Yogo: a Hybrid Toy-System for children with DCD

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Abstract

In the field of Human-Computer Interaction (HCI) several researchers suggested that Tangible User Interfaces (TUIs), due to their "*hands-on*" nature, have a great potential to support children's learning experience [1]. For this reason, the literature of recent years has highlighted the development of a new trend characterized by an increasing number of toys that provide a more seamless bridge between the physical and digital worlds [2]. These toys, defined as hybrid, instead of moving away from the material aspects towards a digital and immaterial dimension, combine the digital and physical dimensions to enrich the user experience [3]. This research aims to study a design system capable to merge the world of medical devices and recreational products, exploring the usefulness of hybrid toys and TUI in a therapeutic field. The overall aim is proposing a reflection from a design perspective, capable to build accessible and inclusive systems designed for children with special needs. To this end, this paper describes *Yogo*, an hybrid Toy-System designed for children with dyspraxia, also known as Developmental Coordination Disorder.

Keywords 1

Tangible Interfaces, Children-Centered Design, Hybrid toy, Developmental Coordination Disorder, Dyspraxia, Children with special needs, Interaction devices, Human-centered computing.

1. Introduction

Developmental Coordination Disorder (DCD) describes a condition of impaired motor function, which cannot be solely explained in terms of any specific congenital or acquired neurological disorder[4]. Although DCD is one of the most common childhood developmental conditions, its impact on long-term health is not well understood as it remains one of the most underestimated and unknown neurodevelopmental disorders [5, 6]. Children with DCD have difficulties with gross and fine motor tasks compared to their peers and manual activities of daily living are profoundly affected [7]. Various studies pinpoint that early diagnosis and interventions lead to potential improvement outcome [8] and suggest that lack of engagement is often identified as a key problem in therapeutic sessions [9]. It is therefore essential to provide the right therapies to the children and actively involve them in the rehabilitation process [8].

From this perspective, the use of digital interactive technologies is regarded as a promising approach that does not replace current therapies but can be incorporated into them and support caregivers in their daily routine [10]. In the field of therapeutic toys, digital devices such as tablets or smartphones, as well as the use of applications, is quite widespread as they are affordable and intuitive [2]. Nevertheless, the limit of apps is that the interaction with the child remains digital. More precisely, the child interacts with an interface rather than a physical object [2]. This is especially counter-productive for children with DCD. For this reason, a hybrid toy seems appropriate to involve children during the therapeutic session: interacting with digital contents but at the same time allowing them to experiment in the

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physical world. "*TUIs enable children to interact with the physical world while augmenting it with relevant digital information used to facilitate and reinforce active learning*" [2].

2. Hybrid Toys Analysis

Based on what has emerged so far, in the second phase of research, an accurate analysis was conducted in the field of hybrid toys. To select the case studies, the TUET (Toys & games Usability Evaluation Tool) a "*method of analysis to evaluate play materials by considering the physical characteristics that are relevant for children with upper-limb motor impairments*" [11] was used. Over 70 toys were analyzed with an inclusive approach that takes into account those suitable for all children. The cases were divided into six categories [12];

1. **Making / Coding**: high-tech toys suitable for teaching the coding methodology allowing the child to create and customize their own toy;
2. **Augmented Learning / Experience**: this category includes toys that use technology in order to enrich the child's experience;
3. **Movement toys**: selection of toys for both gross-motor and fine-motor activity;
4. **Connected Friends**: little-robots playmates of the child, defined as phygital (digital + physical);
5. **New Toys**: included for completeness of research, even if the products in this category is not a toy in the strictest sense of the word. New technologies and tools, now part of the child's reality, such as 3D printing, drones and voice assistants, are included in the research.

The Venn diagram below shows the number of case studies analyzed for each category. The classification applied is not rigid. Therefore, overlaps between different categories, particularly interesting, occurs. In particular, the concept developed took into account the main features of the two categories, Augmented Learning/Experience and Movement Toys to create a meaningful play experience and at the same time suitable for manual therapy.

