled people.

2.1.1 Neurodiversity. While the previously discussed models have been developed with disability as a larger concept in mind, the concept of neurodiversity particularly addresses the notion of neurological difference. It operates from within the identity model of disability[5] but also refuses to subscribe to a clear demarcation of dis/ability [164]. The concept is most popular within the autism community and particularly there has been deemed unsuccessful so far, to move away from a rhetorics and practices of relating to binary dichotomies of belonging [150].

Generally, neurological differences are all seen as an expression of variety that human brains can take on. The majority of human brains then is *neurotypical* while some brains are diverging from these norms, hence, referred to as *neurodivergent*[6]. Dalton has illustrated how this relates to HCI and how designers might take a notion of neurodiversity into their practice [49]. Specifically, the author suggests to establish "mutual respect for different ways of being" [49, p.2302], to attend to neurodivergent people's strength in research and practice and question dominant notions of normalcy. Our work operates from within the understanding of neurodiversity and analyses works

[4]Within Disability Studies, researchers often speak of the notion of a bodymind that does not separate thinking from being and feeling (cf., e.g., [43]).

[5]It should be acknowledged that within a binary understanding of disability models as either medical or social, the concept of neurodiversity is often attributed to the latter.

[6]Note please, that no single person can be 'diverse' and, subsequently, no single person can be 'neurodiverse'. Instead, neurodiversity relates to a multitude of brain differences, similar to biodiversity (which also does not refer to a single plant or organism, for example).

according to the models of disability above while positioning disability politically, i.e. with an eye to the socio-material consequences of discursive practices [10].

2.1.2 Example conditions. While neurodiversity is most commonly referred to in the context of autism (and has been developed there as well), it can be seen as a general approach to neurological difference (e.g., [4] speaks of autism, ADHD, dyslexia and 'other brain differences'). To illustrate the range of neurodivergent conditions referred to in our corpus, we now define those that occur for context (even though our initial search went broader than that).

- *Autism* is characterised by differences in sensory processing and communication [53]. Autistic sociality expresses itself in ways neurotypical people often find difficult to engage in and expect to be altered to fit to their style [125].
- *Dyslexia* is a condition of which individuals "[report] the most frequent challenge [as] learning to decode text" [107, p.12]. Commonly, this is relayed to a neurological dysfunction, though social model analysis identifies a societal norm privileging information presented as text [113].
- *Attention Deficit Hyperactivity Disorder*[7] (ADHD), as many other conditions here, "is situational: in the same individual its expression may vary greatly from one circumstance to another" [122, p.14]. It is often exhibited through distractability, impulsiveness and hyperactivity, though individuals experience their being in the world often as 'soupy', 'made to fail' and 'overwhelming' (cf. [169]).
- *Dysgraphia* is expressed through difficulties in handwriting including personal names and drawing [101], though the condition often remains undetected due to individuals developing "clever compensations" [137].
- *Fetal Alcohol Syndrome Disorder* (FASD) describes a range of effects stemming from fetal alcohol exposure and subsequently the condition comes with a range of (usually negative) stereotypes towards individuals and their parents [7]. However, organisations as well as individuals are aiming to paint a more nuanced picture of the disability as one comprising of challenges as well as strengths [31].
- *Cerebral Palsy* (CP) is a condition usually acquired as a result of brain injury during birth resulting, commonly, in frequent spasms and associated motor difficulties [2]. Associated stigmas and stereotypes are often experienced as exclusions from school and other social occasions [111].
- *Dyspraxia* (often co-occurring with autism [63]) is the diagnostic term for differences and difficulties in motor coordination for everyday tasks. Resulting challenges in academic performance are related to a systemic mismatch not attending to these differences [67].
- *Trisomy 21* (also known as Down Syndrome) is a genetic variation where the 21st chromosome pair is a triplet. As it can be established before birth, children exhibiting the effect are often not carried to term, inciting hefty criticism of prenatal diagnostics by disability activists [165]. Differences in learning that can co-occur to a higher or lesser degree, can be accommodated using approaches from strength based pedagogy [104].

In many cases, individual diagnostics play less of a role and researchers look at specific instances of difference that their technologies could address. Hence, group labels such as cognitive, intellectual and/or learning disability are often used as general sweeps of identification. Such a move can be appropriate if stemming from an understanding of common characteristics that result in

[7] While there is tension between the notion of neurodivergent conditions as diagnosed '*dis*order', due to the lack of an otherwise shared language, we use the medical terms to describe conditions.

shared experiences and structurally equivalent assemblages, i.e. mutually dependant differences in embodiment and societal judgement [44].

The list of conditions above illustrates examples of neurodivergence and is by no means intended to be an absolute enumerations. Shared characteristics lie in differences regarding the processing of external stimuli and subsequent atypical expressions, mannerisms and/or movements. Hence, conditions such as Epilepsy, Obsessive Compulsive Disorder (OCD), (Post) Traumatic Stress Disorder ((P)TSD), Tourette's Syndrome or Dyscalculia could be equally considered neurodivergent (and have been included in our search terms). However, even though they were included in our search terms (see Section 3.1), they are not part of our final corpus which means they are not within a technologically driven research focus of games and/or play.

2.2 Generalised Definitions of Games & Play

The English language distinguishes between *games* and *play* both as nouns and verbs. Cultural analyses of these pastimes have challenged assumptions of free and voluntary play as seemingly mundane [32], attempted to structure different aspects [34], traced histories and influences between physical and digital play [61], and attended to the specificity of digital play [133].

Ludic aspects of games are also used to make everyday experiences more enjoyable and particularly supposed to support digital learning [62, 123]. However, such uses of games as purposeful have been criticised as prioritising extrinsic goals over the freedom and fun of play [19]. Particularly for children, play is an activity they *get* to do compared to activities they *have* to do [182]. In this context, previous work on technological artefacts decidedly enabling *social play* has found out that this marker is often used with neurodivergent populations [156] even though play is also deemed an inherently social human activity [33].

In this work, we take an agnostic definition of games and play. This means, we do not concern ourselves with ontological questions around the nature of these activities, but rather draw on the discursive meanings of what these mean for neurodivergent populations. In this, we contrast our analysis with prior works on generalised definitions of play and its social [33], enjoyable [32] and self-determined [182] character for majority populations.

2.3 Self-Determination Theory and Neurodivergence

Self-Determination Theory (SDT) is a psychological theory that "begins by embracing the assumption that all individuals have natural, innate, and constructive tendencies to develop an ever more elaborate and unified sense of self" [58, p5]. The psychological theory discusses different types of motivation, namely *intrinsic* motivation, the self-regulatory measures involved in *extrinsic* motivation and *amotivation* (the absence of any motivation) [151]. Ryan and Deci identify *autonomy* as a "critical element for a regulation to be integrated" [151, p73], though autonomy is not conceptualised as something asocial, but rather a means to exert control over one's well-being, as in, living one's life self-determined. Hence, this concept does not stand in opposition to *relatedness*, another core aspect of the theory referring to the notion of social belonging and community. Finally, to be assumed and to dare to walk through life with self-determination, people (and their environment) need to acknowledge their own and others *competence* to do so. The three core concepts (autonomy, relatedness and competence) fulfil "basic psychological needs" [58, p7]. Individuals' strength for each of these three needs might differ; however, "[b]ecause SDT maintains that the needs for competence, relatedness, and autonomy are basic and universal, the individual differences within the theory do not focus on the varying strength of needs but instead focus on concepts resulting from the degree to which the needs have been satisfied versus thwarted" [59, p183]. Hence, the focus is not on individual differences but rather systemic factors enabling or hindering them.

Within HCI games research, SDT has seen increasing popularity [173], most prominently in the form of the Intrinsic Motivation Inventory (IMI) and the Player Experience of Need Satisfaction (PENS) [152] questionnaires. While the IMI is concerned with motivation in immersive experiences more generally, the PENS has been specifically developed, tested and confirmed [98] in the context of digital games. Through the PENS, players can assess games according to how these are conducive to supporting the above mentioned needs. Both of them are conceptualising games as a generally positive experience leaving little room for transformative experiences in play [8] or bouts of frustration as enjoyable encounter [100] in games. Additionally, Tyack and Mekler critique how HCI games research tends to treat the theory behind SDT in a shallow way leading to potentially damaging consequences. "Indeed, the prevalence of incorrect or specious interpretations of SDT concepts and propositions is concerning – at worst, a tenuous grasp of SDT could produce misleading implications for the design and evaluation of games, play, and game-adjacent systems, with potentially adverse effects on player motivation and wellbeing" [173, p9]. We illustrate this context to make readers aware of the intersection of HCI Games research and SDT, and that in our analysis, we do not use specific games as the environment interesting to SDT but instead use the triplet of basic needs – *autonomy*, *relatedness* and *competence* – to productively engage with the overall space of games for neurodivergent people.

Here, it is important to note that SDT has also been explored in the context of disability. According to Williams, "[d]isability is not the lack of intrinsic motivations for autonomy, competence, and relatedness – it is what happens when the environment assumes a particular way of supporting these needs that is not, in fact, universal. The needs are universal. The means of support are not" [178]. For this demographic, SDT provides a powerful argument for interdependence [15] and can be seen as a theory subscribing to a social model in disability contexts. As illustrated by the prominent of use of SDT by HCI Games Research, designing enjoyable games for specific populations is expected to address aspects of intrinsic motivation particularly as they relate to autonomy, competence, and relatedness. Due to this use of SDT in both Disability Studies and prior HCI Games Research separately, we conduct our investigation at the intersection of both of these discussions.

