Interactive soft toys to support social engagement through sensory-motor plays in early intervention of kids with special needs

Beste Özcan*
Valerio Sperati*
Institute of Cognitive Sciences and Technologies
National Research Council
Rome, Italy
beste.ozcan@istc.cnr.it
valerio.sperati@istc.cnr.it

Flora Giocondo
Institute of Cognitive Sciences and Technologies
National Research Council
Rome, Italy
flora.giocondo@istc.cnr.it

Massimiliano Schembri
Institute of Cognitive Sciences and Technologies
National Research Council
Rome, Italy
massimiliano.schembri@istc.cnr.it

Gianluca Baldassarre
Institute of Cognitive Sciences and Technologies
National Research Council
Rome, Italy
gianluca.baldassarre@istc.cnr.it

ABSTRACT

Transitional Wearable Companion (TWC) is a novel design concept, implemented as an interactive, smart, soft toy, which aims to stimulate curiosity and encourage social engagement in kids with special needs, during play activities with their caregivers. We propose the TWC as a potential support tool for neurodevelopmental therapists, during early intervention in disorders characterised by impairment in the social area, such as Autism Spectrum Disorder (ASD). The TWC might be helpful to set up sensory-motor games, conceived for encouraging and reinforcing critical social competences, pivotal for cognitive development, such as eye-contact, imitation, joint-attention and turn-taking. In this work, we present two working prototypes of TWC called *PlusMe* and *X-8*, currently used in pilot experiments with children diagnosed with ASD.

CCS CONCEPTS

• **Human-centered computing → Empirical studies in interaction design**;

KEYWORDS

Neurodevelopmental Disorders, Autism Spectrum Disorder, Transitional Wearable Companion, early intervention, interactive toy

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*Both authors contributed equally to this research.

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1 INTRODUCTION

Several Neurodevelopmental Disorders (ND) present often life-long impairments that can manifest with symptoms in social, relational and affective areas of cognitive development. This is particularly true for Autism Spectrum Disorders (ASD) [1]. There is a general consensus that early intervention, especially before childhood and possibly before the full onset of the symptoms, is critical to ameliorate the severity of these conditions, by stimulating and strengthening the atypical social skills of these kind of children [3]. In this regard, interactive technologies are surely very promising tools, which can be used for therapeutic purposes, since they are appealing and arouse a high degree of motivation in children [2].

In this work, we describe two working prototypes of *Transitional Wearable Companions* (TWCs) [6], namely soft interactive toys, specifically designed to help neurodevelopmental therapists to set up sensory-motor activities to exercise, stimulate and strengthen the social competences of children with ASD. The prototypes, called *PlusMe* and *X-8*, feature different characteristics, and are currently used in pilot studies with ASD participants.

2 TRANSITIONAL WEARABLE COMPANIONS: DESIGN CONCEPT

A *TWC* is a design proposal, specifically addressed for ASD, but potentially helpful for young children with special needs. In more detail, a TWC is conceived as an interactive "companion" toy, that lies midway between a simply stuffed teddy bear (namely, a passive object to get attached to), and a complex robot (namely, an active object which arouses interest and curiosity). A TWC is characterised by the following features and properties (Fig. 1):

- *Comfort object*: thanks to its soft plushy textile material and animal shape, it is able to arouse emotional attachment and