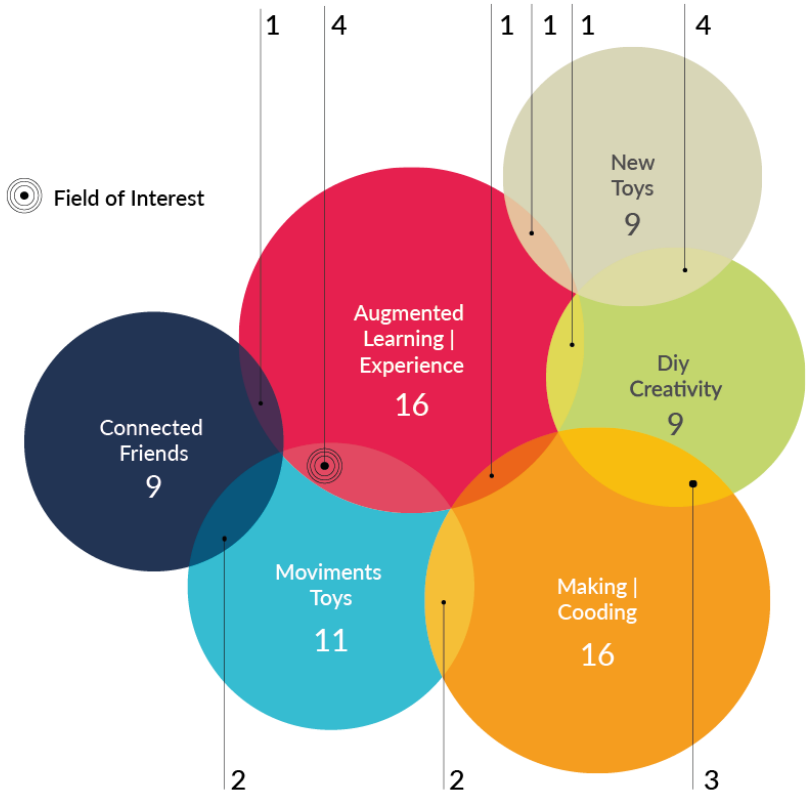

Figure 1: Venn Diagram case studies, the numbers refer to the products in the specific area

The analysis of the case studies was fundamental to understand the world of hybrid toys and identify the possible applications that TUIs have in this field.

The research summarized in a concept that uses TUIs for merging the world of medical devices and recreational toys. Based on this, the idea of Yogo was defined: a product/service designed to allow children with DCD to exercise fine motor skills. The project was carried out with the support of therapists and experts in the pedagogical and therapeutic field.

3. Yogo

According to the United Nations Convention on the Rights of the Child, all children have the right to play. Play is one of the most important activities in childhood and has a key role in children development by promoting cognitive, linguistic and social skills learning [13].

In the case of children with disabilities, the natural attitude to play can be very limited [14]. Their disability and the access to recreational activities, suited to their needs, is often inadequate [15]. Nevertheless, disabled children have the same desire to play than any other child [16]. For this reason, games and toys should be accessible and should be designed to match their needs.

The overall goal for *Yogo* is to create a toy that can be used at home or during a therapeutic session, which is perceived by the child not as therapy but as a purely playful moment. To do this, *Yogo* translates therapeutic exercises - suitable for children with DCD - into a digital game app, with which the child can interact using tangible tools, specially designed to improve their manual motor skills. The following sections of this paper analyse *Yogo* and the parts of the project in detail.

Figure 2: *Yogo System*; Digital Game for tablet, Tangible User Interfaces tools and controlled application for smartphone

3.1. Yogo's Tangible Users Interface

The physical design of *Yogo* is composed by seven wooden tools: 1) One tool button; 2) One tool with inside a sensor for direction detection; 3) One tool with a luminescence sensor; 4) Core module with battery and Arduino board; 5) One tool slider; 6) One tool with a temperature sensor; 7) Base for tool's composition.