As such, SDT offers an adequate lens for analysis for our work, allowing us to draw out how existing games research (fails to) address the basic human needs of neurodivergent players. We formulate the following main research questions (RQs) that we seek to address the previously described gap through our review:

RQ1 What perspective on neurodiversity does existing work adopt, and which neurodivergent *populations* are involved in these projects?
RQ2 What kinds of *research* methods has the HCI research community deployed games research around neurodivergent players?
RQ3 Which games are developed for neurodivergent players and for which envisioned contexts of *play*?
RQ4 What is the *purpose* of play for neurodivergent populations as embedded in these games?

3 METHOD

Our aim is to understand how game research around neurodivergent populations is shaped: Who are the target populations? How is the research conducted? Which play scenarios are envisioned? What is the purpose of play? Given the qualitative characteristics of these questions, we operate from a position of providing situated knowledges [89]. We now detail further how we constructed and analysed the corpus that builds the basis for our investigations.

3.1 Corpus Selection

As our focus was on games research within Human-Computer Interaction and therefore the design of games for neurodivergent people more generally, we limited our search to the Database provided by the ACM Digital Library Guide to Computing Literature[8], which includes a broad range of publishers and outlets. In June 2019, we allocated publications that were displayed using the following keyword combinations. We allocated the keywords by consulting other works explaining neurodiversity [5] and associated categorical language we encountered personally (directed or us or among peers identifying as neurodivergent) as well as professionally (in other publications or through encounters with medical professionals).

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(Autism "cognitive disability" "cognitive disabilities" "cognitive impairment" "cognitive impairments" "learning
disability" "learning disabilities" "learning impairment" "learning impairments" "intellectual disability"
"intellectual disabilities" "intellectual impairments" "intellectual impairment" "special needs" "developmental
disability" "developmental disabilities" "developmental impairment" "developmental impairments" "complex needs"
"complex disability" "complex disabilities" "complex impairment" "complex impairments" "down syndrome" "trisomy
21" "cerebral palsy" Asperger Dyslexia Dyscalculia Epilepsy Hyperlexia dyspraxia  ADHD "obsessive compulsive
disorder" tourette) AND (game games play)
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Note that while some of this language is not positively received within the disabled community, we chose to include them as to not exclude publications using them and biasing our sample in that regard. Our search yielded 756 initial items. We then reviewed titles and abstracts in our first sorting rounds and excluded papers that

- did not discuss a specific game (for example, by using the phrase ‘play a role’ in the abstract in applications that were not games or presenting a review of several papers themselves)
- had a different target population such as general populations or older adults with specific conditions (e.g., addressed stroke or Parkinson’s)
- were focused on different disabilities (e.g., Deaf people, physical disabilities, blindness)
- were concerned with analogue games without any digital components or
- were not in English or German (the languages the authors had sufficient comprehension of[9]).

After the first sorting round, 207 papers remained in our corpus, which we then gave a cursory read. In a second elimination phase, we excluded papers that

- were too short (less than five pages) to expect sufficient depth of treatment or explicit work in progress (including research proposals)
- discussed physical rehabilitation[10]
- were not available to us in full text (two papers in total) or
- any aspects from the first sorting rounds that became clear only in reading the full paper.

This left us with 87 papers, which we then read closely and started analysis with. However, we still excluded papers in this step that

- turned out to be explicitly preliminary
- discussed very early development stages only (i.e., pre-prototype)
- systems that were presented using language around games and play without actually presenting a game (e.g., platforms for games, simulations without any game features)

In the end, the corpus then contained 66 papers (see Tables 4, 5, 6 and 7 for an overview of the papers in the corpus along different categories of analysis as well as Figure 11 in the Appendix). These were read in detail and analysed using our questions and the following approach.

[8]https://dl.acm.org
[9]Though, all papers within the final corpus happened to be in English.
[10]This was often the case for papers concerning themselves with Cerebral Palsy.

3.2 Analysis

In reading all papers closely, we had established a set of lenses that could answer our research questions around the notions of *Population*, *Research*, *Play* and *Purpose*. In that we conducted an approach to thematic analysis that is simultaneously deductive and inductive [71]. Please note that this is a substantially different approach than that developed by Braun and Clarke [25]. The process was followed deductively, as we were already sensitised and interested in answering specific research questions and inductively as below, following the overall steps as layed out by Boyatzis [21]:

- *Sensing themes* refers to the first author reading most of the work in depth jotting down notes that allowed them to identified commonalities and contrasts between papers on a surface level.
- *Doing it reliably* was ensured by having set up a template within a spreadsheet which had to be filled for every paper and gave an additional opportunity to add overall notes. [11]
- *Developing codes* was conducted using the codebook approach by Crabtree and Miller [45], which we detail further below (see also, Figure 1).
- *Interpreting the information and themes in the context of a theory or conceptual framework* comprises the final step. We have decided to rely on theories stemming from Critical Disability Studies and Self Determination Theory (see above). This larger scale interpretation happens largely in the Discussion section.

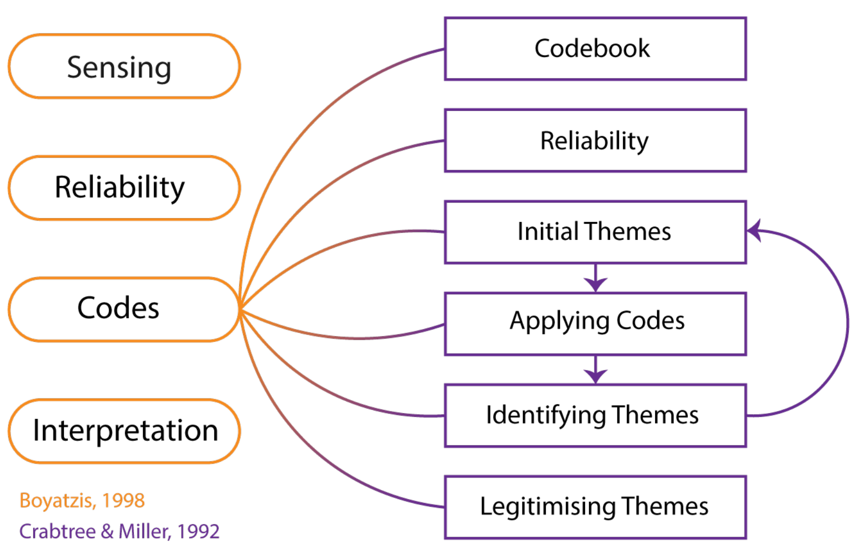

Fig. 1. Inductive and deductive thematic analysis process as conducted in this literature review

To develop a codebook and code our data reliably while being open for changes to the codebook as they might inductively constructed, we used the flexible approach offered by Crabtree and Miller [45]. It consists of the following steps, of which the ones marked with * are to be repeated to ensure consistency:

(1) *Developing a codebook:* Starting with our four research questions, we developed initial codes around *populations of interest* (diagnosis, age group and gender), *research methods* (design

[11]Interested readers can find the original analysis spreadsheet in the supplemental material.

and evaluation), *play scenarios* (location, context) as well as *purpose of play* (medical, social or self-determined).

(2) *Testing the reliability of codes:* We tested our codes with a subset of six papers and refined them further. In this stage, we added the code *language* to the population category as we noted that the papers even within this limited sample had fundamentally different ways in which they would discuss neurodivergence.
(3) *Summarising Data and identifying initial themes*:* Step 3, 4 and 5 were iterated as a loop over patches of six papers to ensure systematic check-ins with the reliability of our coding. Initial themes were labelled *dispassionate positioning to the other* and *predominantly medicalised play*.
(4) *Applying templates of codes and additional coding*:* We now applied codes as we identified them previously on batches of papers. Whenever we identified a new code (e.g., *single/multiplayer* in play scenarios), we retroactively coded all previous papers as well.
(5) *Connecting the codes and identifying themes*:* In a rolling procedure, we identified further themes as we connected codes. For example, in this stage, we developed the theme of *playing (alone) for neurotypicals*. Please note, that the higher level themes are presented as part of the discussion as they cut across categories and individual research questions.
(6) *Corroborating and legitimating coded themes:* During the write-up stage of this research, we revisited all papers and connected the prior coding with quotes to solidify our analysis.

In summary, starting with the research questions, we established initial lenses for our reading that we added upon as we were reviewing papers. The categories within each lens has been developed inductively from the material, using largely the terminology the individual papers in the corpus used. As *interpretative* approach, quality and rigour of our analysis rely on more qualitative aspects. Fereday and Muir-Cochrane refer to [158] in their assessment of reliability [71]. Relevant quality parameters are *logical consistency* as it relates to a clearly delineated presentation of the work and approach. Further, the argument should be presented coherently, in a stringent manner that can be logically followed. In that, the *subjective authorial position* also shapes the quality of analysis. Hence, we disclose to our readers that both of the authors are neurodivergent and conduct their reading from a point of lived experience. Finally, the work needs to be *adequate*; categories should be applied consistently and sensibly following a coherent scheme where deviance is appropriately traced and explained. We deem these quality characteristics to be relevant to all steps of the research and writing processes, starting with the presentation of the source material.

4 CORPUS DESCRIPTION

The final corpus consists of 66 papers overall. The papers span across 14 years starting from 2005 until 2019, when we conducted our search. In Figure 2, we illustrate how there is an overall trend in more and more papers being published surrounding notions of neurodivergent play. Given that our search took place in June 2019 and the high number of extended abstracts and short papers within our search results, we expect this development to continue for the foreseeable time. Hence, a closer look at the trends and implications of this somewhat nascent but steadily growing research field is not only timely, but of pivotal importance at this point.

