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The Conversational Agent "Emoty" Perceived by People with Neurodevelopmental Disorders: Is It a Human or a Machine?

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Abstract. This research explores the anthropomorphic perception of Emoty by its target user. Emoty is a Conversational Agent specifically designed as an emotional facilitator and trainer for individuals with neurodevelopmental disorders (NDD). NDD is a group of conditions that are characterized by severe deficits in the cognitive, emotional, and motor areas and produce severe impairments in communication and social functioning. Our application promotes skills of emotion expression and recognition and was developed in cooperation with psychologists and therapists as a supporting tool for regular interventions.
We conducted an empirical study with 19 people with NDD. We observed their behavior while interacting with the system and recorded the commentaries they made and the questions they asked when the session was over. Starting from this, we discovered a twofold nature of Emoty: for some aspects, it is perceived more like a machine, but for some others, it is more human-like. In this regard, we discussed some relevant points about gender, fallibility, interaction, and sensitivity of the agent, and we paved the ground towards a better understanding of the perception of people with NDD concerning Conversational Technology.

Keywords: Conversational Technology · Neurodevelopmental disorder · Technology perception · Anthropomorphism

1 Introduction

Neurodevelopmental Disorder (NDD) denotes a group of conditions that are characterized by severe deficits in the cognitive, emotional, and motor areas and produce severe impairments in social functioning. Recent research acknowledged interactive technology as a potentially useful tool to support existing therapies and new approaches to improve the learning process [24][2][19][1].

A conversational agent (CA) is any dialogue system able to interact with a human through natural language [6]. Emoty [4] is a spoken, emotionally sensitive CA that has been specifically designed as an emotional facilitator and trainer for individuals with NDD. Emoty entertains the users with small talks and asks them

to verbalize sentences expressing specific emotions (joy, sadness, fear, anger, surprise, and neutrality) with their tone of voice.

It has been developed in cooperation with psychologists and therapists as a supporting instrument for regular interventions; its goal is to mitigate a specific disturb called Alexithymia, which is the inability to identify and express emotions.

From a more general perspective, its usage might pave the ground towards a better understanding of the cognitive and emotional mechanisms associated with NDD and towards new forms of treatments for these subjects. From a technical point of view, the system is based on the architectural framework presented in [5]. Emoty exploits Dialogflow to perform Automatic Speech Recognition and an original Deep Learning model for emotion detection using the harmonic features of the audio. An initial exploratory study has already indicated Emoty as a suitable tool for persons with NDD and has acknowledged that it has the potential to support emotion regulation in the target users [4].

From that first study, we realized an anthropomorphic perception of the agent by the participants, so we decided to investigate it further. In this research, we conducted an empirical study with 19 people (average age: 35 years) with NDD, including Down Syndrome and mild, moderate, and severe cognitive impairments. We wanted to observe their behavior while interacting with the system, and we took note of all commentaries they made and the questions they asked to their caregivers and us when the session was over. Our research goal was to explore the anthropomorphic perception of people with NDD concerning Emoty during a repetitive usage period. Assessing the potential of Emoty to mitigate Alexithymia and its effects is beyond the scope of this report.

The Oxford English Dictionary defines anthropomorphism as *the attribution of human personality or characteristics to something non-human, as an animal or an object*. The term has its origins in the Greek words *anthropos* for man and *morphe* for form/structure. Anthropomorphic perception and perception in general affect the user experience [16] and play a vital role in the user's cognitive decision-making process about whether to use (or continue using) a new system [8]. Duffy and colleagues [9] described anthropomorphism as a useful mechanism to facilitate social interaction between humans and machines and to make a machine socially engaging. Besides, they concluded that anthropomorphism changes the user's expectations and beliefs on technology. Anthropomorphism has been already studied in many contexts so far [23] and conversational technology appears to perform better its intended design when simulating a human-like mind [26].

The contribution of this work concerns the research about Conversational Technology for people with NDD: this study is innovative because it explores the perception of these subjects with respect to Conversational Technology and technology in general. Consequently, our outcome might lead to the development of more tailored applications for people with NDD able to create a safer and more comfortable context for them (e.g., for therapeutic interventions, daily assistance). For example, the findings of this study will be taken into account

during the next iteration of the Emoty design process to improve the user experience and adapt it to the target audience.

