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Collaborative Design through Play for Children with ADHD and Peers: an Exploratory Study

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Abstract. While diverse initiatives promote technology design as an empowering tool for children, few consider those with attention-deficit or hyperactivity-disorder (ADHD) in technology design. So far, research has focused on children with ADHD as users of technology designed to manage or correct their behaviours. A recent research line instead tries including them in the initial design of technology with their peers. This paper considers how to use the potential of games to engage children with ADHD as co-designers alongside their peers, fostering their participation in shaping their own technology. It presents a version of a board game of cards, CoDePlay4ADHD, which invited a child with ADHD and three of his peers to design simple smart technologies together, e.g., smart bracelets that react to a change in temperature with light effects. The paper presents the main game elements and gameplay of CoDePlay4ADHD to foster collaborative behaviours. It analyses and discusses the results of a workshop with the four children. It concludes discussing the main findings for future editions of game-based design or similar initiatives for engaging children with ADHD and their peers in collaborative technology design.

Keywords: game, inclusion, ADHD, children, collaborative, design, computing.

1 Introduction

1.1 Background and Motivation

The Human-Computer Interaction (HCI) community has increasingly focused on technologies for neurodivergent individuals, particularly autistic people, e.g., [32]. Little attention has been paid so far to children with Attention-Deficit or Hyperactivity-Disorder (ADHD) and their well-being. Technologies for the well-being of children with ADHD often focus on managing their functioning or behaviour within the medical model. These include technologies for executive function training, behaviour regulation, and routine creation. However, it is important to go beyond activities with technologies that promote solely the management or containment of behaviours or ways of functioning associated with ADHD [34].

Recently, scholars have begun to move away from a purely clinical perspective on technology-based activities for individuals with ADHD and to explore ways to improve theirwell-being overall. Strefanidi et al., for instance, have identified “communication and reflection as key concepts for empowering and promoting the well-being of children with ADHD and their care ecosystem”, thus contributing to initial guidelines for the design of activities children with ADHD and their care ecosystem, which target their well-being [34].

In line with recent calls to adopt the neurodiversity paradigm [36], this study frames ADHD not as a deficit to be managed but as a different way of experiencing the world that requires inclusive, enabling contexts. Rather than focusing on behavioural correction, our work explores how technology design can serve as a means for neurodivergent children to express creativity, agency, and collaboration. We acknowledge that inclusive co-design approaches for children with ADHD remain rare, and our study contributes to this emerging direction by embracing compassionate and neuroaffirmative educational strategies [36, 8].

Peers are part of the care ecosystem of children with ADHD. A possible way forward is thus to engage children with ADHD in the design of technologies with peers, to foster their communication skills, and to avoid the risk that “the beneficiaries of these technologies […] become a secondary audience to the largely externally defined purposes”, as it happened in the past with autistic individuals [32].

However, engaging children with ADHD and peers in collaborative technology design presents unique challenges. children with ADHD’s tendency towards restlessness and difficulty maintaining focus can hinder their participation in extended design processes [4, 26]. Moreover, their distinct characteristics may require specific collaborative strategies, particularly within heterogeneous learning contexts [22, 34].

1.2 Research Challenge, Methodology and Contribution

The work presented in this paper aims at contributing to research concerning technology-based activities for the well-being of children with ADHD and their peers. It addresses the following specific *challenge*:

> *How to engage children with ADHD in collaborative technology design alongside their peers.*

qBuilding upon existing research on collaborative design utilizing cards and games, it proposes a novel approach: a board game incorporating cards and technology to facilitate the design of simple smart things, such as smart bracelets that respond to children's movements with amusing sound effects [16]. q

The game is developed by embracing the Research through Design (RtD) methodology [39]. RtD is particularly well-suited for addressing under-constrained challenges, such as the one of this paper, as it emphasises the power of prototypes to drive innovation and understanding. While RtD is a well-established methodology in HCI, its application to design practices involving children with ADHD remains limited. Our work contributes to this gap by exploring how RtD can be used not only to design with, but also through, neurodivergent perspectives—supporting agency and creativity in mixed-neurotype groups.

This paper delves into the design of CoDePlay4ADHD, a specific iteration of the board game featuring cards and embeddable programmable devices. CoDePlay4ADHD draws inspiration from the IoTgo toolkit, which aimed at fostering social digital well-being among young generations [15].