Within our corpus, we deem it relevant to point out that neither *play* nor *neurodivergence* are popular as keywords. As illustrated in Table 2, authors instead choose to refer to specific diagnoses (most prominently *autism*) or prefer medical groupings (i.e., *developmental disabilities*). The only age group mentioned often enough to be specifically relevant within the corpus are *children*. In addition to identifying their target population, authors also tend to refer to games as relevant for their publications; with *serious games* playing a much more prominent role than *games* even

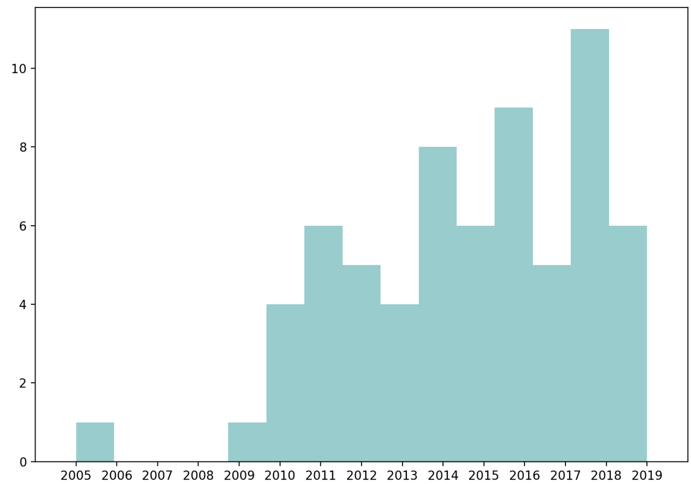

Fig. 2. Histogram for papers in the corpus along the years on which they have been published

though the former could be understood as a subset of the latter. Hence, author keywords already allow us to identify a purpose-driven understanding of play, also supported by the keyword *social interaction*, which is the only one occurring at least five times within the corpus that is not related to games or populations.

Keyword	#	%	Keyword	#	%
autism	29	43.9%	games	6	9.1%
serious games	15	22.7%	developmental disabilities	5	7.6%
children	8	12.1%	ADHD	5	7.6%
dyslexia	7	10.6%	social interaction	5	7.6%

Table 2. Keyword categories that occurred at least five times within the paper corpus.

The games in our corpus are predominantly (n=21, 31.8%) played on desktop computers, followed by mobile (including smartphone and tablet games) and tangible approaches (each n=10, 15.2%). Less than ten times, games are based on web related technologies, played on multi-touch surfaces, explicitly use virtual reality, or are positioned within multi-sensory immersive environments. Game consoles such as the Kinect or Playstation are, to our surprise, less common than we thought given the context of our search; only three out of the 66 papers (4.5%) use them explicitly as a platform. Even considering the sum of game console and virtual reality games (n=8, 12.1%), dedicated game environments play a comparatively small role in research on games for neurodivergent people. Figure 3 illustrates the distribution visually.

Within our corpus we find 39 (59.1%) conference publications and 27 (40.9%) journal papers. Most prominently represented are ACM SIGCHI conference venues (n=19, 28.8%) followed by Springer

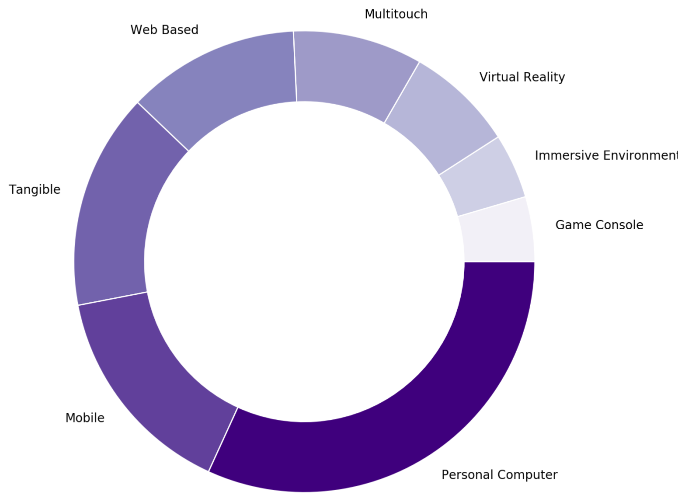

Fig. 3. Technologies used throughout papers in the corpus

(*n*=11, 16.7%) and Elsevier (*n*=8, 12.1%) journals and ACM SIGACCESS outlets (*n*=5, 7.6%). For an overview of publication venues that occurred more than once within our corpus, please consult Table 3. Notably, the most prominent venue is one that is not directly associated with notions of accessibility or disability, but rather one focused on children.

Geographically, games research surrounding neurodivergent people occurs–as per our corpus–predominantly within European countries (including the United Kingdom). Of all papers that are part of our corpus, 34 (51.5%) are European based projects, 11 of which were conducted in Spain followed by 8 in the United Kingdom. Note that authors on a paper might be located in more than one of these geographical areas; in such cases, we coded the location in which the research was conducted even if authors themselves might not come from the area. Figure 4 illustrates the spread according to world regions.

Across the 66 papers in our corpus, we have hence collated a diverse set of publications covering a range of different technological approaches as well as quite a spread regarding publication venues. While a big set of studies was conducted within European countries, the works additionally originate from all over the world albeit notably with absence from African entries within the southern hemisphere. We now more deeply investigate the implications the current state of the art in researching play for neurodivergent populations has particularly pertaining target populations, game design, notions of play and purpose thereof.

5 RESULTS/ANALYSIS

Drawing on prior work and critical lenses surrounding disability and neurodivergence, we chose to analyse the implications of a range of parameters on how the field across the 66 papers in the corpus, conceptualises play for neurodivergent players. Specifically, we look at demographic parameters that make up the target *population*, look at the design and evaluation methods that

Publication	Name	#	%
Conference	ACM Interaction Design and Children (IDC) Conference	5	7.6%
Conference	ACM SIGACCESS Conference on Computers and Accessibility (ASSETS)	4	6.1%
Conference	ACM CHI Conference on Human Factors in Computing Systems	4	6.1%
Journal	The Computer Games Journal (Springer)	2	3.0%
Conference	ACM CHI PLAY Conference	2	3.0%
Journal	Personal and Ubiquitous Computing	2	3.0%
Conference	PErvasive Technologies Related to Assistive Environments (PETRA) conference	2	3.0%
Conference	ACM Conference on Computer-Supported Cooperative Work and Social Computing	2	3.0%
Journal	Computers & Education (Elsevier)	2	3.0%
Conference	EAI International Conference on Pervasive Computing Technologies for Healthcare	2	3.0%
Journal	Entertainment Computing (Elsevier)	2	3.0%
Conference	Web for All Conference	2	3.0%
Conference	Conference on Serious Games and Applications for Health, IEEE SeGAH	2	3.0%
Conference	Brazilian Symposium on Computer Games and Digital Engagement	2	3.0%

Table 3. Publication venues occurring more than once in the corpus

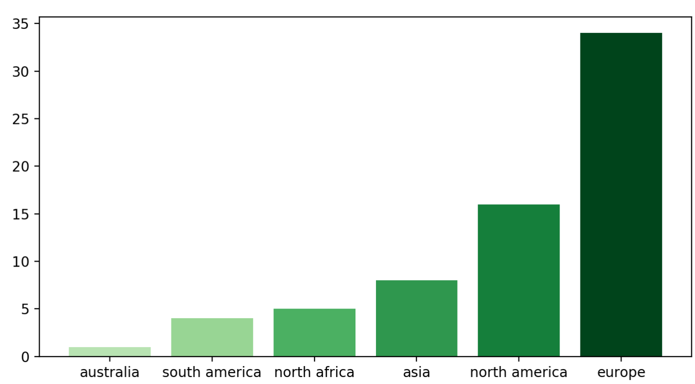

Fig. 4. Geographical spread of works on neurodivergent play

drive the associated games *research*, take a closer look on the context of *play* and then try and understand the *purpose* of the games and how they relate to different models of disability.

5.1 Population

While our search terms contained a range of different neurodivergent conditions, we illustrate here which conditions are specifically prominent within our corpus. We then augment this by a brief discussion on which age groups are present and how gender is represented. All population relevant data is captured in Table 4 as well.

Papers	Condition	Language	Age Group	Gender
[38]	autism	deficit	children	more women
[1, 41, 69, 85, 90, 97, 109, 143, 177]	|	|	|	more men
[17, 28, 77, 79, 108, 134]	|	|	|	not recorded
[14]	|	|	|	only men
[37, 124]	|	|	adolescents	only men
[172]	|	|	adults	not recorded
[115, 127, 131]	|	individual	children	not recorded
[162]	|	|	|	more men
[144–146]	|	neurodiversity	|	not recorded
[106]	cognitive	deficit	adolescents	more women
[29, 120]	|	|	|	not recorded
[50, 116]	|	|	children	more men
[170]	|	|	|	not recorded
[119]	|	social	|	more women
[183]	|	|	all	not recorded
[40]	learning	deficit	children	more women
[93]	|	|	undisclosed	more men
[26]	|	social	|	balanced
[13, 68, 78]	dyslexia	deficit	children	not recorded
[138, 141]	|	|	|	more women
[175]	|	individual	|	balanced
[23]	|	|	|	more men
[140]	|	|	children and adults	more women
[142]	|	|	|	balanced
[149, 155]	ADHD	deficit	children	not recorded
[166]	|	|	|	more men
[184]	|	|	young adults	more women
[129]	|	|	all	more men
[47]	|	individual	children	not recorded
[84]	|	social	|	|
[83]	dysgraphia	deficit	children	not recorded
[114]	FASD	deficit	children	more men
[80]	Cerebral Palsy	deficit	children	not recorded

[171]	dyspraxia	deficit	children	only men
[24]	Trisomy 21	deficit	children	not recorded
[65]	unspecified	deficit	children	not recorded
[39]	|	|	adults	more women
[66, 75]	|	|	|	more men
[22, 161]	|	individual	children	not recorded
[76]	|	neurodiversity	all	more women

Table 4. Population parameters around disability age group and gender for papers in the corpus.