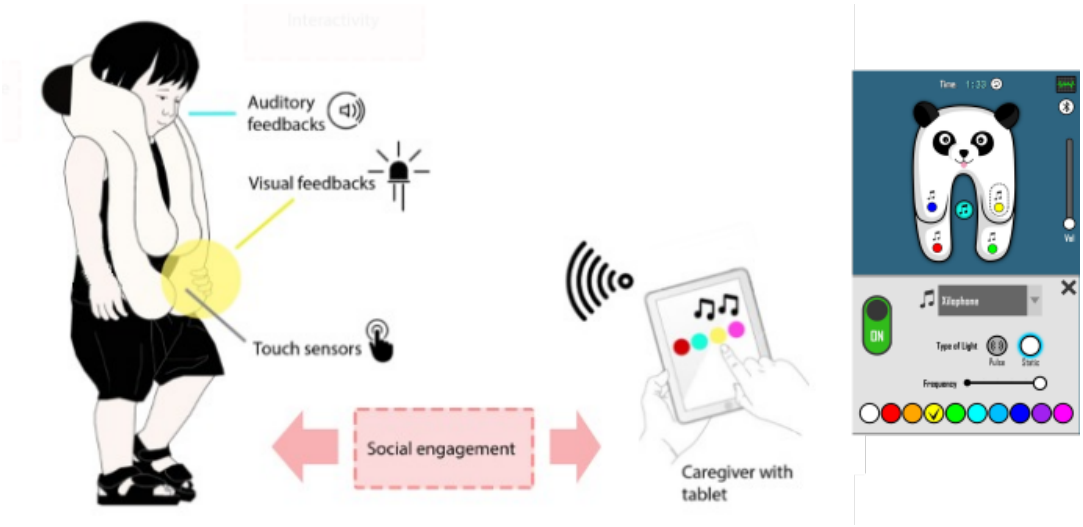

Figure 1: *TWC* design concept. The typical features of a transitional object and an interactive toy, along with a user-friendly App for the device control (on right in the image), could support the therapist in setting up play activities aimed to encourage social engagement with the child.

reassuring feelings, typical characteristics of *transitional objects*. This is also favored by the attribute of *wearability*: the shape is in fact designed so that a TWC could be potentially worn around the child's neck or shoulders, so promoting a closer body contact;

- *Rich interactive behaviours*: when touched, it is able to stimulate the child's attention and curiosity, by producing simple – yet attractive – sensory response (such as coloured lights, amusing sounds, mild vibrations), thanks to embedded electronics and hidden sensors. Importantly, these rewarding outputs can be combined in order to create always novel gratifying sensory patterns;
- *Shared control with an adult*: its interactive behaviour depends not only on the child, who triggers the outputs touching the toy, but also on an adult caregiver. This is achieved through a bluetooth-connected tablet; the control App allows the adult to modify the toy responses, and adapt them to the child's preferences and reactions;
- *User-friendliness*: the TWC is easy to use for a caregiver. The App on the control tablet, needed for the toy customisation (for example for setting different sensory-motor games) is designed to be intuitive and user-friendly.

Given the above characteristics, we propose the TWC concept as a support tool, potentially useful for neurodevelopmental therapists, to set up amusing, socially engaging, floortime[1] activities with children aged between 30 and 60 months. Especially the *shared control* feature could encourage key social skills at the basis of social behaviour, such as imitation, eye-contact, joint attention and turn-taking. In other words, a TWC could be used as a *mediator* between therapist and child. The idea of using a transitional object as an *attentional anchor* to facilitate triadic interactions (i.e., namely interactions between two people, mediated by an object) in ASD is discussed in [4].

2.1 The panda *PlusMe*: a TWC to encourage social engagement

PlusMe is the first working prototype of TWC (Fig. 2). With the shape of a panda, it was designed to be possibly worn around the neck, thus encouraging a close, reassuring contact with the body; this potential use, although not yet tested, could be important to arouse reassuring feelings and reduce stressful situations.

Technically, each of the four paws can light up with different colours, by means of embedded LEDs strips. The output is triggered when a hand touch is detected by invisible, capacitive patches (i.e., *touch sensors*), sewn in the toy textile. The touch detection can also trigger several, brief sounds and music or mild vibrations, respectively by means of embedded speakers and mini vibrating motor discs.

The type of response is mediated in real-time by the caregiver through a control App. He/she can select which colour is produced,

Figure 2: *PlusMe* design concept (left image), the prototype realised (central image), and *PlusMe* worn by a researcher (right image).

[1] www.autismspeaks.org/floortime-0

which sound is played and if the vibration has to be present. Importantly, the outputs are independent of each other: the caregiver can decide which combination is more effective – plausibly, more satisfying – to capture the child's attention. In this way, the toy can be customised, and tailored to the child's preference, selecting the most gratifying outputs[2].

In addition to this basic operating mode, the App makes available also other *functions*, which combine inputs and outputs in more elaborate way: just as an example, the toy could produce a rewarding pattern only if the upper paws are touched at the same time, or if its head is caressed between the furry ears. These *functions*, requiring a more precise motor coordination, can further encourage the child's imitative gestures towards the caregiver[3].

The rich set of available sensory outputs, along with the extensive control exerted by the adult through the tablet, was designed to provide the maximum freedom in creating socially engaging play activities.

2.2 The octopus *X-8*: a TWC to support turn-taking games

Figure 3: *X-8* design concept (left and central image), and the prototype realised, and worn by a researcher (right image).

X-8 is the second working prototype of TWC, with the shape of a six-legged octopus (Fig. 3), characterised by new features and technical improvements [7]. In respect to the previous toy, *X-8* is able to autonomously detect the identity of hand touch: in other words, it can "understand" if its tentacles are touched by the child or the caregiver, and then respond differently according to the user.

Such functional feature allows to implement play activities based on *turn-taking*: this is a key social competence, fundamental for the communication activities based on reciprocal back-and-forth exchange (e.g., during a dialog). Importantly, this skill is often impaired in kids with ND (and particularly with ASD children), as it relies on a complex cooperative temporal coupling between two people, based on visual, verbal and nonverbal signals.