After extensively testing initial prototypes of CoDePlay4ADHD with design experts and in university HCI initiatives, besides with individuals with ADHD, proxies and peers, CoDePlay4ADHD was revised and played by 4 children, aged 7–12 years, and one adult. One of the players, aged 11, is ADHD. Together, they played and experienced parts of the design process of simple smart things. Analysis of the data collected indicates which elements of the game promoted collaboration between the players as well as their self-esteem. The results reported here concern especially how the child with ADHD played the game and how the child interacted with peers in the game.

The conclusions of the paper critically analyse which aspects of the process could be improved, exploring the reasons for these changes and proposing actionable strategies for implementation. Through this analysis, the paper aims at <to the advancement of guidelines for designing activities that effectively engage children with ADHD and their peers. These guidelines will serve as a valuable resource for practitioners and researchers seeking to leverage technology-driven design for the well-being of children with ADHD and their support network, including peers.

2 Related Work

2.1 Relevant ADHD Characteristics for Technology Design

Designing technologies is often considered an empowering opportunity for all children [14, 15]. Due to their characteristics, the design of technologies has so far involved children with ADHD in a few design phases, if any [9, 12, 23]. Until now, they have mainly been involved as informants or testers in the relative initial and final phases of the design process and often in an individual rather than collaborative manner.

Engaging children with ADHD in a prolonged activity as technology design can be, fostering collaboration, means considering their needs. In particular, they will tend to need breaks and relax times to conclude design tasks. They will need a quick and rapid feedback to avoid disengagement. Moreover, they will tend to prefer a hands-on experiential approach to tasks [27, 34].

When children with ADHD conduct an activity, they can easily get distracted or restless and not conclude it, and it is not unusual to have support teachers with them in mainstream schools [22, 25, 29]. However, recent studies show that, when in need of support, children with ADHD tend to relate better to peers than adults [13, 22]. This has also been mostly demonstrated with neurodivergent children such as autistic children, whom most studies focus on [7]. That said, McDougal et al. suggest that working in small groups or pairs allows also children with ADHD to learn by imitating their peers, who can stimulate ideas and provide information [22]. Hamilton and Petty also suggest that planned breaks and switching between tasks might be effective in the educational context. Acknowledging and accepting the differences in students might also reduce anxiety in classrooms and foster self-compassion in students, within the so-called "compassionate pedagogy" context [17].

Considering that, to engage children with ADHD in technology design collaboratively, some studies suggest both individual and collaborative design actions, also to enhance their social skills, pertaining to communication [7, 22, 36].

Several studies suggest employing specific collaboration techniques besides mutual support [19, 20, 24]. Others suggest, generically, employing "play strategies" as well as the use of tangible elements to enhance the design experience of those with ADHD [31, 29, 35]. Moreover, it is important to use repetitive positive feedback when working with students with ADHD as they learn more through it [10]. Therefore, peer support besides adult support, making, tangible or game elements in design emerge as viable strategies for including children with ADHD in collaborative technology design [11, 22].

Furthermore, we extend prior work by applying these inclusive principles specifically to collaborative technology design—an area less explored than individual engagement or therapeutic applications. We also incorporate design principles identified in prior ADHD-focused game research, such as providing immediate feedback, task variety, and multi-sensory stimuli [38, 39].

Moreover, design principles from ADHD-focused game design (e.g. 2, 10) highlight the importance of rapid feedback, multimodal interaction, and reward structures. These insights informed the development of CoDePlay4ADHD's game elements like character cards and dynamic interactions.

Interaction Design and Architecture(s) Journal - IxD&A, N.66, 2025, pp. 85 - 104
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2.2 Collaboration in Board Games

The Mechanics-Dynamics-Aesthetics framework has been often used to design digital games [18]. The research work presented in this paper instead frames CoDePlay4ADHD around the game design document by Adams, which is more general and hence better suited to collaborative board games like CoDePlay4ADHD [1].

Designing a collaborative game requires to clearly articulate what collaboration means. The concept of collaboration in games, however, is still debated [30]. Recent work has conceptualised it in the context of digital game design [5, 6].