5.1.1 Neurodivergence. Even though we aimed at a broad search, 40.9% of papers (27) are around a context of autism. Dyslexia (9, 13.6%) and ADHD (7, 10.6%) garnered larger interest as well, whereas Trisomy 21, Cerebral Palsy, FASD, Dyspraxia and Dysgraphia are only in the focus of one paper each (1.5%). 18 papers (27.3%) did not provide a specific diagnosis; instead 11 talked about cognitive or learning disabilities without concrete reference as to which they discussed and seven noted down otherwise unspecified 'mental illness'. Figure 5 illustrates the spread of conditions mentioned in the corpus further.

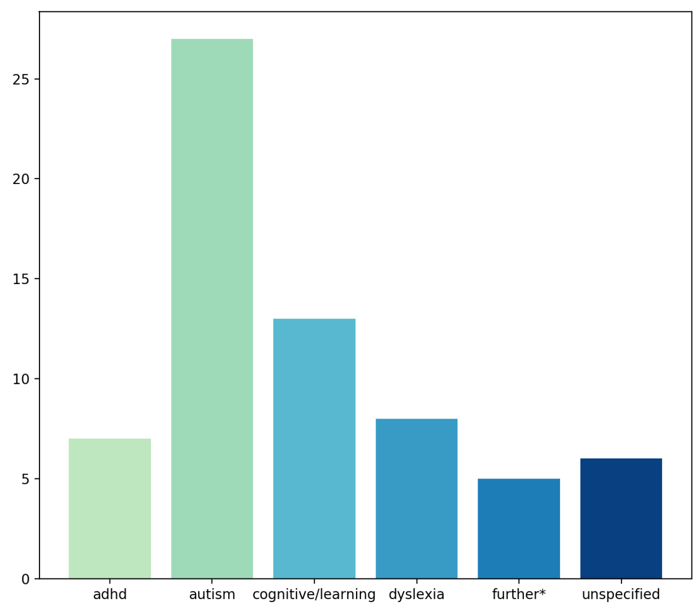

Fig. 5. Representation of different neurodivergent conditions across the corpus. Further* includes one instance for each: Trisomy 21, Cerebral Palsy, FASD, Dyspraxia and Dysgraphia

The high prevalence of autism within the corpus indicates that play for different forms of neurodivergence is of lower interest to the research community so far, and that understanding of neurodiversity remains shallowly attributed to autism [49]. In that regard, though, it should be noted that there exist quite a number of games for Cerebral Palsy, albeit most of them target motor skills and have been excluded from this specific corpus. However, the complete absence of, for example, Dyscalculia, Epilepsy, Hyperlexia, OCD or Tourette's Syndrome indicates that there is a limited understanding of the range of neurodivergent conditions that could be catered to in play as well as a clear gap for future research opportunities.

5.1.2 Description of Conditions. The language used to describe neurodivergence places the understanding largely within a medical model of disability. 58 of the papers (87.9%) use medicalised language to refer to specific conditions. Of those 47 (81.0%) papers use deficit oriented language and 11 (19.0%) describe conditions as being largely an individual responsibility to address. Papers we classified as using a deficit approach, largely used the term themselves; for example, [39, p183] state s that "Deficits in visual-motor coordination can hinder an individual's ability to perform activities of daily living (*e.g.*, getting dressed) and physical or leisure activities (*e.g.*, playing ball sports) (...)" (emphasis in the original). While this might be the case, exclusively focusing on a deficit understanding of disability hinders research to go beyond recognising disabled lives as anything but broken and an opportunity to insert technology (and games) as a matter of a quick solution. An individualised medicalised reference to neurodivergence considers, for example, that "(...) many children with autism may find it difficult to self-regulate, self-express, self-organise and to process the many sensory inputs that we receive from social and environmental interactions" [131, p2]. This understanding is still driven by a medical notion that places disability within an individual pathology; however, it also opens up the notion of difference without strictly qualifying it as deficit.

Of the remaining eight papers, four (6.1%) reference a social model and another four (6.1%) refer to a notion of neurodivergence being part of neurodiversity more generally. Referencing a social model indicates placing the disabling factors in the social environment of a disabled person; for example by indicating that "[t]he limited availability of suitable toys that can engage [disabled children] in playful activities causes deficiencies in the children's cognitive development as well as in their social relationships" [119, p216]. A paper we classified as following a notion of neurodivergence states that "[m]embers of the Autcraft community have created spaces within the virtual world and the other platforms to help even the youngest members learn to deal with these sensory needs" [145, p37]. Such phrasings acknowledge a difference without necessarily qualifying it as less, while also addressing specific needs and how they can be met individually but also as a matter of social environmental responsibility.

5.1.3 Age Distribution of Participants. As age was not always reported, we roughly allocated the number of participants in each age group as part of Figure 6. In there, it then becomes apparent that the focus of games and play research around neurodivergence lies on children and young adults with older age groups (and larger brackets) being substantially less involved. This may also be a reflection of the high prevalence of medicalised perspectives, which identify the time for intervention and therapy during childhood and adolescence.

For general age groups represented not in number of involved participants, but across instances in the corpus, 53 (80.3%) of papers contextualised games and play for children (ages 2-14), 7 (10.6%) targeted teenagers and adolescents (15-25) or adults (26-70) respectively whereas only one (1.5%) specifically included older adults (70+). Such a distribution indicates an overall infantilisation of not only play as an ageless activity but also one of disability. Given that children (including disabled children) are in a state of constant change, adaption and learning per se, this age group is fundamentally rewarding to work with particularly when aiming at showing the effect of

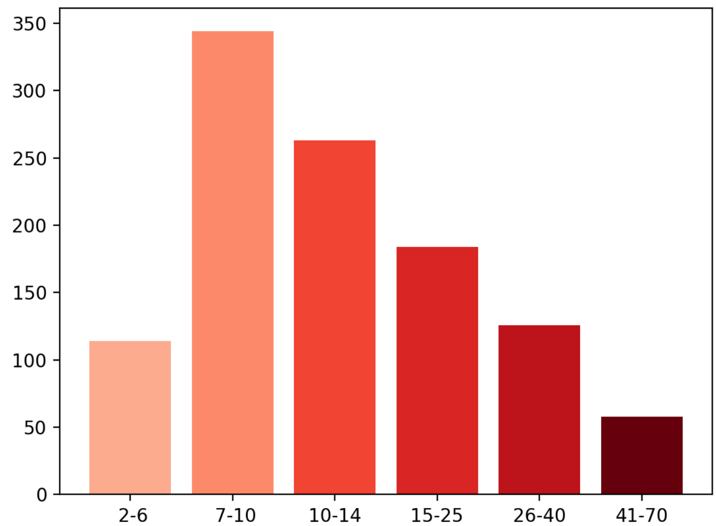

Fig. 6. Age distribution of participants across all studies within the corpus with the x-axis denoting the age groups and the y-axis providing a frequency count (per participant)

technological interventions. However, this comes with a systematic neglect of the perspectives of older generations who might be equally interested in having access to digital play that caters to their sensory processing and preferences. Here, we see a research opportunity exploring the potential of play for older groups of neurodivergent players.

5.1.4 Gender. None of the referenced studies indicated an understanding of gender that would be inclusive of non-binary and/or trans identities, although (at least for autism) gender is often a more variable identity [96] than possible within a notion of strictly binary cisnormativity. Due to this circumstance, though, we can only report within a binary notion of gender. Overall, 21 papers (31.8%) did not report the gender of their participants and nine papers (13.6%) had not conducted a study with participants. Of the remaining 36 (54.5%) of papers in the corpus, 464 women participated compared to 652 men indicating roughly a 2:3 ratio (41.6% : 58.4%). Most of the studies with participants (22, 61.1%) involved more men than women, which is also shown in Figure 7. Given how diagnostic criteria are often geared towards traditionally male-associated social expressiveness (see, e.g., for autism [88]), the overall gender ratio of participants is generally appropriate, even if still skewed in the context that gender is largely not a factor for occurrence (just for diagnosis [55]).

Whereas gender and age are largely reported within our corpus, we see little explicit reflection on other, potentially intersecting markers of identity such as racialisation or class (see for a larger critique on this issue within HCI, for example, [157]). In an understanding of unmarkedness as that of the dominant group, we have to assume that most papers include mainly white and (upper) middle-class participants insofar as class relates to the parents. For adults, this is complicated by generally prevalent unemployment and institutionalised housing.

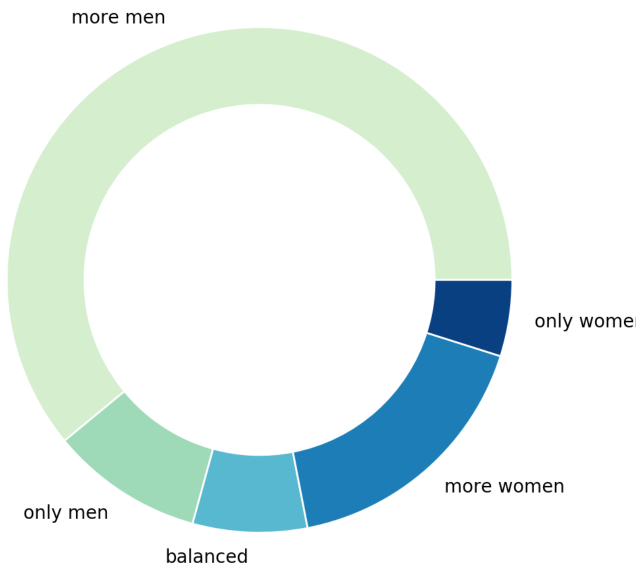

Fig. 7. Gender distribution of participants across all studies along the reported binary notions

5.2 Research

As the research methods have general implications for the knowledge we create, we now focus on the design and evaluation approaches of the papers in the corpus. In addition, Table 5 shows how we categorised each of the papers along these dimensions.