The tools are *Yogo*'s TUI and they are used by children to interact with the screen. In fact, the child will not use the touchscreen to play, but in order to exercise motor skills, they will interact with the physical tools to operate on the digital game.

The shape of the tools loosely resembles five characters. This design was chosen primarily because it evokes a playful and child-friendly design. The goal was to create something that would hide buttons, knobs and sliders - which the child finds difficult to manage and to manipulate - and translate these into something playful and friendly. In addition, the shapes and dimensions fulfil with the rules of the TUET[11], the TUIs are designed to be easily used by children with motor coordination difficulties.

Yogo's tools can be used individually or joined in pairs, according to the needs of the specific therapeutic activity. The composition is possible thanks to a magnet. The tools are inspired by the regular therapy and aim at exercising resistance and strengthening, development of the arches of the hand, skilled control of the radial fingers (thumb, index, and middle fingers) and stabilization of the ulnar fingers (ring and little fingers).

For the sensorial aspect and sustainability, wood was chosen as material. Besides, the tactile sensation offered by wood makes this material particularly suitable for tactile hand stimulation. Furthermore, according to the Spielwarenmesse blog, one of the trends for involving children in manual play activities is to create a synergistic combination of technology and nature [17].

Each tool is automatically recognized by the digital device and interacts with it, that will be the guide for the child during the activities. The therapeutic exercises are proposed to the child as various games on the tablet.

Figure 3: The seven components of Yogo's Tangible User Interfaces

3.2. Yogo Digital Game

Yogo is the name of the main character in the digital game. In fact, in order to guide the child during the game activities, a friendly virtual character was chosen. *Yogo* guides the child through the interactive elements of the app, which take place visually on the mobile device's screen, reacting to the child's inputs with the tools.

Yogo's games bridge the digital and the physical worlds by tracking, via an integrated connected circuit, physical movements performed by children. The various games offered are a reinterpretation of the activities used during the manual therapy sessions. More precisely, the games were inspired by the therapeutic activities for dyspraxia contained in the book "*La disprassia: giochi ed esercizi*" [18] by *L.Sabbadini e L. Michelazzo.*

In order to support a range of abilities, the concept of grading was introduced (Figures 4,5). The exercises/games are developed to make harder or easier the tasks for the child. This concept could drive the creation of a wide range of various activities in order to customize *Yogo* according to the needs of children. More precisely, the therapist can set the difficulty and choose the most suitable games for the child.

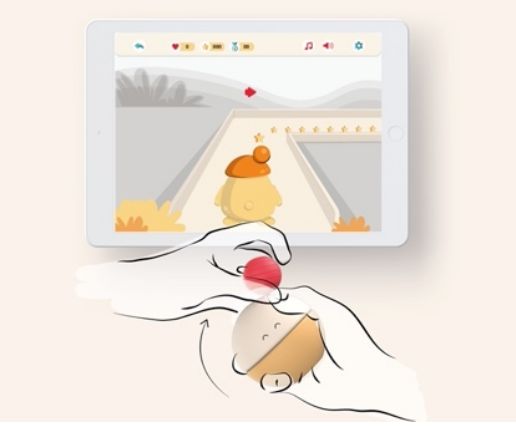

Figure 4: Example of exercise and interaction with physical tool

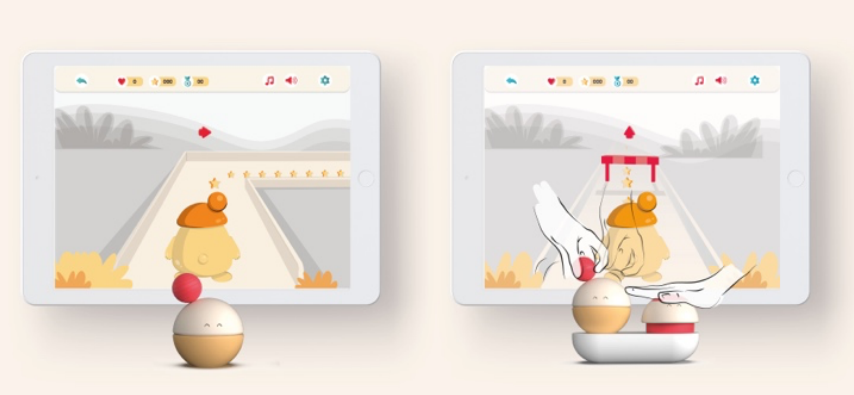

Figure 5: Example of two levels of complexity, one with a single physical tool the other with the composition of two tools