The Collaborative Interaction framework, based on Activity Theory (AT), has been used to conceptualise and analyse collaboration during play. Our analysis draws on Bardram's Collaborative Interaction framework [3], which identifies the following three lenses as distinct yet interrelated collaboration lenses:

- *coordination*, that is, the interaction between individual subjects and the mediating object to serve an overarching shared goal (subject-object relation);
- *cooperation*, that is, intersubject interaction mediated by the object (subject-object-subject relation);
- *reflective communication*, that is, redefining the object, reformulating the problem, re-conceptualising roles, rules, or routines, and changing or transforming practice.

We operationalised these by observing both verbal exchanges and physical behaviours, such as turn-taking and joint decision-making, consistent with research on neurodivergent interaction dynamics, which stresses the value of behavioural observation over self-report in design-based tasks [37]. Observable indicators such as turn-taking, co-strategising, and voluntary resource sharing were defined prior to coding, but additional themes emerged inductively. This lens provided a structure for interpreting gameplay dynamics, guiding our thematic analysis.

The research work presented in this paper analyses the gameplay of CoDePlay4ADHD by taking inspiration from this conceptualisation of collaboration. However, in analysing the gameplay, players' behaviours are mainly considered instead of relying only dialogues, in line with the literature related to children with ADHD: ADHD experts, in fact, emphasise the importance of observing children with ADHD rather than relying on what they say when tackling tasks [37].

3 The CoDePlay4ADHD Game Design

CoDePlay4ADHD is a collaborative card-based board game. The goal of CoDePlay4ADHD is to engage children with ADHD and their peers, from primary school and the first years of middle school. It invites them to collaboratively explore what smart things are and how to prototype their ideas of smart things quickly.

Its design is inspired by IoTgo and similar game-based toolkits, which support and guide especially young people in rapid prototyping smart things for their well-being [14, 15, 16]. It is also inspired by the design of children's computational toys and kits [38], and popular card-based entertainment games like Munchkin [21]. CoDePlay4ADHD introduces a distinct focus on narrative-driven collaboration. Rather than supporting rapid prototyping alone, it centres on character identity, social negotiation, and shared decision-making, offering an inclusive experience.

CoDePlay4ADHD evolved through the literature analysis briefly reported above, studies with design experts, individuals with ADHD, proxies, peers and in university HCI initiatives. The workshop reported in this paper is centered around a version of CoDePlay4ADHD for 7–12 years-old children, including a child with ADHD, playing together. The CoDePlay4ADHD game comes with a board, decks of play cards, and embeddable programmable boards with onboard input and output devices, illustrated in Figure 1.

CoDePlay4ADHD requires a *game master*, experienced in smart-thing design. She or he invites players to design collaboratively. *Players* can be 2–6 children. Ideally, players should have all similar experience in smart-thing design.

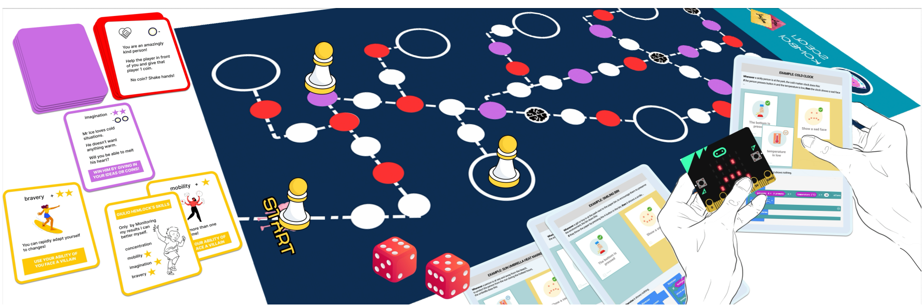

Fig. 1. Playing with CoDePlay4ADHD to design simple smart things

The *game board consists of a path* with colored spots for cards, and for players to move their pawns by throwing dices. The game and its board are structured into two main progressive *levels,* part of the design process, explained in the following.

3.1 Exploring

At the *start* of the game, the master randomly assigns each player a character card and a pawn to place on the start spot on the board. During the gameplay, players *take turns in rolling the dice and advancing their pawns* on the board, where they *face obstacles for their characters: unexpected event* and *villain cards*. To face them, players can use different *ability cards* to boost their characters.

This level *ends* when players have all *ideated* smart things *for their characters* and have reached the border of the board. Details on the design of play cards follows.