The rest of the paper is organized as follows. In the section below, we describe the context of Conversational Technology for people with NDD, and we mention some previous studies about user perception methods and experiments. In the next section, we make a parenthesis on the user experience (UX) with Emoty. In the following part, we provide the methodology of our empirical study, describing participants, setting, and procedure of the experiment. After that, we report and discuss our observations. Finally, we provide general conclusions, and we outline the following steps in our research.

2 Context

Any kind of NDD is a chronical state, but early and focused interventions are thought to mitigate its effect. Several studies explored the role of interactive technology in NDD. On the one hand, the high children's exposure to chaotic sensory stimulation given, for example, by video-games and multimedia applications, was identified as a possible cause of the increasing number of cases of cognitive disorders during the developmental age [13]. On the other hand, recent research about children's development acknowledged interactive technology as a potentially useful tool to support existing therapies and new approaches to improve the learning process [11][24][2][21][19][1].

The main challenge of interactive technologies (such as conversational agents) for people with NDD is to be accessible for the target user and to accommodate her/his needs. Because of the wide spectrum of NDD and users' needs, NDD-specific CAs should be able to adapt their contents to the user and to customize the way they interact with her/him. Indeed, special user's needs imply special system's requirements.

Some cognitive-disability-specific Conversational Agents became commercially available in the last years. For example, three mobile and tablet applications were recently launched to mitigate anxiety and support depression treatment by simulating the conversations with the therapist: Woebot [27], Tess [25] and Wysa [28]. Furthermore, a recent exploratory study used Amazon Echo in speech rehabilitation [20] for users with cognitive disorders. There are also CAs supporting skills related to communication, emotion expression, and socialization; Rachel [18], for instance, is an embodied CA designed to help autistic children in the creation of semantically emotionful narratives. From some preliminary experiments, children having severe impairments in the interactions with others were more likely to interact with Rachel and more motivated to improve their communication and emotion expression skills.

For assessing technology usability and perception by the users, we considered different validated theoretic frameworks based on questionnaires and self-reports [3][12]. However, these tools require critical and self-critical skills by the user that are often lacking in people with NDD. So far, the investigation on the perception

of Conversational Technologies by users with NDD is still in its infancy, and to our knowledge, there is no structured framework to perform it.

Previous studies explored the tendency to merge the real or imagined behavior of non-human agents with human-like characteristics, motivations, intentions, or emotions [10][14]. Saarem [22] evaluated the anthropomorphic traits of two commercial chatbots and concluded that anthropomorphism plays a central role in our perception of chatbots. The author says that, if applied thoughtfully, anthropomorphic traits in chatbots can increase user engagement and preference of a commercial service, and make a chatbot appear more understandable and predictable to the user.

3 Emoty - The user experience (UX)

In this section, we encompass the main aspects of the end-users interaction with the agent. Since Emoty is a web application, it enables both vocal and visual interactions. Indeed, our Conversational Agent exploits the visual channel as a support to the user. Emoty shows for the entire duration of the game a big button to be clicked by the user before speaking. Besides, the agent provides the user of visual feedback about its status (idle, listening, or speaking) to help her/him to handle the interaction and to understand the system better. Moreover, to facilitate the conceptualization of emotions, the application exploits emojis and colors. The combination emotion-color works as reinforcement to the spoken feedback by the system: joy is represented as yellow, fear is dark green, surprise is cyan, sadness is blue, and anger is red. We associated neutrality to light grey, used as background for the app as well.

Since Emoty is a proactive Conversational Agent, it completely controls the dialogue flow during sessions. After the user logs in, the agent asks her/him a series of questions to steer her/him to familiar domains. It calls the user by name, speaks gently, and with continuous repetitions and explanations of the concepts in order to create a comfortable environment. The user can ask the system to repeat the last non-answered question at any time. The session is structured as a single conversation. Each conversation has a starting and an ending point, and it is structured the same:

- in the first part of the dialogue, Emoty welcomes the user, it puts her/him at ease, it explains her/him the rules of the game, and it asks her/him three questions one by one: "How are you?", "Do you want to play with me?", and "Did you understand the rules of the game?";
- in the second part of the conversation, dialogues follow the four-stage Non-Formal Education model by the American theorist Kolb [15], who promotes education starting from your own experience:
  1. **"experience" stage.** The application asks the user to repeat a sentence trying to express a particular emotion with the tone of her/his voice. At this point, the user sees on the screen both the sentence to verbalize and the emoji of the emotion to express. The emotion is randomly selected among joy, sadness, fear, anger, and surprise. Sentences are picked up

in a randomized order from a pool of very short and easy to pronounce utterances. If a sentence is wrongly articulated, the user has to repeat it;
2. **"reflection" stage.** Emoty lets the user reflect on how she/he faced the assigned task. This phase happens just once out of three because, as we observed during the pilot study, it slows down the game reducing the attention paid by the user;
3. **"conceptualization" stage.** Emoty evaluates the performance of the user just according to the emotion detected from her/his voice. The application provides a correct/wrong feedback to the user. When she/he was correct and properly played the requested emotion, it celebrates her/him with visual and acoustic rewards and then jumps to step 4. Otherwise, Emoty tries to facilitate the task of the user by playing an audio recording by an actor properly reading the sentence; this is to let her/him understand how the task should be performed. At this point, the user can try again to repeat the sentence (as in step 1) up to two more times. When she/he cannot complete the task, Emoty jumps again to step 1, but with a different sentence and a different emotion;
4. **"application" stage.** the CA invites the user to think about common situations where she/he can feel and recognize the emotion just expressed and then jumps to step 1 with a new sentence and a new emotion.

– whenever the user says she/he wants to quit, the conversation ends with some greetings.

4 Methodology

We designed this research following the guidelines of NDD expert therapists and psychologists of the care centers "L'impronta" (Noverasco di Opera, Italy) and "Collage" (Milano, Italy). They also contributed to review the writing of this paper.

With this study, we would like to explore how a population of people with neurodevelopmental disorders anthropomorphically perceives Emoty. To do so, we observed their behavior while interacting with the system, and we took note of all commentaries they made and the questions they asked to their caregiver and us when sessions were over. Advised by the caregivers of both centers, we decided not to administer any questionnaire to participants or hold structured interviews. This choice was dictated

– partly from the lack of the necessary critical ability and self-knowledge in the great majority of our subjects,
– partly from our wish not to let them feel under examination and pressure.

Indeed, our main concern was to let them enjoy a gamified experience with the hope of seeing some emotional learning evidence after a continuous period of use of Emoty.

Starting from their analysis, we looked for behaviors and patterns common among the population and related to the anthropomorphic perception.

4.1 Participants

Participants consisted of 19 people with NDD from the care centers "L'impronta" and "Collage". They included people with Down's Syndrome (3 subjects) and individuals at mild (2), moderate (8), and severe (6) level of cognitive impairment. Most of them were women (9 M, 10 F). Participants varied a lot in age, from 29 to 45 (M = 35, SD = 5,3). The distribution of the population is depicted in Fig. 1. The size and heterogeneity of the population is a limitation to the study.

Only one of the 19 participants offered information about daily experiences with a laptop, but all of them already knew what a computer is, and most of them have a smartphone. Nobody reported previous interactions with similar agents (e.g., Google, Siri, Alexa, and Cortana). All participants provided us an informed consent to take part in the study signed by their parents. Furthermore, to each participant, a unique code was assigned to guarantee the respect of their sensitive data. In the context of this paper, participants' names are changed.

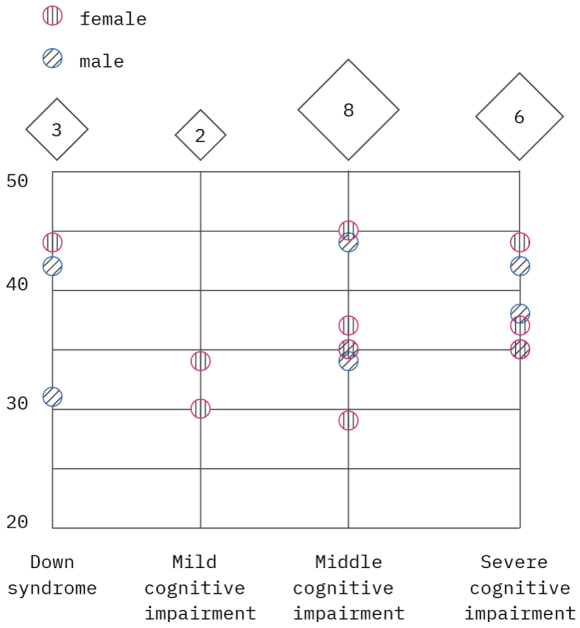

Fig. 1. The overview of the participants to the study

4.2 Setting

The study was conducted in a small quiet room with an internet connection within the daycare centers. This setting was to let participants feel as comfortable

as possible in a familiar space to them. In the room, there was a 15" laptop on a desk and a chair in front of it. On one laptop's side, there was a mouse connected to the PC via Bluetooth. On the other side, there was a desktop microphone connected to the laptop via cable. To create a more welcoming setting for the user and avoid making her/him feel under examination, together with the caregivers, we decided not to use any camera to record the experiment. In addition to participants, people involved in the study were:

- *the Facilitator*: a psychologist or a caregiver known by participants; her role was to manage the experiment at the forefront and to help participants as was necessary (e.g., when they could not click on the mouse by themselves, when they did not understand the task to complete);
- *the Test Observer*: A member of our team, who silently observed the experiment from the background and took notes. We are aware that the presence of an external person could affect the experience of the participants, and this fact could be considered a limitation of our study. To mitigate the impact of this issue, the test observer's position was on the sideline in the room and did not interact with the subjects. In addition, before starting the whole study, the observer introduced himself to the subjects and took part in some activities in the centers (without the use of technology).

4.3 Procedure

The study was designed as a ten weeks experimentation organized in scheduled sessions taking place every week in parallel with daycare centers' activities. Every participant was involved for five times in total (see Fig. 2).

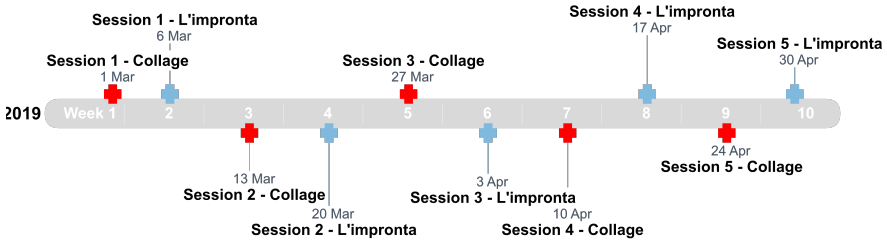

Fig. 2. The timeline of the study

It was explained to the participants that Emoty is an interactive application to discover and learn emotions playing. They spontaneously showed up one at a time to take part in the game. The facilitator received each participant in the experiment room and invited her/him to sit down. Afterward, she performed the login on behalf of the subject to permit a personalized experience (e.g., the user was called by name), and the session started. The user experience was the

one described above in the dedicated section. During the session, the observer focused on how users perceived Emoty and took notes on:

- comments aloud by participants and the facilitator,
- questions from subjects to the facilitator,
- reactions, gestures, and behavior of participants during the experience,
- usability issues (e.g., difficulties interacting with the application due to the use of the button or to participant's pronunciation defects),
- breaking points in the conversation.

Every participant used the application for 8-12 minutes under the supervision of the facilitator. The NDD experts determined the duration for each participant considering her/his engagement and ability to maintain a high level of attention on the same activity. During each session, the facilitator helped the participant with the use of the technology, and by asking her/him whether the received task's instructions were clear. If not, she explained the task again to ensure a correct understanding. When the participant did not feel comfortable with going on with the game, she/he could stop anytime. At the end of each session, participants commented on their experience with the facilitator, but only if they wanted to.

Each study day ended with an hour of discussion among the observer, the facilitator, and us. We schematically described what had happened during the sessions and to collect and organize observations and opinions.

5 Findings and discussion

On average, participants played for 10 minutes and 44 seconds (SD = 3 minutes and 34 seconds).

It only happened twice out of 95 times that one user asked to stop playing because he was not feeling comfortable. Both of the times, the facilitator asked him for explanations, and he said that he did not feel able to deal with this game. The facilitator reassured him and respected his opinion making him stop. Overall, people with NDD, caregivers, and psychologists positively evaluated the experience with Emoty, and almost everybody among the subjects enjoyed interacting with it coherently with the pilot study's outcomes [4]. Caregivers in both centers reported that, even after a considerable time from the end of the experimentation, people keep asking about Emoty.

Even if language impairments have to be considered as a limitation in the use of Emoty, as long as the verbal channel is the only one input, they seem not having influenced the likeability of the experience. In fact, two subjects with middle and severe mental disabilities took part in all five sessions, but they stopped at the introduction every time without accessing the playing part; this was due to their big language impairments. It is relevant to say that their intelligibility is usually difficult even for caregivers, and it is permitted just due to the high-developed capability of humans to read lips, to understand by assonance, to exploit non-verbal channels (e.g., gestures), and to read the context. Anyway,

Fig. 3. One of the participants playing with Emoty[1]

their experience seemed positive; indeed, they both wanted to take part in every session and waited for us to arrive at the center at the front door.