The exercises/games are designed to meet a specific rehabilitation function such as:

1. **Wrist Mobility**: activity used to exercise abduction, addition but also flexion and extension of the wrist. The digital game is an obstacle course with which the child interacts with the direction sensor tool;
2. **Eye-Hand coordination**: the purpose of this activity is to coordinate the child's manual actions to the request made by *Yogo* on the tablet screen. The digital game is a track where the child has to steer *Yogo* left or right using the slider tool;
3. **Implicit Alert**: to exercise alertness ("ready and go" principle [18]). The child should be promptly ready and react to the character's request. The tool they will use in this case will be the button tool. In the more difficult levels, the slider tool can be added;
4. **Double Task**: this type of activity consists of making two different requests and allows the child to perceive the differences reaction to their actions. The double task game consists of directing a cannon with the direction tool and firing the shot with the button tool. This activity, even at its lowest level, can be very difficult for the child due to the requirement of a double task and the involvement of both hands at the same time.

Even if the activity/game respects the features required for the manual therapeutic activities, the children will perform the activity as in a real digital game: they will have levels to overcome and medals to conquer.

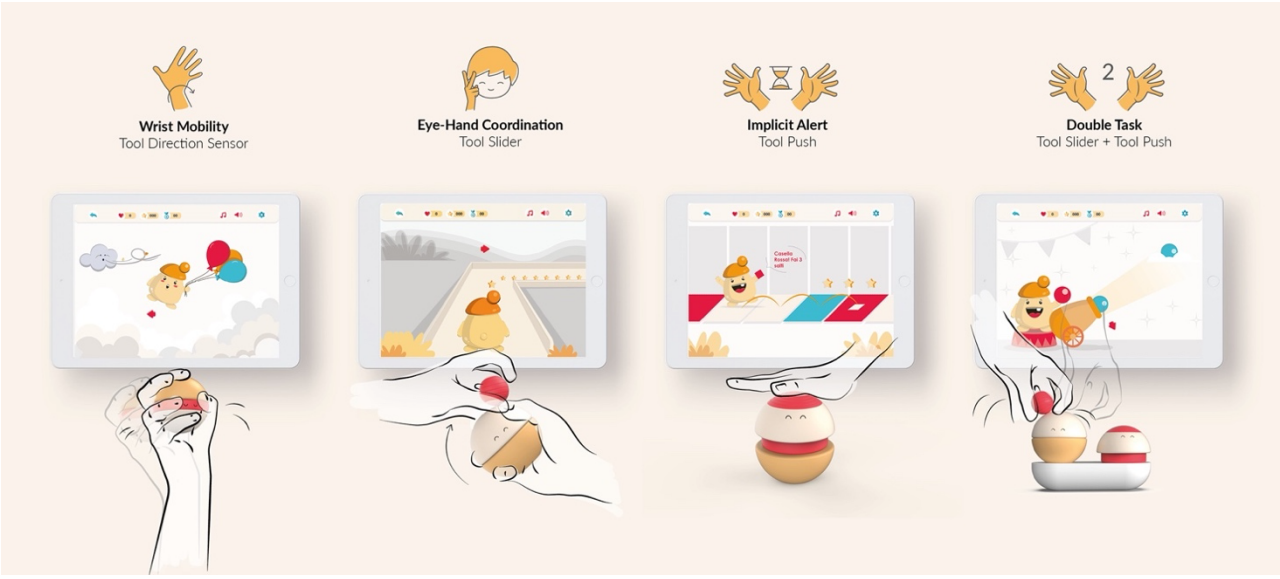

Figure 6: Example of *Yogo* exercises/games for specific rehabilitation function

3.3. The Service System

The project value relies on its service and it benefits not only children but also their caregivers. The system behind *Yogo* is particularly useful to tailor activities for each child and for collecting data. *Yogo* is a means for the therapist to involve new users and include parents in the therapeutic process, as well as to monitor the child even at home within the hours devoted to therapy.