Character cards portray personas. See for instance the two left-most images in Figure 2. On the front side, they group four characteristics often associated with children with ADHD, and portray them as abilities (e.g., relentlessness as bravery). Each card represents the initial degree of each ability with *stars*; in case the number of stars is 0 then the character may need to boost such ability during the gameplay. For instance, the left-most character card in Figure 2 has 2 stars for mobility and 1 for bravery, whereas the other abilities have 0 stars and may need further boosting. On the back side of a character card are the character's two things (e.g., backpack, glasses in Figure 2) that the character desires to be made smart.

Ability cards present ways to boost abilities of characters when facing obstacles; see the middle yellow card in Figure 2 for an example. As explained above, obstacles are unexpected events and villain cards.

Unexpected event cards also consider the characteristics of children with ADHD and embed them in the gameplay. For instance, some children could be hyperactive and need to move frequently. Thus, the *unexpected event card* in Figure 2 asks to move or the player with the unexpected event card to exchange an ability card with another. In so doing, players are invited to collaborate on shared strategies (e.g., moving versus exchanging an ability). The card, moreover, enables children with ADHD to satisfy their need to move and collaborate strategically with others. Unexpected event cards, in general, enable players to acquire or lose abilities for their characters, and foster collaborative play.

A *villain card* features a villain to defeat. Each villain card is similarly structured with abilities and stars as character cards are. See the right-most image in Figure 2, with the Mr Ice villain. To win villains, players must put together and share their stars for their characters. Together, they need to decide if to ally and fight or flee. Together with unexpected event cards, they invite children with ADHD to be strategic and take risky initiatives together with others.

Challenge and *ideation cards* invite players, respectively, to discover how the provided microcontroller works and makes a thing smart, and to ideate their own smart things. In other words, challenge cards, during gameplay, enable players to learn smart things by experiencing and reading of them; see an example in Figure

Interaction Design and Architecture(s) Journal - IxD&A, N.66, 2025, pp. 85 - 104
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3. Ideation cards, placed at the end of the game board, ask players to imagine their own smart things, starting from the challenge cards they have all experienced.

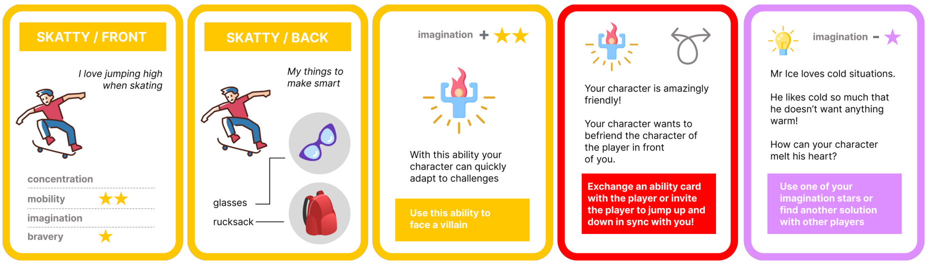

Fig. 2. Relevant game cards

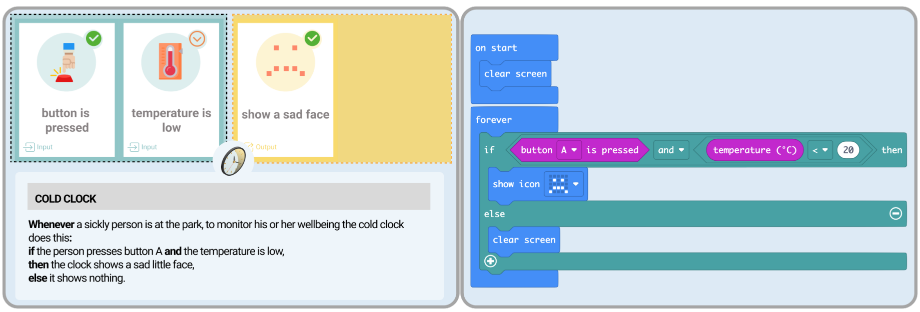

Fig. 3. Relevant part of a challenge card.

3.2 Prototyping

Upon reaching the border of the board, players are **challenged** to prototype their smart-thing ideas. They can select a challenge card that they have experienced during the first level and that best aligns with their idea for their characters. They can adjust its program, input and output devices with the assistance of the game master.

The game terminates when the **winning** condition is reached: each player has prototyped his or her own smart thing.

