THE iRECHECK PROJECT - A SOCIAL ROBOT HELPING CHILDREN WITH DYSGRAPHIA IN A LEARNING-BY-TEACHING SCENARIO

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ABSTRACT

Dysgraphia is a deficit in the production of written language that has large impacts on childrens quality of life, especially at school. New technologies have been described as a promising strategy for its rehabilitation. Here, we propose the use of social robotics and new technologies to develop an innovative approach to enhance writing skills acquisition for children with dysgraphia exploiting the "learning-by-teaching" paradigm. In our research, we will focus on children with dysgraphia, collaboratively working with teachers and therapists in a rehabilitation scenario. We propose the design of social robots' behaviors which support children engagement and learning as well as metrics to evaluate our system's acceptability for therapists, teachers and children. We will use Luxai's QTRobot together with a serious game, Dynamico, that focuses on improving children handwriting skills. We will assure the system's acceptability through its iterative design, improving it by exploiting users feedback. We will also use the gold standard test for writing evaluation to assess whether the system maps with the learning objectives.

***K*eywords** Dysgraphia · Learning-by-teaching · Writing skills · Social robot's behaviors

1 Background

Writing is an essential skill. It is one of the main mean for describing things and expressing emotions. For most people, learning to write seems like a natural process, but some children have real difficulties : this is called "dsygraphia", a disturbance in the production of written language that can concern the product of writing (the written trace and its legibility) as well as the process of writing (the movement produced during writing for example, writing speed)[1]. Dysgraphia can be associated with neurodevelopmental disorders (NDD), in particular with developmental coordination disorders (DCD)[2], which appear in the early stages of development and can cause a deterioration in personal, social, academic or professional functioning[3].

Children with dysgraphia are often viewed as neglectful or lazy by teachers at school, rather than suffering from a learning disability they cannot control. This kind of situation attacks the child's self-esteem and self-confidence as well as his social relationships[4, 5, 6, 7, 8]. These negative effects will cause children to reject further learning to handwriting, increase school-performance anxiety that can lead to an increased trait anxiety[5], which trapping them in a vicious cycle[9]. Hence, dysgraphia has a large impact on childrens quality of life, especially at school, and can also have long term impacts on their academic trajectory[6] .

Therefore, it seems essential to have methods and tools to help children with dysgraphia as efficiently and as early as possible, in order to prevent short term as well as long term consequences. When dysgraphia is detected, it is usually addressed either by teachers, in school setting, or by occupational or psycho-motor therapists[9]. However, there is no gold standard method for dysgraphia rehabilitation, even though several strategies have been investigated . The use of new technologies have been described as a promising avenue for the rehabilitation of dysgraphia. But to this day, the few tools developed have not encountered a great success among teachers and therapists and are not used in practice[6].

Our research aims at using social robotics and new technologies to develop an innovative approach which can positively influence writing training for dysgraphic children[9]. The iReCheck project, a follow-up of the CoWriter project[10], aspires to develop a semi-autonomous robotic platform endowed with social skills, acceptable both for children and for teachers and therapists, and able to explicitly take into account the child and the caregiver presence in its perception-decision-action loop.

Our hypothesis is that the use of social robots in this context can overcome the limits of the standard learning approaches by proposing more engaging and individualized interventions to those children with special needs. However, the use of such technology raises several questions, mainly:

- How should a social robot behave to support children engagement and learning?
- Could it be acceptable for the caregivers involved in the training activities, both teachers and therapists ?
- Can it help on breaking dysgraphia's vicious circle by improving children's self-confidence and limiting writing avoidance?

Responding to such questions will give hints on the possibility of developing an autonomous system able of assisting the caregiver in real use-case scenarios.

In our research, we propose the use a robot in a "Learning by teaching" paradigm[11], a pedagogical method in which students learn by teaching to someone else.Learning-by-teaching has been proven to be effective for acquiring new knowledge and new skills[12], while increasing motivation and self-confidence[13]. In our setup, the robot will ask the child to play the role of a teacher while it plays the role of a student who seeks help to improve his writing skills[11].

The *social capabilities* of the social robots in learning-by-teaching is particularly important: most theories propose that the efficiency of such learning schema relies on the social involvement it elicits [14]. Compared with the traditional handwriting training activities, the use of a small humanoid robot can make children more comfortable and at ease: the simplified human-like embodiment of the robot will be able to provide simple, stereotyped and clear feedback; at the same time, the non-judgmental nature of the companion robot will reduce the stress of children during the training.

2 Design

In our research, we will focus on children with dysgraphia, aging from 6 to 15 years old, with or without NDD, collaboratively working with teachers and with psycho-motor therapists.

We will use our robot in conjunction with a serious game for a tablet, "Dynamico"[1], that, while focusing on improving children writing, is able of describing handwriting in term of a large variety of features (handwriting direction and size, handwriting speed, pen pressure and pen tilt)[15, 16].