In fact, one of the main advantages for the therapist is the monitoring function. This is available in real-time and it is an objective method for evaluating the progress of therapeutic activity conducted with *Yogo*. The app keeps the progress history and documents the difficulties faced by the child, allowing the therapist to change the game in progress. In this way, the therapy is tailored and can fully meet the needs of the specific child.

Through the app interface, the therapist can customize the activities by changing the game setting and modifying the scenario according to the child's preferences. In this way, they can optimize the difficult to a specific level adapting the activity to the specific child therapeutic needs. Furthermore, the therapist can, by consulting the data, understand which game is the most difficult for the child and consequently intervene in the planning of activities.

In the system the expert could also carry out advanced customizations, modifying the interaction between the TUIs and digital games. In this way the expert has the opportunity to experiment and go beyond the limits imposed by the design of activities at the current state, proposing new ideas and different ways of playing. It is important to note that this type of personalization is more complex and requires specific technical training and user testing with the therapist. Nonetheless, it was an important aspect considered in the project. Still, Yogo's customization remains one of the main features that need to be explored and expanded in its future developments. Considering that in disability each user is different and therefore greater personalization can add value to the project [19]. In the future development of Yogo, personalization should become a key feature; by implementing the system with machine learning and applying artificial intelligence, personalization can become more and more

automatic and timely. Indeed, if the intervention of a therapist is now required to adapt the specific activity, machine learning algorithms could be to modify the game accordingly to the user's behaviour [20].

The system also includes an app for parents. The advantages for the parents consist in the possibility to verify the efficiency of the therapy and to communicate directly with the therapist. Parents can also observe the activity progress, verify the correct use of the digital device and actively play with their child.

The parent app is a means to control and support the child at home and even while they are playing alone with *Yogo*. Indeed, if the child is facing a difficulty, for example they take too long to combine a TUI tools, parents will receive a phone notification inviting them to pay attention to the child in order to understand the reason for child difficulty. In conclusion, another feature is the parental control option: to avoid addiction and prevent the child from spending too much time using the tablet, parents can set a usage timer, after which the game will stop. In this case, what the child will see is *Yogo* asleep, that encourages they to stop playing until *Yogo* will be awake.

4. Conclusion

Yogo is an interdisciplinary tool that combines psychology, inclusive design, education theory, and human-computer interaction. This new interaction paradigm, its co-designed features, and focus groups with therapists reveal an unexplored potential to optimize learning through customized and motivating stimuli. In addition, it will encourage cognitive and motor development in a personalized playful environment. The main interest of this project is to investigate the value that a hybrid system brings to the products-services, paying particular attention to the users' experience. The project validates the importance of designing in an inclusive perspective, which makes products and services accessible to all, even in the case of disability.

The project presented in this paper is a starting point for raising awareness of the DCD.

Future developments of Yogo will be prototyping and testing to directly test the efficiency of TUI in children rehabilitation. To achieve this, it is necessary to increase multidisciplinary relationships and involve more experts and therapists who will become an increasingly active part in the project. In this prospective, the design should go beyond disability and considering the user first of all as a person. Specifically, when it comes to children, disability should not limit play and its natural desire for recreation: it is essential to make the world in which children live, and the objects they interface with, accessible. Although therapy is essential for a child with disabilities, playful activities must also have a significant role in the childhood routine. We aimed with this project, at exploiting tangible interfaces in a hybrid approach, and at investigating the right balance between gaming experience and therapeutic exercise.