5.2.1 Design Method. Most papers within the corpus (56, 84.8%) were developed in a theoretically informed top down fashion, where systems were designed *for* rather than *with involvement of* neurodivergent players. This means that game designers drew largely on existing medically positioned works describing specific conditions to inform their designs regarding (presumed) needs and preferences of their target audience. Of those papers, six (9.1% overall) draw from commercially available games, where three of the papers all concern *Minecraft*. Of the remaining ten projects (15.2%) that actively involved relevant stakeholders, four (6.1%) actively solicited information through interviews (two) and observations (two). Note that one paper was using both interviews and observations as their source of information. Finally, six papers (9.1%) conducted participatory design (PD) in some way or another. While two of the papers conducted PD with their neurodivergent target group, two seem to not follow the method too closely and use the method without the necessary epistemological grounding. One worked with proxies and another one with 'experts', presumably neurotypically presenting ones (cf. [126]), suggesting that only eight papers in our corpus involved neurodivergent people in system design. Across publication years, we identify a slight increase of works involving lay experts either directly, via proxies, in observation or through consultation of professionals (see also, Figure 8).

We have already outlined above how game designers and researchers largely operate from within a medical model of disability when it comes to neurodivergence (See Section 5.1.2). Here, we show how they also ground their designs largely within medical literature. While observing approaches situate their designs more directly, participatory design – at least nominally – acknowledges a lived

Papers	Design	Evaluation
[24, 37, 40, 41, 65, 66, 75, 76, 78, 79, 84, 90, 93, 114, 129, 143, 166, 171, 175, 177]	top down	exploratory
[28, 38, 50, 97, 116, 161, 183]	|	observation/interview
[119]	|	field study
[14, 29, 68, 69, 106, 109, 124, 138, 140–142, 149, 155, 184]	|	controlled study
[13, 47, 83, 120, 170]	|	none
[80, 172]	|	proxies
[77]	|	heuristics
[144–146]	commercial	field study
[22]	|	exploratory
[23]	|	controlled study
[108]	|	none
[26, 39]	interviews	exploratory
[1]	observation	exploratory
[131]	|	observation/interview
[85]	proxy participation	exploratory
[162]	‘expert’ participation	|
[127]	participation	controlled study
[17, 115]	|	observation/interview
[134]	|	none

Table 5. Research approaches in papers in the corpus

experience of participants. However, within the little work that used this framing of their work, only two worked directly with the target population and none were free in allowing participants to shape the purpose or technological background of the games. Hence, there is a potential for future research to approach methods that allow for co-construction of game and play scenarios with neurodivergent populations, i.e., not only allowing them to operate within the limitations of refining given designs but also setting the scene for game development more generally in terms of genres, features and themes.

5.2.2 Evaluation. The large majority of papers reported some form of evaluation; only seven papers (10.6%) have not conducted or reported on an evaluation study yet. Researchers have used exploratory studies (including pilot testing and case studies) in 26 (39.4%) cases, followed by controlled or quasi-controlled studies aiming at experimental validation in 16 papers (24.2%) whereas observations, interviews or ethnographic field studies are found in 14 articles (21.2%). The remaining three papers (4.5%) use heuristics (i.e., largely theoretical expert evaluations) or proxy assessments to acquire knowledge about their games.

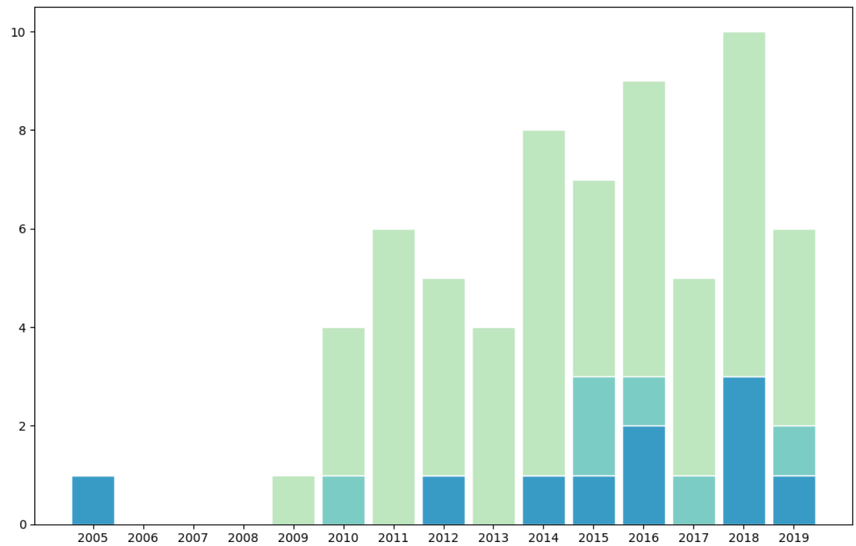

Fig. 8. Histogram of design approaches per year with green bars indicating top down design (with dark green referring to commercial games) and blue marking games with any kind of participatory involvement

The high amount of papers reporting on playtesting largely including the target audience (59, 89.4%) indicates that there is a priority within the community to report on at least some testing for the games. However, the large number of exploratory tests indicates that the resulting games are largely prototypes and less fully fledged robust generally usable games. Given comparable results of general technologies with autistic children [168], the high rate of direct inclusion of neurodivergent testers in evaluation indicates that games and play researchers in HCI are focused on gathering insights directly as well. Given the strict constraints of knowledge construction within medical research, it was surprising to us, to see how comparatively little work (24.2%) aims at experimental verification of results. Note, that we have not looked more closely on whether the evaluations hold within the paradigmatic requirements (e.g., sample size) for such research.

5.3 Play

In this section, we take a closer look at how play is conceptualised for neurodivergent populations. For this, we specifically investigate the context of play, whether games are intended to be played by oneself or with others, what the envisioned setting for play is and which genres are deemed relevant. Table 6 provides an overview of all papers within the corpus along these aspects.

5.3.1 Single/Multiplayer Scenarios. Most papers within the corpus (40, 60.6%) discuss games that are exclusively envisioned in a single player context. However, another large part (15, 22.7%) concerns multiplayer scenarios with an additional nine (13.6%) allowing flexibility for both. The remaining two (3.0%) are played within single player scenarios that are either public or explicitly observed.

The high percentage of single player games has implications for the sociality of neurodivergent people (which is often deemed deficitary within this corpus). This context furthers the medical stance that places divergence as an individual responsibility and isolates play. Given the overall high trend towards multi-player games indicated by the popularity of *Dota 2*, *League of Legends* or *World of Warcraft* and the opportunities for individually different play with others [121] as well

Papers	Players	Setting	Genre
[37, 90]	single	home	serious game
[75]	|	|	exergame
[142]	|	|	chess
[1, 38, 65, 66, 79, 83, 120, 141, 161, 166, 184]	|	therapy	serious game
[93]	|	|	therapy game
[40]	|	|	exploration
[155]	|	|	casual
[39, 124]	|	|	exergame
[13, 78, 109, 129, 140, 149]	|	doctor	serious game
[80, 138]	|	|	unspecified
[177]	|	|	toys
[22, 24, 29, 50, 68, 77, 84, 85, 97]	|	school	serious game
[106, 170]	|	workplace	serious game
[76]	multi	exhibition	exploration
[175]	|	therapy	therapy game
[17, 23, 28, 115, 116, 119, 134, 143]	|	school	serious game
[14]	|	|	puzzle
[26]	|	|	flipper
[127, 131]	|	|	exploration
[162]	|	|	unspecified
[144–146, 183]	both	home	exploration
[108, 114]	|	|	unspecified
[171]	|	therapy	therapy game
[172]	|	|	serious game
[69]	|	school	exploration
[47]	single in public	exhibition	unspecified
[41]	single with observation	therapy	unspecified

Table 6. Context of play in papers in the corpus

as the medical drive to address "social skills" [92], it is surprising that only three papers (all by the same first author) investigate a game, *Minecraft*, that allows neurodivergent players to explore sociality with others online from their home environment [147]. Other games that do include multiplayer options are envisioned to be played either in school or medical settings, and therefore provide more structured experiences. Hence, a further gap in current HCI related games and play research lies in the investigation of how to support neurodivergent socialities in play with others.

5.3.2 Setting. Table 6 shows how most multi-player games as well as a fair amount of single player games are envisioned in a school setting. Subsequently, school (23, 34.8%) is the most prominent context for play, with home or private settings only occurring in ten (15.2%) instances. However, taken together therapeutic settings (19, 28.8%) and dedicated medical environments (i.e. at a doctor's office) (9, 13.6%), make up 42.2% (28) instances of the corpus, mostly in single player settings. Further, two (3.0%) games are part of an exhibition and another two (3.0%) are part of workplace environments as part of onboarding and acquiring specific work skills (see also, Figure 9).