4 Workshop

4.1 Context, Participants and Protocol

A workshop with CoDePlay4ADHD was held in January 2024 at an after-school meeting for children. It lasted 1 hour and an half circa. Four 7–12 years-old children voluntarily participated in it: three males (ID1, 7 years old; ID2, 12 years old; the child with ADHD, 11 years old), and one female (ID4, 12 years old). Their parents authorised their participation via consent forms, and the data processing was approved by the ethical committee of the Free University of Bozen-Bolzano. The workshop was run by a researcher familiar with the meeting location, expert of interaction design and children. She acted as moderator and game master.

Ethical procedures adhered to standard guidelines: informed consent was obtained from parents, who received full information about the study aims and procedure. Children were briefed in child-friendly language, and their verbal assent was requested before and during the session.

The protocol closely followed the CoDePlay4ADHD gameplay, explained above. In other words, the protocol started by asking players to collaborate in exploring components of smart things. Then players were invited to choose challenge cards that best match their ideas of smart things for their characters and adjust the related implementations with the help of the game master, if needed.

4.2 Leading Research Question and Data Processing

The overall goal of the workshop was to understand whether CoDePlay4ADHD helped children collaborate in smart-thing design. The leading research question was as follows:

> *Does the game foster collaboration between the child with ADHD and his peers in the design process?*

Our qualitative methodology was grounded in a bottom-up thematic analysis. Both the participant researcher and a second coder independently analysed the video recordings and diary entries, identifying behaviours in relation to Bardram's collaboration lenses. Indicative behaviours for each lens (e.g., turn-taking, resource sharing) were defined in advance, while remaining open to emergent patterns through inductive coding. Coding discrepancies were resolved through joint discussions and video re-examination, strengthening the validity and rigour of the analysis.

5 Results

In the following, the main results of data processing are thematically reported in relation to the game and the leading research question. The themes are discussed through the lens of Bardram's framework, with examples of coordination, cooperation, and reflective communication drawn from the children's observed interactions.

5.1 Board

The board game provided opportunities for players to mainly interact in a coordinated manner and autonomously reflect on roles, e.g., ID2 and ID4 often took on the role of assisting others in moving their pawns to follow the rules of the game correctly.

5.2 Character and Ability Cards

All players cooperated, combining the stars of their character and ability cards. Only the player with ADHD initially reacted in the opposite way. He avoided sharing stars for fear of losing them. Then, he started to cooperate, encouraging other players to negotiate and share stars. They also took turns reading aloud their characters' details. By following the instructions on the cards, players could coordinate and follow the gameplay, respecting other players' turns and reflect jointly, communicating strategies related to ability cards.

5.3 Villain Cards

The villain cards allowed players to cooperate and communicate reflectively, offering autonomy in individual decisions and collaboration in strategic choices, therefore encouraging mutual support. For example, villain cards encouraged players to cooperate, forming alliances based on star possession and their sharing. All players decided to cooperate and support each other, autonomously deciding whether to share the available resources or not.

Notably, the player with ADHD offered support to a peer. The child with ADHD tended to attribute to ID2 a guiding role. Subsequently, the child with ADHD, who had been initially hesitant about relinquishing his game resources, started proposing cooperative solutions to include his peers, ID2. Thereby, he shifted his game strategy accordingly, to include ID2.

5.4 Unexpected Event Cards

Unexpected event cards promoted coordinated interactions via resource sharing and actions that shortly interrupted the game's flow but resulted in an engaging experience. For instance, ID2 drew an unexpected event card that forced him to exchange his ability cards with another player: ID2 chose to do so with the Player with ADHD, who was lost in observing the board and refocused when ID2 called him.

Subsequently, the player with ADHD picked another card that required him to move around the table. When he finished, ID2 congratulated him by kindly touching his head and the player with ADHD reacted enthusiastically. Then, ID2 reflected that he had thought that unexpected event cards were all like punishments, and hence reinterpret them: the play resumed, with ID1 and ID2 eagerly raising their hands to roll the dice and face unexpected event cards.

5.5 Challenge Cards

After consulting their challenge cards, all players interacted co-ordinately with each one in turn and the programmable board running what represented on the card. The player with ADHD was in trouble with the first challenge card, also after reading it twice; this used an accelerometer as input, for triggering the interaction.