5. References

[1] Zuckerman, O., & Gal-Oz, A. (2013). To TUI or not to TUI: Evaluating performance and preference in tangible vs. graphical user interfaces. International Journal of Human-Computer Studies.

[2] Cerezo, E., Marco, J., & Baldassarri, S. (2015). Hybrid games: designing tangible interfaces for very young children and children with special needs. In *More Playful User Interfaces* (pp. 17-48). Springer, Singapore.

[3] Tyni, H., Kultima, A., Nummenmaa, T., Alha, K., Kankainen, V., & Mäyrä, F. (2016). Hybrid Playful Experiences: Playing between Material and Digital-Hybridex Project, Final Report.

[4] World Health Organization. (1992). The ICD-10 classification of mental and behavioural disorders: clinical descriptions and diagnostic guidelines. *Weekly Epidemiological Record= Relevé épidémiologique hebdomadaire*, *67*(30), 227-227.
[5] Harrowell, I., Hollén, L., Lingam, R., & Emond, A. (2018). The impact of developmental coordination disorder on educational achievement in secondary school. *Research in developmental disabilities*, *72*, 13-22.
[6] Mind, S. (2019). *Disprassia Evolutiva: definizione, criteri e valutazione - Psicologia.* [online] State of Mind. Available at: https://www.stateofmind.it/tag/disprassia-evolutiva/ [Accessed 5 Sep. 2019].
[7] Carslaw, H. (2011). Developmental coordination disorder. InnovAiT.
[8] Reynolds, J., & Miedel, W. T. (1997). *The Effectiveness of Early Intervention.*
[9] Coulter, A. (2012). Patient engagement—what works?. *The Journal of ambulatory care management*, *35*(2), 80-89.
[10] Wilson, M. (2002). Six views of embodied cognition. *Psychonomic bulletin & review*, *9*(4), 625-636.
[11] Costa, M., Périno, O., & Ray-Kaeser, S. (2018). *TUET Toys & games usability evaluation tool*. AIJU
[12] Spielwarenmesse. (2019). Spielwarenmesse: Here are the toy trends 2020. Disponibile da: https://www.spielwarenmesse.de/magazine/article-detail/spielwarenmesse-2019-toys-trends/language/1/ [Ultimo accesso 28 Nov. 2019].
[13] Sutton-Smith, B. (2009). *The ambiguity of play*. Harvard University Press.
[14] Stagnitti, K., O'Connor, C., & Sheppard, L. (2012). Impact of the learn to play program on play, social competence and language for children aged 5–8 years who attend a specialist school. *Australian occupational therapy journal*, *59*(4), 302-311.
[15] Besio, S., Bulgarelli, D., Iacono, I., Jansens, R., Mizzi, M., & Perino, O. (2018). Becoming expert in playing with children with disabilities. The Ludi training school "play and toys for all". *Today's Children are Tomorrow's Parents*.
[16] Encarnação, P., Ray-Kaeser, S., & Bianquin, N. (2018). Guidelines for supporting children with disabilities' play: Methodologies, tools, and contexts. De Gruyter Open.
[17] Costa, M. (2018). Spielwarenmesse: Trends on baby toys design. Disponibile da: https://www.spielwarenmesse.de/magazine/article-detail/trends-on-baby-toys-design/ language/1/ [Ultimo accesso 28 Nov. 2019].
[18] Sabbadini, L., & Michelazzo, L. (2016). *La disprassia: giochi ed esercizi* (2nd ed.). Carocci Faber.
[19] Toussaint-Thorin, M.et.al (2013). Executive functions of children with developmental dyspraxia: Assessment combining neuropsychological and ecological tests. Annals of physical and rehabilitation medicine, 56(4). p.268-287.
[20] Birnbaum, Faith & Lewis, Dana & Rosen, Rochelle & Ranney, Megan. (2015). *Patient Engagement and the Design of Digital Health*. Academic Emergency Medicine. 22. 10.1111/acem.12692.