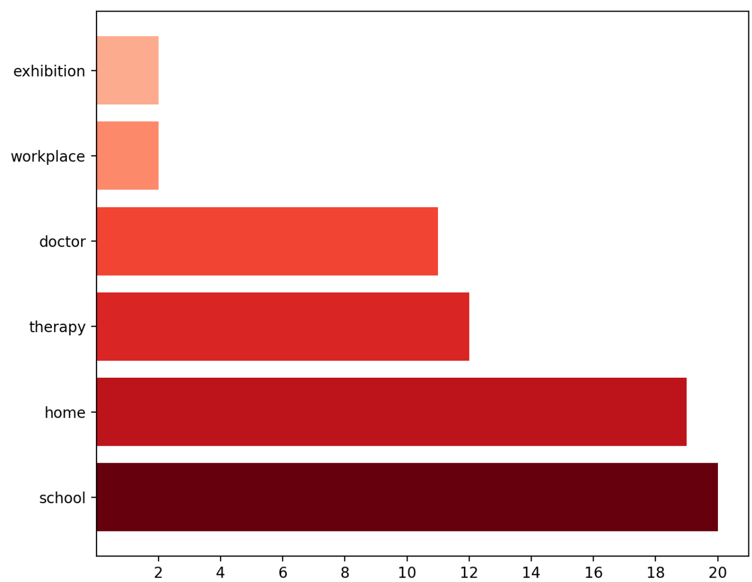

Fig. 9. Envisioned play setting of games within the corpus

Play settings, hence, further illustrate the effect of the high medical context that is part of play for neurodivergent people (see below). The high count of school based approaches directly follows from the above mentioned focus on children as the primary age group of interest. Given how many games that are intended to be part of education and school environments, it is surprising that nine of 20 papers discuss single player games. While games tend to be situated in some location or another, we identify a gap in works that span across people's lived contexts.

5.3.3 Genres. Within the corpus, most games (39, 59.1%) can be classified as "serious games", small, closed games that have a real life purpose, predominantly with educational intent (which we discuss in more detail in the following paragraph). Nine games (13.6%) follow a mode of exploration (though three of those are all papers on *Minecraft*), six (9.1%) are explicitly therapy games of which three are exergames, i.e. games that aim at motivating players to use their entire body for play. Five papers (7.6%) discuss games within a unique genre (casual game, toys, chess, puzzle, flipper). For seven games (10.6%), we were unable to specify a clear genre.

As a large proponent of the corpus, we focus here on serious games. This genre exists on a continuum ranging from purposeful software with a high degree of fun and challenging tasks to more experiential less game-driven applications [118]. The games within the corpus are predominantly short and have a high degree of playfulness, even if those might be somewhat repetitive. For example, an unnamed game for measuring attention span for children with ADHD makes ample use of game design and elements from which to infer the clinical measures [149]. *Speech Adventure* is a game for dyslexic children that is intended to be played for about ten minutes a day. Players are encouraged to give a slug commands for daily tasks by reading them out loud [66]. This is a game predominantly focused on tasks that could be understood as a game environment to the purpose with comparatively fewer 'game' elements. The unnamed game for money identification by Hassan et al. can be seen more as an simulation allowing, in this case, autistic children to practice real life skills in a safe environment that is prepared for failure [90]. The high prevalence of serious games in our corpus indicate that game development is driven by predefined notions of purpose that are deliberately part of play for neurodivergent youth.

5.4 Purpose

Given how externalised purpose is so heavily represented within our corpus, we now take a closer look at the purpose of play that researchers envision for neurodivergent players. Table 7 illustrates which model of disability applies to specific purpose groups and provides high level categories.

Model	Purpose	Papers
Medical	Therapy	[1, 38–41, 65, 66, 83, 93, 114, 120, 129, 161, 166, 171, 172]
	Diagnosis	[13, 47, 80, 109, 129, 138, 140, 149, 155, 177]
	Training	[77–79, 124, 141, 175, 184]
Social	Collaboration	[14, 17, 23, 26, 28, 69, 116, 127, 131, 134, 143, 162]
	Education	[22, 29, 37, 50, 68, 84, 85, 90, 97, 115, 119]
	Communication	[24, 65]
	Sports	[50, 75]
	Work Skills	[106, 170]
	Art & Public	[47, 76]
Self-Guided	Free Play	[108, 142, 144–146, 183]

Table 7. Purpose categorisation with papers in the corpus

Some papers span more than one purpose, sometimes even across models of disability. One such instance is the work by Craven et al. which is intended for public, artful engagement as well as envisioned within diagnostic contexts [47]. Similarly, Durango et al. incorporate simultaneously communication and therapy purposes in their game [65]. Within models, Navalyal and Gavas target therapeutic and diagnostic aspects, both part of a medicalised stance [129] and Dandashi et al. equally include educational as well as sports-related motivations [50]. Hence, the overall count of instances across purpose categories is larger than the number of papers within the corpus. Figure 10 illustrates the distribution further.

5.4.1 Medical. Almost half the papers in the corpus (32, 48.5%) are driven by a medical purpose. Of those, 16 (50.0% within medical) follow therapeutic intentions, ten (31.3% within medical) are intended to be part of diagnostic procedures and seven (21.9% within medical) towards training

Fig. 10. Purpose of play as distributed within the corpus. *Th*erapy, *D*iagnosis, *Tr*aining, *Co*llaboration, *E*ducation, *C**ommunication, *S*ports, *W*ork Skills, *A*rt & Public, *F*ree Play

(e.g., attention). The high number of instances of games incorporating a medical purpose indicates that play is understood as a means to identify (through diagnosis) and correct (through therapy and training) a perceived deficit. We now illustrate the consequences of how play is meant to serve these purposes for one paper as an example along each of the categories.

MEDIUS offers a suite of small games with *therapeutic* purpose all of which targeting different skills an autistic child is assumed to have difficulty with [1]. The authors specifically refer to PECS (Picture Exchange Communication System) approaches and ABA (Applied Behavioural Analysis) methods as informing their work–without critically contextualising the controversies, particularly surrounding ABA (cf. [105]). Context-specific, the game allows players to fail without reprimanding them until they are presumed to master a skill, although their progress is systematically recorded and reported. "The player will not be judged either by the number of failures or by the duration that puts in each scene (these information will be registered in the Data Base for the tutor)"[12] [1, p9]. Hence, the medical purpose is, apart from the setting, not made entirely transparent to the child echoing previous analyses of technologies for autistic children more generally (see [168]). In that regard, player enjoyment plays a role predominantly in how it might facilitate compliance, which is why it has to be monitored as well. "[MEDIUS is] equipped with a facial recognition part added in order to calculate a degree of concentration to know if the autistic child is interested or not in this game" [1, p3].

Li et al. also present a suite of games, though with *diagnostic* purpose, intended "to quantitatively assess children's executive functioning (EF) skills" [109, p1]. Subsequently, the authors discuss how "stimuli" are presented within the game and are interested in how reliable the data is in predicting a set of diagnostic criteria. Similar to therapeutic purposes above, the interest in players' engagement

[12]The paper calls therapists "tutors" throughout. However, the setting is clear from contextual descriptions.

is not a self-sufficient question of enjoyment, but rather an indicator on compliance in not playing but rather *finishing all elements of the game*. In this context, the authors implemented feedback loops, as their "EF game design pilots indicated that participants were more engaged into the game with those feedbacks" [109, p4]. In that regard, not just play itself, but also player involvement are relegated to the purpose of the game. Appropriation and enjoyment caused by disruption are not valued opportunities for intrinsically conceptualised playfulness in such games.

As an example for a game, with a *training* purpose, *Imagination Soccer* "is designed to motivate training, improve hand-eye coordination in 3D interaction task, and increase bodily emotion recognition ability for ASD individuals" [124, p157]. The authors investigate the effect of several customisation features on players' motivation to engage with the game. However, here as well, the extensive discussion of this feature serves a purpose that identifies said player effectively as deficient and in need of training, not as a self-determined agents (cf. for autism in particular, [178]) making informed and self-guided choices following their own interests in play.

The detailed discussions of these papers is not meant as a condemnation of those papers, rather, they are instances of a larger systemic context in which play for neurodivergent people appears to be generally purpose driven as we show above regarding the genres that are prominently represented. More than half of the papers in this corpus use notions of game and play to disguise or automate procedures that usually require highly intricate engagements of human experts even within these medical settings [54]. Diagnosis, therapy and training interventions are nigh impossible to be fully automated, and even if it would, the desire to do so casts neurodivergent people as "individuals that have to be managed", always dependent and other. It also becomes ethically questionable because a supposedly intrinsically enjoyable activity is leveraged for an extrinsic purpose.

5.4.2 Social. Overall, 29 papers (43.9%) in the corpus implicitly or explicitly follow a social model of disability, in which environments and social structures are, at least partly, seen as contributing to making an experience disabling to an individual player. Of those, twelve (41.4% within the model) are explicitly envisioned in a context of collaboration and cooperation, whereas eleven (37.9% within the model) are related to education in schools or structured learning environments. The remaining eight are equally distributed across communication, sports, work or job training as well as artful or public experiences (two/6.9% each).

For example, Boyd et al. presents *Zody*, a game that is intended to implicitly create a range of different social scenarios relevant to cooperation and *collaboration* [23]. Players solve tasks in minigames together and can use a range of interaction strategies to succeed together. Consequently, the authors state that autistic people "often experience difficulties developing social relationships (...), leading to social isolation" [23, p3:2], a description of the target population that describes an effect of different modes of interaction without making a causal interference that this is only a result of individual embodiment.

However, the description of neurodivergent populations does not always follow the context or intent of the game. As an example for an *educational* purpose Dandashi et al., propose a physical mat with pressure sensors as input for a memory game focused on teaching fundamental maths [50]. In describing their target group, though, they state that "[c]hildren with intellectual disability (ID) often have several characteristics, which hold back their development" [50, p1]. Such statements are embedded in a notion of individual pathology, even though the game itself operates within a social model of disability as it adapts learning processes to the needs of neurodivergent learners.

Games in the other categories are similarly embedding game design in a notion of altering inputs to serve neurodivergent communities and specifically develop to their needs in contrast to using games as a mode of expecting individuals to act more in line with neurotypical modes of expression. However, the purpose of these games and the specific situated support provided is largely defined by researchers and neurotypically presenting 'experts' without consciously reflected lived experience. In that regard, these games are not oriented towards play as an activity in and of itself but rather use games as a tool with the main intent of the software being external.

5.4.3 Self-Guided. Only six out of the 66 papers in the corpus (9.1%) concerned themselves with free play driven by self-guided exploration and enjoyment. Half of those (three), though, present research on the commercial game *Minecraft*.