With the help of other players, in a cooperative collaboration act, he managed to interact with the programmable board correctly, as represented on the card. Later, when he faced a challenge card using a noise sensor as input, the player with ADHD did not read the card and started shacking the programmable board, as he had done in the previous challenge. In a cooperative manner, ID2 pointed the player with ADHD's attention towards the challenge card and the input this used. The player with ADHD reacted by bringing the programmable board closer and shouting. When he realised that this was the correct interaction, he smiled and repeated his action softly, testing and joyfully experiencing it several times, searching for ID2's complicity.

5.6 Ideation Cards and Prototyping

All players initially appeared disoriented in sketching their smart thing ideas; however, their engagement grew as they realised that they could use challenge cards as scaffolding examples, redefining the game's rules based on reflective communication. All players but the player with ADHD cooperatively finalised their ideas and endeavoured to find a challenge card that best matched their idea and the character's desire.

Interaction Design and Architecture(s) Journal - IxD&A, N.66, 2025, pp. 85 - 104
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The child with ADHD struggled to ideate, probably feeling ignored by his peers who were busy with their sketching; he struggled to choose a challenge card for his character card. He abandoned the game for circa 10 minutes. However, he decided to return to the game to conclude it. He verbally communicated his idea and prototyped it with the help of the game master. With the game master, he selected an appropriate challenge card to replicate and then successfully programmed his idea.

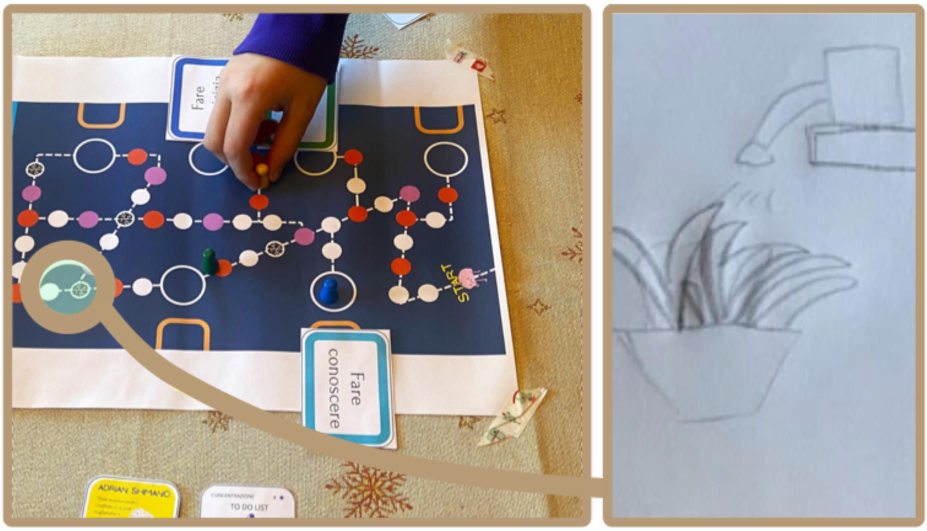

Fig. 4. Left: children play with CoDePlay4ADHD. Right: the sketch of a smart thing idea.

6 Discussion

To revisit existing guidelines or refine them for designing games like CoDePlay4ADHD, the results above related to collaboration are discussed and reflected upon in the following, considering the most relevant related literature.

6.1 Shared Obstacles for Cooperative Strategies

Baykal et al. argue that shared obstacles foster intersubject solidarity by emphasising cooperative interactions. They note that solidarity is dependent upon children's roles and limited resources, prompting players to strategize their actions [5]. The results of the reported study, related to character and ability cards (see Subsection

5.2), sustain *that shared obstacles foster cooperative strategies* that continue in the gameplay, but that can happen *independently of the availability of resources*. Initially, the scarcity of resources in CoDePlay4ADHD did indeed encourage players to share or give up their ability cards' stars, fostering cooperation interactions. Players then continued to cooperate strategically, even after acquiring sufficiently many resources to play individually. This suggests that participant children decided to continue adopting a cooperation strategy once experiencing it, regardless of the chance that others could acquire more resources than they had got.

6.2 Negotiation for Reflective Communication

A collaborative game was developed by Bei et al. for children with autism, with elements that encourage negotiation [7]. Bei et al. suggest that negotiation strategies around such elements improved cooperative acts among peers. The inclusion of similar elements in CoDePlay4ADHD, in the form of ability and villain cards (see Subsections 5.2 and 5.3), led indeed to cooperation in playing. Moreover, in the CoDePlay4ADHD gameplay, players not only cooperated but, at times, reflected on the strategies to adopt. Specifically, *strategies around cards to negotiate became a key means of promoting cooperative interactions* among peers and the child with ADHD by fostering *reflective communications* about the choice of the most inclusive strategy to adopt. These strategies provided players opportunities to communicate and discuss, share their opinions, and consider those of others.