We will design two scenarios: a first is set in a one-to-one remediation context (**Fig 1**). Here, the caregiver will have a total control of the robots behaviors through a simple interface within a tablet. The results obtained in such scenario will be preliminary to a second one, in which we will propose a more autonomous system that will be employed in classrooms. In this case, the robot will be able to display reactions without being explicitly triggered by caregivers that can, in any case, retake its control, preventing it from acting if needed.

Before this research, we did a pilot study with one children, using the NAO robot for twenty sessions. Considering our needs, we observed some limitations with the NAO robot, such as the fragility of its fingers, the instability of its body, and also the insufficient range of its social expressive abilities[16].

[1] The serious game "Dynamico": `https://www.dynamico.ch/`

Figure 1: Installation for the cowriter session

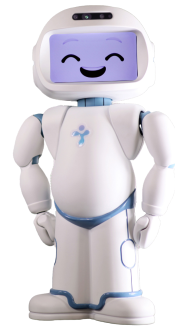
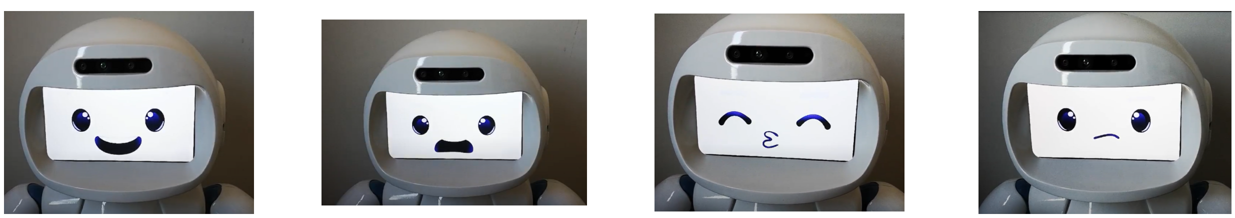


Figure 2: QTRobot's apperance. [Public domain] via symbioïde.

Luxai's QTRobot (**Fig 2**) was chosen as the preferred social robot platform for our research, as provided by an extensive range of expressive abilities, a broader set of facial expressions and a better stability extremely useful for long-term usage[17]. Moreover, it has a childish appearance and voice, appropriates for our scenario in which the robot should be perceived by children as their peer. In terms of hardware, QTRobot integrates two PCs, a ReSpeaker Mic Array composed by 4 microphones installed on its head and an Intel RealSense 3D camera on its forehead. Its face is a screen that can display various emotions (**Fig 3**). The robot's head allows for yaw and pitch rotation. Both anthropomorphic arms have 3 degrees of freedom. Besides, QTRobot's programming interface (API) aims to facilitate access to basic robot functionality by leveraging a set of user-friendly ROS interfaces. The functionalities of each robot are accessible using the publish/subscribe and service/client interfaces of the ROS (Robot Operating System[2]). The main interfaces are those of the engine, those that regulate the displayed emotion, speech, audio, higher-level gestures, and the 3D camera.



(a) Happy (b) Angry (c) Kiss (d) Confused

Figure 3: Examples of QTRobot's different facial expressions

3 Assessment

To answer our research questions and to assess whether our system reaches its goal, we will proceed to following measures, shown in **table 1**

The design of social robot's behavior will be grounded on a tight collaboration with teachers and therapists. We will iteratively collect users' feedback thanks to semi-directed interviews as well as questionnaires (SUS, AttrakDiff and Godspeed), modifying our robot's behavior according to their responses. Caregivers' interface logs will be used to know which behaviors are actually selected by them. Data collected by the external perception system will let us perceive in which condition these behaviors are selected. The external perception system also allows us to record and study the triadic interaction (caregivers - children - robot) in detail. Notably, all those measures will be exploited also to study both the system's acceptability from the point of view of the caregivers, as well as its degree of engageability and likability from the perspective of children.

To assess whether our system maps with our learning objectives and if it can help breaking dysgraphia's vicious circle by improving children's self-confidence while limiting writing avoidance, we will collect and analyse multiple observations of the self-perception profile and of the BHK results. This will give us the possibility of studying the progression in

[2]Robot Operating System: https://www.ros.org/

Measures	Description
BHK[18]	Gold standard test for writing evaluation
Self-perception profile for children[19]	Children's self-confidence evaluation
System Usability Scale (SUS)[20]	Users' experience assessment
AttrakDiff scale[21]	Users' experience assessment
Godspeed questionnaire[22]	Perception of social interactions with robots
Semi-directed interviews	Participants' subjective experiences and opinions
Serious game logs	Handwriting features, sessions duration and number of games played
Caregiver's interface logs	Caregiver's control activity
External perception system	RGB and RGB-D camera, microphones, Human-robot interaction information

Table 1: Description of collected measurement

time of self-confidence and writing efficiency. Together with such measures, serious game logs can draw the evolution of handwriting skills and the time spent on writing training.

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