The CoWriter robot: improving attention in a learning-by-teaching setup

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Abstract. In this paper we compare three learning-by-teaching scenarios in which a robot, a virtual agent or a voice, guide users and provide them feedback aimed at improving their handwriting abilities. The presented system is part of an effort focused on assessment and remediation of dysgraphia and dyspraxia. Results show the performances and the limits of the robot on inducing co-presence and attention.

Keywords: Social robot · Co-Presence · Virtual Agents · Writing disorders

1 Introduction

Developmental coordination disorder (DCD or dyspraxia) is a neurological disorder that impairs the acquisition and the execution of coordinated motor skills [3]. It can be usually associated with learning disorders and in particular with disgraphya, a deficency in the ability of writing, affecting its execution in legibility and speed. Nearly 6% of children between 5 and 11 years in France is diagnosed with dysgraphia. Researchers highlight the fundamental importance of early intervention of handwriting skills, as soon as possible in children' educational path. With an onset in the early developmental period, the assessment of dysgraphia is performed through a standard test called Concise Evaluation Scale for Children's (BHK) [5]. This assessment can be difficult due to its high costs and subjectivity. However, recently [2] has been shown how information and communication technology can help doctors in tackling such issues, by rapidly performing semi-automated, detailed diagnosis.

In this context, social robotics can help both the assessment and the remediation of children with dyspraxia and, more in general, with handwriting difficulties. A team from EPFL[7] recently proposed a learning-by-teaching scenario in which children teach handwriting to a robot through a tablet (Figure **??**). The robot is able to fake its handwriting skills, proposing on the tablet purposefully deformed letters that take in account children performances and errors. Robot's handwriting skills can improve according to the quality of children' examples. The idea is to create an emphatic link between the child and its 'protégé', the robot, stimulating motivation and commitment. Children will act as mentors who help their protégé robot in the handwriting activities, getting themselves practicing without even noticing.

The main elements of this learning-by-teaching scenario are the robot and the tablet. This last one is used to collect handwriting samples from users, as well as to present handwriting feedback. It is possible to speculate about the importance of the presence of the robot and its ability on stimulating concentration and engagement. The experiment reported in this paper explores the role in this scenario of such agent, comparing users performances in three different conditions: handwriting sessions with the CoWriter robot; handwriting sessions with a virtual agent; handwriting session with the tablet only, guided by a voice. The hypothesis is that the social robot would be able to elicit an higher attention than the virtual agent or the vocal guide.

Fig. 1: A use case example of the CoWriter robot: the user teaches the robot how to write.

2 Materials and Methods

In this experiment we compare three CoWriter-based scenario experiments: in a first one, according to its original implementation [7], a user will interact with Nao robot, from Softbank Robotics (CR); in a second experiment the user will interact with a virtual agent, a simulated Nao (CA); in a third experiment, the user will be guided by a voice (CV).

A total of 12 adults (7 males, 5 females) in age between 12 and 31 years old (mean=23.9; std=2.75) participated to the experiment. Each participant interacted in the three conditions in a randomized way. For each condition, 5 words where chosen. For each word, in turn, the agent or the voice proposed its handwriting sample through the tablet; then the human user proposed his correction (Figure 2). The process repeated for each word, until the user positively judged the last handwriting sample.

At the end of the experiment, a questionnaire, the "Networked Minds Social Presence Inventory" was administered [4]. The purpose of this questionnaire is the measuring of the perceived social presence during an interaction, whether is face-to-face between two people, in telecommunication or with a non-human agent. While the original questionnaire is composed by six dimensions, this work focuses only in four facets, keeping apart the affective perception as not the focus of this experiment [6]:

- **Co-Presence**: the user's awareness of the presence of the interaction partner;
- **Attentional allocation**: the perceived attention received by the partner as well as the attention allocated towards the partner;
- **Perceived message understanding**: the bidirectional communication understanding between the partners;
- **Perceived behavioral interdependence**: the of the mutual behavioral connection between the partners.

Each dimension is composed by 6 questions and use a Likert scale 1-7 as response.

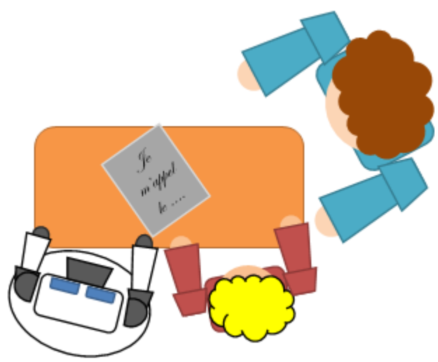

Fig. 2: The learning-by-teaching scenario implemented by the system.

3 Experimental Results

A one-way ANOVA test within subjects, comparing the three condition (CR, CA, CV) has been accomplished on the questionnaire data, revealing an effect on the *Co-Presence* dimension ($F_{2,22} = 8.69$; $p = 0.002$). As in Figure 3 (left), post-hoc tests highlight a significant higher score in the robot condition compared to the voice condition ($CR > CV$, p=0.030) or the virtual agent condition ($CR > CA$, p = 0.039), but no difference is highlighted between virtual agent and voice (p = 1.000).

The ANOVA test revealed an effect also in the dimension of *Attentional allocation* ($F_{2,22} = 6.50$; $p = 0.006$). As in Figure 3 (right), a significant higher score is found in the robot condition compared to the voice condition ($CR > CV$, p = 0.027), but still no difference between CV and CA (p = 0.595) and between CR and CA (0.085) is found.

The ANOVA test was not able to reveal any effect in the *Perceived message understanding* dimension ($F_{2,22} = 1.16$; $p = 0.33$) as well as in the *Perceived behavioral interdependence* dimension ($F_{2,22} = 1.56$; $p = 0.23$).

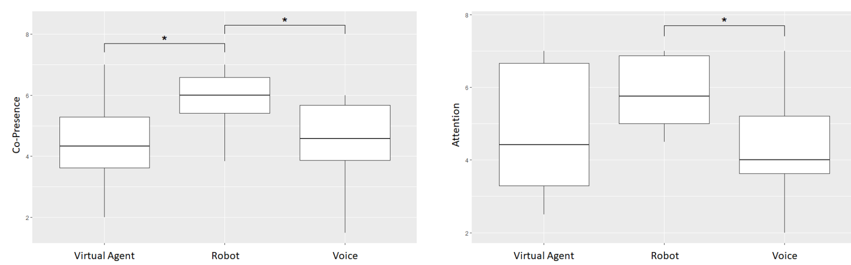

Fig. 3: The results of the questionnaires: co-presence, on the left; attentional allocation, on the right.

4 Conclusions and Future Works

Results on the *Co-Presence* dimension highlight that participants feel more the physical presence of the robot than its virtual agent. It is surprising, however, to note the absence of difference between the virtual agent and the voice. Results on the *Attention allocation* highlight how the robot is able to elicit more compliance than the vocal guidance. It should be noted in this case the absence of difference between the virtual agent and the robot. Such results can also highlight the possibility of the agent of capturing too much the attention of the user, acting as distraction of the task. The absence of difference in the two other dimensions, *Perceived message understanding* and *Perceived behavioral interdependence*, is not strange due to the particular task chose. In particular, the presence of a physical robot or a virtual agent seems does not impact on the comprehension of the exchange. At the same time, it is possible to hypothesize that the interpersonal exchange is too simple to be impacted by the presence of the artificial agents.

It should be noted how the small number of participant and their age do not permit a generalisation of the obtained results to children. Also, questionnaires information should be reinforced by behavioral measures (head movements, body movements, ...) that will be interpreted as the engagement state of the user during the shared task [1].

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