6.3 Autonomous versus Supported Cooperative Decision-Making

Players had to decide if to collaborate when they picked villain cards. They consistently chose to cooperate and support each other, autonomously deciding whether to share resources; notably, the player with ADHD offered support to a peer (see Subsection 5.3). McDougal et al. and De La Guía et al. emphasise the importance of giving children with ADHD more autonomy in deciding whether to cooperate with peers or play cly. This seems crucial for facilitating spontaneous interactions with children with ADHD. This is indeed an aspect that is increasingly considered in schools to facilitate children with ADHD who struggle in socialising or making friends [11, 22]. In contrast to Benton et al.'s advocacy for a supportive adult presence during the entire design process, this study aligns with Fekete et al.'s recommendations: the study hereby reported underlines the importance of *enabling children a certain degree of autonomy related to cooperative decision-making, prompting a reassessment of the necessity of constant adult support* [12].

Interaction Design and Architecture(s) Journal - IxD&A, N.66, 2025, pp. 85 - 104
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6.4 Coordination and Self-Reflection on Roles

This study's results indicate that players autonomously assumed different roles, particularly when they interacted with the game board (see Subsection 5.1) and villain cards (see Subsection 5.3). In Bei et al.'s collaboration model, which evaluates players' roles across 4 levels, autistic children initially recognised and subsequently chose their roles through mutual planning. However, they tended to control both roles during gameplay, limiting collaborative interactions [7]. In contrast, children using CoDePlay4ADHD, self-assigned roles to interact with others coordinately, mainly driven by a desire to enforce game rules as well as correct their actions, e.g., moving their pawn on the board. It is thus recommended to design game elements and the board itself to enable for some forms of *coordination and self-reflection on roles.*

6.5 Unexpected Breaks and Movement for Coordinated Gameplay

In heterogeneous contexts, such as schools, children with ADHD's teachers identified various strategies to meet the needs of their learners. One significant approach they mention is the importance of "allowing children with ADHD to move freely and giving them errands to perform as movement breaks" [22]. Recent research emphasises the necessity of focusing not only on the needs but also on the desires of children with ADHD [29], while others suggest focusing on play as a tool to promote children's involvement [35]. In CoDePlay4ADHD*, game elements,* such as the unexpected event cards, *enabled players to move and take breaks, momentarily shifting their attention before returning to the game* (see Subsection 5.4). They also allowed players to exchange their resources through *coordinated interactions.* Overall, such game elements not only prevented downtimes during the gameplay, motivating the child with ADHD to fulfill the requests of the drawn card, but also fostered coordinated interactions through, for example, the exchange of cards.

6.6 Fun for Reflective Communication and Self-Esteem

When the player with ADHD picked a fun unexpected event card, he reacted enthusiastically, engaging all participants with a positive attitude towards such game element, and earning recognition from the group (see Subsection 5.4). After that moment, all players became enthusiastic and interested whenever someone drew one of these cards. In line with Bardram's concept of reflective communication, this result suggests that players gave a new interpretation to those game elements [3]. This result indicates that game elements perceived *fun* *challenges* that the player with ADHD enjoys can trigger *reflective communication* exchanges and help in improving *the ADHD's players self-esteem.*

6.7 Joint Exploration of Complex Challenges instead of Instructions

The player with ADHD did not read the instructions described on the challenge card but managed to understand the challenge by experiencing the interaction and cooperating with other players (see Subsection 5.5). This suggests that the player with ADHD may have needed a different approach to tackle a rather *complex challenge, based on extensive exploration with peers*. As also noted by Raman et al., extensively experimenting with technology can ease children with ADHD's grasp of abstract concepts [28]. This observation aligns with what Stefanidi et al. noted about the tendency of ADHD to have fun in experimenting with tasks [35].

Similarly, while players seemed disoriented when they started to ideate smart things, they reflected together and changed their attitude once they used challenge cards. This was not the case for the player with ADHD who struggled to connect challenge and character cards and abandoned the gameplay for a little while. At the end, the player with ADHD shared his idea verbally with the game master who cooperated with him also in prototyping his ideas (see Subsection 5.6). This self-exclusion requires an *overall reevaluation of the game materials and strategy to foster the prototyping* stage.