There are subtle differences sometimes that make a game freely explorable and self guided instead of falling into either a medical or a social model of disability. The *Stomp* system Wyeth et al. present [183], for example, is similar to the pressure mat described above [50]. However, they describe their games as a range of experiences and aim to make those broadly accessible to neurodivergent players; in their own words: "Stomp afforded opportunities for experiences that would otherwise be inaccessible to service users" [183, p2:15]. While sociality and collaborations were addressed as desirable effects of play, the games are not directly focused on promoting these as an inherent purpose of play. Hence, while some might argue that the game follows a social purpose, the difference is in how the authors subtly negotiate play experiences with a notion of autonomy of neurodivergent players – of which there appears to be comparatively little work given the context of play for majority populations.

6 DISCUSSION

Individually, our analytical lenses already aided us in understanding HCI games research approaches to games for neurodivergent people. Revisiting our research questions, we can state the following:

RQ1 *What perspective on neurodiversity does existing work adopt, and which neurodivergent* POPULATIONS *are involved in these projects?*
Research in this area predominantly adopts a medical view on neurodivergence with autism being the most prominently represented condition, which indicates a limited understanding of the concept of neurodiversity overall – although reflecting a general reduction of neurodivergence to autism as prevalent in Western societies. Included in research are predominantly men, though this is to be expected given diagnostic biases of these conditions. Further, participants are predominantly children and the research largely conducted in Europe and North America.

RQ2 *What kinds of* RESEARCH *methods has the HCI research community deployed games research around neurodivergent players?*
Neurodivergent participants are in majority included only in testing, whereas the design of games is predominantly problem-centred and driven by medically defined needs regarding diagnosis or therapy as well as social expectations, e.g. regarding learning or sociality in school.

RQ3 *Which games are developed for neurodivergent players and for which envisioned contexts of* PLAY*?*
Within our corpus, games mostly envisioned a medical or educational context of play (even at home) with a stark preference for single-player scenarios. Subsequently, "serious games" are the most prominent genre[13] with other genres being much less represented.

RQ4 *What is the* PURPOSE *of play for neurodivergent populations as embedded in these games?*
Play is reduced to a vehicle of medically and socially defined aspects neurodivergent players are expected to perform. With very few exceptions, the purpose of play is to dress up activities,

[13] We are not terribly convinced that "serious games" make a genre in and of itself, though as most papers in the corpus who situated themselves as such named it as their genre, we use the term to stay close to the source material.

which are otherwise perceived as tedious, and, sometimes, even hide the original intent of play (e.g., in diagnosis).

We now detail more specifically, what the dominance of medical contexts and the subsequent lack of support for self-determined play mean for neurodivergent populations, and the implications that this has for otherwise desirable experiences in play such as immersion and enjoyment.

6.1 Medical Knowledge – Simultaneously Omnipresent and Absent

The medical model of disability is omnipresent in the papers discussing games for neurodivergent people. For one, the language used is drawing on a notion of neurodivergence as a deficit instead of a difference. Further, most research draws on medically tinted knowledge to identify opportunities for play that are deemed suitable for diagnosis, therapeutic or educationally useful. This tendency leads to three distinct issues that are present in the majority of the works we analysed:

(1) While many games are contextualised as medically appropriate, their evaluation rarely follows the strict requirements put on studies within Medicine and Psychology (see, e.g., [188]. Hence, medical knowledge is omnipresent in the argument and context for games, but HCI games research does link back to relevant domains in an appropriate way. Subsequently, the medically flavoured claims that are made about the (potential) usefulness of such games seem slightly overemphasised given the lack of rigorous testing as common in such contexts.
(2) With the medical language oriented towards a deficit, the research largely takes on an *othering* perspective [60], i.e., one where neurodivergent players are seen as a group distinct from the research group and in that "less than". With this dominance of medical arguments within the corpus also comes a biased position, one in which these medically driven othering arguments and motivations are established as an *unmarked norm* [27] other researchers and particularly junior ones are expected to follow. This makes it much more difficult to argue within concepts of disability culture and self-determination.
(3) As medicalised language is largely used rhetorically to argue for the extrinsic usefulness of games within an assumption of neurotypical readers and colleagues[14], it also ties into *solutionism* [18] – the need to "solve" any "problem" by finding technical solutions. Hence, using medical arguments, HCI games research traps itself in a rhetoric around having to identify a "cure" [43], mitigating characteristics or otherwise ensuring that neurodivergence presents itself in alignment with neurotypicality.

Taken these three issues together, the overbearing tendency towards drawing on medical arguments (without following them through methodologically or epistemologically) harms neurodivergent populations' play experiences. This does not mean that any medically oriented game is inherently problematic, rather through the dominance, the space for enjoyable and self-determined play is actively constricted.

6.2 Lack of Support for Self-Determination

As part of the Background (Section 2), we detailed core parameters of *competence*, *relatedness* and *autonomy* as they pertain to Self-Determination Theory (SDT). Each of these is differently addressed within our corpus and through different papers within the corpus.

6.2.1 Competence. This parameter is highly conducive for intrinsic motivation. "When an experience leaves one feeling and perceiving oneself to be more competent, one will be more intrinsically motivated" [56, p40]. In this regard, our corpus is very nuanced. Regarding the age level, most games are geared towards children or young adults. Hence, competency is related to this age

[14]This constitutes an assumption that is damaging and problematic in its own right, see [185].)

level and without further empirical work on the competency target populations report, there is actually little knowledge in how this trait can be supported. Further, making games too easy might counteract notions of flow [153], where competency is achieved through an ideal match corridor of skills and challenges.

What we can identify, though, is that competency is implicitly not attributed as neurodivergent populations are largely left out in contributing to the design or meaning making of games for them. Hence, competency is presumed to lie in the neurotypical assessment, evaluation and judgement, echoing questions from disability research on who can be an 'expert' on which topics [126]. Similarly, with the high amount of educationally oriented games and envisioned school settings, neurodivergent players are conceptualised as those who do not know (yet), as incompetent and in need of neurotypical assistance to become competent. On that route to achieving competency, games that adopt medicalised or educational perspectives therefore seek to challenge players in areas where they experience (actual or perceived) difficulty, rather than playing to their strengths. This could further hinder the experience of play as a positive and engaging activity supporting and strengthening competence as part of one's identity.

6.2.2 Relatedness. Another relevant factor for intrinsically motivated play comes in "relatedness, the need to feel belongingess and connectedness with others, [which] is centrally important for internalization" [151, p73]. However, within our corpus games are largely conceptualised as single-player or within social contexts that neurodivergent people have little control over (i.e., schools, doctors' offices and hospitals). The exception here is Ringland's work on *Minecraft*. Given how games dedicate little space to actual sociality, and in particular neurodivergent sociality, it seems telling that participants in their study asked "Will I Ever Be Social?" [147]. Additionally, with the persistent othering identified above, these games act as artefacts embodying a notion of difference. If neurotypical people are assumed to play with a focus on experience and enjoyment, neurodivergent play as articulated through HCI games research is markedly different in its predominant focus on purposefulness. Hence, neurodivergent populations are largely not invited to relate to their environment and create connections on their own terms but rather further reminded of how they are different to a dominant norm, how their neurotypical environment fails to relate to them as peers.

6.2.3 Autonomy. Finally, SDT theoretically conceptualises autonomy as a contributing aspect to intrinsic motivation. "Autonomy connotes an inner endorsement of one's actions, the sense that they emanate from oneself and are one's own. Autonomous action is thus chosen, but we use the term *choice* not as a cognitive concept, referring to decisions among behavioural options (...), but rather as an organismic concept anchored in the sense of a fuller, more integrated functioning" [57, p1025] (emphasis in the original). Hence, actual choice and the opportunity to exercise agency over which choice is preferred is relevant to support autonomy.

The high amount of games with diagnostic or therapeutic intent oriented towards "correcting" a perceived deficit is here counterproductive to support autonomy beyond refusal which often comes with unclear ramifications for one's safety and is even more compromised as an option for children [130]. Instead of installing play as something neurodivergent players "get to do", it becomes a tool to package what they "have to do".

6.2.4 Motivation. Within this distinction between "getting to do" and "having to do" also lies a productive difference that can guide purposeful play as well. The issue is not assigning purpose to a game or using games to tech content effectively, the issue is *who* decides for whom which aspects are relevant in play. Some of the games might very well be interesting to neurodivergent players in their own right as is, however, the envisioned settings and the way they have been developed and assess provide little to base knowledge on how that might be the case. Instead, superficial drivers of enjoyment (like high scores, simple rewards, etc.) are (sometimes) used and only to support an argument for acceptance of the externally driven play experience.

However, "by failing to provide supports for *competence*, *autonomy*, and *relatedness*, (...) socializing agents and organizations contribute to *alienation* and ill-being" [151, p74] (emphasis our own). Hence, if the named core components in SDT are not supported in play, even when it is meant to be persuasive, it will not even reach the purpose it intends to be (regardless of whether this is therapy, education, or enjoyment) and it will fail providing neurodivergent populations with play contexts that they find appropriate and desirable.

6.3 Marginalised Immersion

In our results, we illustrated how play is relayed to externally driven purposefulness. In that regard, most of the games could be understood an attempt to gamify [62] therapy and education. As previous critiques illustrated [19], though, gamification often operates from a point of uninformedness and misses out on what makes play fun and enjoyable. Similarly, general youth is already in conflict with game developers of serious games in defining what it means to be 'serious' and what constitutes a 'good' game [154]. As we cannot refer to specific analyses on the perspectives of neurodivergent players, we cannot state whether this critique holds from their perspective; though part of the issue is that this is not a question that is asked as of yet.