X-8 is in fact designed to support games relying on *turn-taking* rules. Through the control App, the caregiver can select 3 different *functions*, which implement games with increasing complexity[4]:

- *Function 1*: *X-8* produces a magenta colour when touched by the child, and green when touched by the caregiver. This means that the child has to wait for the caregiver's touch to observe the toy glowing in green (hopefully, a *desired* outcome that the child cannot trigger). This is the most simple games;
- *Function 2*: *X-8* glows for about two seconds in magenta, suggesting that it is the child's turn to interact with the toy, then it gets dark. If the child touches any of the tentacles, the toy glows for about four seconds with different colours and emits a nice music. After about three seconds, *X-8* glows in green, indicating that now it is the caregiver's turn to touch the toy. Importantly, if *X-8* recognises the violation of the rule (i.e., the user touches the toy when it's not his/her turn), no reward pattern is produced. This game requires a fixed sequence of turns, where child and caregiver has to respect their turn to play and trigger the rewarding patterns;
- *Function 3*: a random tentacle glows intermittently in green or magenta, suggesting which user has to touch the active tentacle. If the turn rule is respected (i.e., the correct user touches the correct tentacle) the toy glows for about four seconds with different colours and emits a nice music. Then the game starts again with another random tentacle and a random colour (green or magenta). This game is more complex than the previous one, as it feature a non-fixed sequence of turns.

Figure 4: *PlusMe* is currently used with high-functioning ASD children aged between 36-50 months, in experimental therapy sessions which aims to stimulate social competences as imitation, eye-contact and joint attention.

3 CONCLUSIONS AND FUTURE WORK

Transitional Wearable Companions are promising technological tools, originally designed to support early intervention in ASD, but reasonably also helpful in general, with children with special needs.

Some pilot researches, aimed to evaluate the effectiveness of TWCs, have been done. *PlusMe* was used in two scoping studies with both typical developed and ASD children [8, 9]. These tests aimed to assess the *acceptability* of the toy, namely its efficacy in keeping the children focused on a single, ten minutes long, play session. Currently *PlusMe* is tested with a small group of high-functioning ASD participants, aged between 36 and 50 months (Fig. 4). In this promising study, featuring four consecutive play sessions (one per week), the device is used – for the first time – with a therapeutic purpose, specifically to encourage the social engagement between therapist and child [5]. Preliminary, promising results, showing the increment over time of some key social behaviour, such as imitation and eye-contact are presented in [5]. About *X-8*, a pilot experiment

[2] A brief video about the device features is available at the following link: www.plusme-h2020.eu/video/#PlusMeToy

[3] Currently, 7 different functions have been implemented

[4] A short video showing the 3 functions is available at the following link: www.plusme-h2020.eu/video/#the_octopus_x_8

[5] A brief video about this study is available at the following link: www.plusme-h2020.eu/video/#ExperimentalSessionMayJune2021

with ASD children is in preparation, to evaluate the toy usefulness in supporting turn-taking activities.

Although the presented pilot studies are targeted to ASD, several feedback from neurodevelopmental therapists suggested the potential use of TWCs also for other conditions, such as Communication Disorders (to encourage the communicative behaviour), or Cerebral Palsy (to improve motor skills).

The TWC prototypes are continuously improved in terms of design and functionality: currently, most suitable fabric and textile materials, along with a more professional pelouche design, are used to enhance the toys aspect; moreover, novel software and hardware features are under development, to enrich the interactive behaviour of the toys.

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A DEMO PRESENTATION FORMAT

The prototypes of *PlusMe* and *X-8* will be available at the authors' desk. The visitors will be able to try the toys, observe live demonstrations and ask explanations to the researchers. To assure hygiene requirements due to COVID-19, the prototypes will be regularly disinfected and the visitors will be required to sanitise their hands before use. A brief video summarising the content of the demo is available at the following link https://drive.google.com/file/d/1snoWpjV0C-C3zMSddJDJSulzM6B-LThJ/view?usp=sharing

B SELECTION AND PARTICIPATION OF CHILDREN

The pilots described in sec. 3, including the processing of collected data for research purpose, were authorised by the Ethics Committee of the National Research Council of Italy. Parents, informed about the purpose of research, gave written informed consent before starting the experiments. The study including TD participants [9] took place at nursery schools at Rome. The studies including ASD participants [5, 8] took place at the Department of Human Neuroscience, University of Rome *La Sapienza*; participants were selected by the Medical Director of the center on the basis of a formal diagnosis of ASD.

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