While the results are based on a single exploratory session with a small group of children, they point to specific design elements that foster inclusive collaboration. This includes providing autonomy in cooperative decision-making, using movement-based mechanics, and creating negotiation scenarios that children can reflect upon. Future studies should replicate the protocol with older age groups to validate its applicability within the broader context of digital wellbeing for adolescents.

7 Conclusions, Limitations and Future Work

7.1 Conclusions

Positioned within the current landscape of research focused on enhancing child well-being through technology design, this paper describes the design of the CoDePlay4ADHD board game of cards. The paper addresses the problem of collaboratively engaging children with ADHD and their peers in the design of smart-thing technologies. Adopting the Research Through Design (RtD) methodology outlined by Zimmerman et al., CoDePlay4ADHD underwent a process of iterative prototyping and testing [39]. The outcome of this research is the development of the CoDePlay4ADHD version of this paper, along with a documentation of the design elements and their evolution throughout the design process, and a refined problem framing.

The CoDePlay4ADHD gameplay employs ad-hoc strategies to keep children with ADHD and peers in the game, e.g., the unexpected event cards and the villain cards challenge players to shift the focus of attention and move, or to team up to strategically tackle events, or to think together about what risks taking, and reflectively communicate. After testing it extensively, the version of CoDePlay4ADHD presented in the paper was tested in a workshop with four children aged 7–12 years, including one child with ADHD. Guided by a game master, expert of interaction design and children, they played and designed simple smart thing prototypes with CoDePlay4ADHD. Overall, results suggest that all players worked collaboratively, where collaboration is declined as explained in the related-work section, that is, in terms of coordination, cooperation, reflective communication in the game play [3].

A key aspect that emerged is that negotiation game strategies fostered cooperative collaboration even after this was no longer required by the gameplay. Furthermore, negotiation solicited peers to freely reflect on the negotiation strategies. While not assigning predefined roles, playing with the CoDePlay4ADHD villain cards enabled players, and especially the player with ADHD, a certain degree of autonomy to choose cooperative interactions or to make individual decisions when cooperation was not necessary in the game or not spontaneously sought. The board also invited players to promote coordination and self-reflect on roles to take autonomously to reach the end of the game board. Through CoDePlay4ADHD unexpected event cards, the player with ADHD effectively took breaks and cooperated, showing a positive attitude and becoming a valuable collaborator. Additionally, these cards were engaging for the player with ADHD, and his enthusiasm engaged all players in re-interpreting and reflecting on them and cooperating in the gameplay.

Such results were reflected over and related to existing literature to derive or refine guidelines for designing future games that, like CoDePlay4ADHD, aims at fostering the collaboration of children with ADHD and peers in the design of technology for themselves.

7.2 Limitations and Future Work

The study and the design of CoDePlay4ADHD presented in this paper were informed by the literature, expert reviews, and tests with previous versions of CoDePlay4ADHD. The results are however of a contextual nature and the revised guidelines should be read as indications for future design endeavours.

Moreover, although promising, the findings are drawn from a single workshop involving a limited number of children, one of whom had a diagnosis of ADHD. Further work is needed to evaluate CoDePlay4ADHD's effectiveness in larger, more diverse samples and across age groups.

Additionally, while CoDePlay4ADHD was designed to enable children's agency in collaborative design, we acknowledge that our approach does not fully qualify as participatory design in the strict sense. The children were invited to engage in a game-based co-design process but were not involved in shaping the design of CoDePlay4ADHD itself. Future work should explore more iterative, child-led design cycles to deepen participatory engagement.

Specific challenges emerged during the prototyping stage. Difficulties were especially observed in the peruse of challenge and ideation cards. These cards were not immediate for the child with ADHD to connect and use to prototype smart things. In line with past results with children with ADHD, an alternative approach could be to allow players to test various smart things without reading instructions first, and then collaboratively create their own ideas [15]. The length of the workshop is also likely to have affected its results. Future workshops should thus try to differently scaffold smart-thing ideas and consider longer play experiences with breaks and re-focus points.

In conclusion, this work presents and suggests game elements and strategies to collaboratively engage all children, including those with ADHD, in the design of smart things, fostering coordination, cooperative interactions and reflective communication.

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CRediT author statement

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