Playfulness as an enjoyable, self-determined, voluntary, fun, and essentially unproductive concept (as for example defined by [33]) is largely absent for neurodivergent players. Instead, the rhetorical concept of fun and games is exploited for the sake of othering neurodivergent populations further, to 'cure' them, to 'identify' them through diagnosis, to imply that their sociality and knowledge is insufficient and to use notions of inclusion while pointedly conceptualising neurodivergence as deviant from neurotypical norms. This comes with fundamental consequences communicating to neurodivergent people at large – including neurodivergent researchers as peers[15] – and research in this space needs to be careful not to fall into a trap where their existence is undesirable and abnormal [43, 73].

With respect to enjoyment and immersion in games, the tangible consequence here is that it appears to constitute a privilege for the neurotypical akin to how immersion appears to be a privilege for White people [132]. However, it does not need to be and as Ringland's work shows, asking how neurodivergent people already carve out their own places for play on their terms [144], can provide insightful answers that may guide game design for neurodivergent people with more self-determination and create opportunities for such immersion and enjoyment.

6.4 Recommendations for Future Work

With the dominant representation of medical arguments and the social model of disability largely being reduced to educational contexts, there are plenty of opportunities for games supporting self-determined play. However, it is not our intent to argue against the work that largely comprises our corpus, instead our argument is that we are missing out on additional research regarding what makes games enjoyable for neurodivergent populations and how to cater for them as well as

[15] In coding the corpus, the first author of this paper created a field for 'unfiltered' responses in which they let their emotional reaction to the papers flow freely. Some examples of these remarks include: "this is... utterly demeaning", "this is one boring ass game", "I am really tired" and only rarely comments like "actually neat for what it is". There were several moments where the researcher had to take a break from this work as the emotion work [9] connected to reading these works and parsing through the descriptions of neurodivergent people as descriptions that also refer to themselves. These are the moments when it became abundantly clear how there is a distinction made of 'us' vs 'them' and the first author not being included in that artificial 'us'.

understanding preferences and interests of neurodivergent players for more explicitly purposeful play – particularly for adults.

6.4.1 Talking about Neurodivergent Play. How we talk about populations of interest is shaped by societal constraints, but also shapes them in return. Hence, we urge HCI Games researchers concerned with neurodivergent play to reflect more deeply on the language they use. Specifically, talking about 'deficits', 'disorders' and 'developmental delays' reduces the actual people described with these terms[16] not only to their medically articulated condition, but also describes them as lacking and insufficient. Acknowledging neurodiversity as a notion of neurological variance requires us to respectfully use language that avoids stigmatisation and does not primarily focus on the minority needs (akin to 'minority bodies' [11]) of this population, essentially rendering them as incomplete and faulty. It further requires us to shift away from concepts driven by medical diagnosis and considerations of 'illness'. Seeing how dominant the medical model is within our corpus, there is a large potential in HCI related Games & Play research for work that comes from a perspective that acknowledges disability as a complex, lived difference and also conceptualises play from that perspective. The field has here a unique opportunity to shift attitudes towards disability from the starting point of design, development and evaluation as progressively aligned with disabled people's needs and perspectives.

6.4.2 Understanding Neurodivergent Play. Some of the works within our corpus already set out to understand the specificities and similarities of Neurodivergent Play compared to neurotypical play (e.g. [144, 146]). However, the field largely misses out on investigations across different genres and non-autistic notions of neurodivergence. Further, all of this work is focused on children and youth indicating that we have little to no knowledge around the play practices of neurodivergent adults. HCI Games research on critical and nuanced understandings of play and neurodivergence as a mode of neurological difference [49] with existing games can set the basis for our understanding on how potential alternatives might look like.

6.4.3 Expanding Neurodivergent Play. To break outside the largely medically dominated contexts of play explicitly attending to neurodivergent players, HCI Games researchers and designers might look to Self-Determination Theory and Critical Disability Studies to understand how they might make existing games more accessible to this population (e.g., like [114]) or taking their specific needs, desires and wishes as a starting point. As an example, we could envision research on embodied play of neurodivergent bodyminds (e.g., considering fidgeting as a resource for play) or games specifically designed with neurodivergent populations to communicate their lived experiences to larger audiences (akin to e.g., *Depression Quest*).

6.4.4 Designing Neurodivergent Play. Design research on neurodivergent play could augment, e.g., the work conducted by Robb et al., who developed considerations for participatory design with neurodivergent children [148]. However, as Linehan et al. showed, following participants' requests in game design too literally can be problematic [110]. In that regard, we suggest HCI games researchers to consider *accountability* towards neurodivergent populations, one where they are included as it pertains the expertise over their lived experiences [181] – so that they may exercise autonomy in relationships built with designers who assume them as competent – a notion, which also follows Dalton's more general call to HCI work on neurodivergence [49]. An expert advisory board consisting of neurodivergent members can potentially provide useful on-going feedback on research and design without requiring them to be continually involved or running into issues of over-fitting to a specific co-creating group of participants.

[16] Hi.

7 CONCLUSION

We started our work curious about how HCI games research conceptualises and serves neurodivergent populations drawing on a lens combining models from Disability Studies with Self-Determination Theory. Through a deductive as well as inductive thematic analysis of 66 papers, we identified four relevant parameters: *participants*, *research*, *play* and *purpose*, illustrating how neurodivergent populations are largely identified through a medical lens, excluded from design and meaning making about the games, supposed to play predominantly in medical as well as educational settings driven by an extrinsic purpose. In contextualising these four parameters we could identify how medical knowledge appears to be simultaneously omnipresent and absent and how current games fail at supporting intrinsic motivation and self-determination in this context. Instead, they prescribe an externally driven mode of play which effectively marginalises immersion and enjoyment for neurodivergent players. However, work oriented more explicitly and methodologically on the needs, preferences and desires for play of neurodivergent people could aid to closing this gap in existing works.

7.1 Limitations

What this work does not provide is a systemic review of all HCI games research concerning neurodivergent populations. Instead, our focus was on games as artefacts and their discursive properties and implications thereof. As such, our analysis comprises in-depth engagement driven by a privilege of partial perspective [89] and does not offer a systematic review. Further, our corpus has been limited to the ACM Guide to Computing Literature which means that digital games research outside of Computing that might feasibly create and discuss games for neurodivergent people was not part of our analysis. Additionally, we did not specifically investigate the graphical components of each game or their overall design. Hence, our recommendations are potentially less relevant to game designers in practice.

7.2 Future Work

As we identified above, HCI games research has largely not been concerned yet with creating games allowing self-determined play for neurodivergent people. What we envision from here is large scale work identifying the needs and preferences as articulated by the population and creating thoroughly tested games and play artefacts evaluated along player experiences. This could augment existing work on design methods with neurodivergent participants (e.g., [16]). We envision participatory processes that are oriented towards community [103] but allow for surprise from both participant sides – game designers and players. That way, future work may be oriented less towards exploiting fun for the sake of othering and instead focus on curiosity for what fun and enjoyment in games and play could mean for different people.

7.3 Contribution

Our work complements previous reviews on games for neurodivergent populations by adding a holistic perspective not driven by singular diagnoses. As such, it can be understood as following a concept of disability culture where kinship is seen in the weird and atypical. With the work being largely driven by the first author, a neurodivergent scholar themselves, our analysis further explicitly carries a perspective from within the marginalised population we researched. As such work is currently still rare within HCI generally [180] and HCI games research specifically, the collaboration of the authors comprises an act of passionate witnessing [179]. While the outcomes of our analysis might be difficult to hear particularly for those who honestly mean well for neurodivergent populations, it is our hope that it stimulates reflection and encourages researchers to delve deeper into what potentials there may lie in more neurodivergent forms of play.

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AUTHOR STATEMENT REGARDING PRIOR WORK

This paper entirely presents original work that has not been published or submitted elsewhere.

A PRISMA-STYLE FLOWCHART OF CORPUS SELECTION

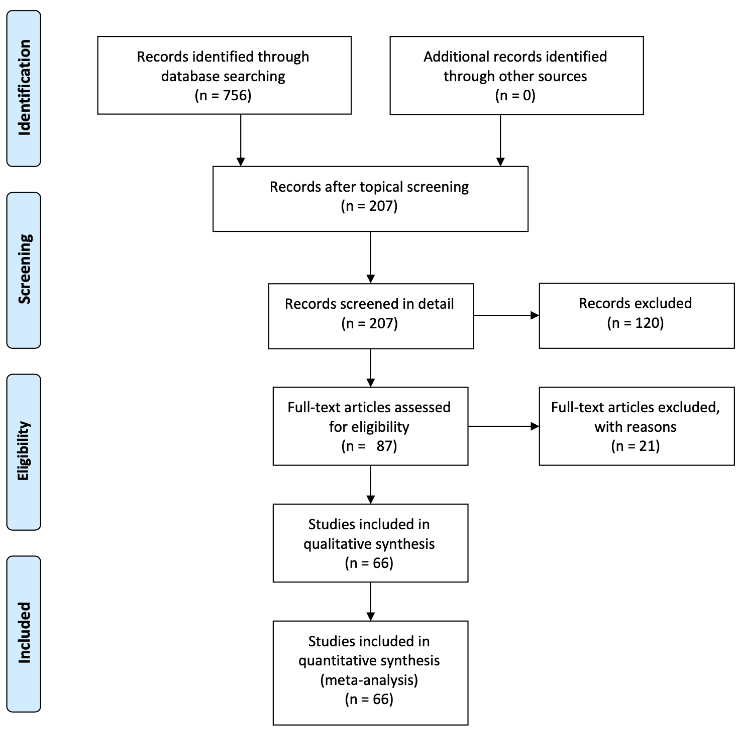

Fig. 11. Prisma-Style Flowchart of Corpus Selection

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