Another limitation of this study is that it is not based on any theoretical framework. Indeed, our investigation into a deeper understanding of how users with NDD perceive Emoty is based on qualitative observations of behaviors, gestures, and commentaries of participants and on the opinions of caregivers and experts. As explained in the *Methodology* section, this choice was dictated mainly from the lack of critical ability in the great majority of our subjects and, consequently, the impossibility to administer any questionnaire. We believe that the lack of a validated framework is not a big issue for our research as it has been conducted under the supervision of NDD experts.

Considering the observations in the reports of every session, we identified four recurring aspects linked to anthropomorphism: gender, fallibility, interaction, and sensitivity. By their analysis, we detected a twofold nature of Emoty perceived by our the participants: in some respects, it is human-like or anthropomorphic, but in some others, it is machine-like.

In this study, we did not observe any differences in perception among participants with different cognitive levels, genders, and ages. However, in future works, we would further explore the variety of perception in different cognitive groups varying the scenarios.

Below, we go into the details of Emoty's dual nature perceived by participants, and we discuss the four main categories of observations we identified.

[1] The participant consented to the picture to be taken and shared.

5.1 Gender

Emoty speaks by exploiting one of the Italian feminine voices by Google. Since this is not metallic and pretends to be human, some of our participants talked about Emoty as it is a she. For example, they asked: "May I am the next one playing with her?" or "How does she remember all our names?". According to Mayer, voice plays an important role in the perception of Conversational Agents and impacts the whole user experience [17]. In this case, Emoty's feminine tone might have contributed to its anthropomorphism process. In the future, we plan to repeat this study changing the voice to a man to see whether or not the "she" changes into a "he", which would make the anthropomorphism argument stronger.

Another important role affecting users' perception of the agent is played by its shape [7]. Emoty has no embodiment but seems to live within the computer. For this reason, some subjects referred to Emoty as a it (i.e., the computer). By doing so, they highlighted the detached, programmable nature of machines. They asked us: "How can it understand me?" or "Did you developed it?" or even "How can I develop my own Emoty?".

In order to reduce the biases attributed to the experimental procedure, the caregivers and we used to answer to their questions by avoiding the use of personal pronouns to refer to Emoty or by using the same one they used in the question.

It was curious to notice more than once that the same participant used both the neutral and the feminine pronoun in different situations. This aspect can be interpreted as a little evidence of the fact that both the human and the mechanical natures of Emoty are perceived and can coexist.

5.2 Fallibility

All participants experienced various challenges getting the agent to understand their utterances. In total, the application was unable to detect them speaking after the button was clicked 1010 times out of 2415 attempts (42%). Participants associated this issue to the fact that Emoty had to be deaf (they said: "She is deaf, isn't she?"), that is a typical characteristic of humans. As a consequence, several subjects tried to increase the level of their voice or make more pauses in their speaking, things that may help people understand them. However, it did not always lead to better recognition with the agent. Moreover, they figured out that when Emoty committed mistakes, it could learn from them as human beings do; they told us: "Today Emoty was a little brat... We hope that she is going to be better next time!".

Regarding the ability of Emoty to recognize emotions from the pitch of the voice, it was notable how everybody facing the application accepted critics and feedback completely trusting the computer because, from their point of view, "a computer cannot commit mistakes". It happened that the same feedback by the facilitator was not taken as kindly as the one by Emoty a couple of seconds later. This episode brings to light the other perceived nature of Emoty that is

the fact that it is an automatic machine and inherently cannot be wrong. After all, the Romans said *"Errare humanum est"* (i.e., "to err is human").

We did not observe any correlation between the perception of the agent by the users and their performances in the game. With *performance*, we mean the number of correctly expressed emotions by all participants divided by the number of attempts. Tab. 1 describes the average performance of the population across sessions. In this context, we do not analyze further these data because, as already stated in the introduction, assessing the potential of Emoty to mitigate Alexithymia and its effects is beyond the scope of this report.

Table 1. The average performance of the population across sessions

Emotions	1^{st}	2^{nd}	3^{rd}	4^{th}	5^{th}
Joy	0,11	0,04	0,18	0.29	0.20
Sadness	0.43	0.40	0.46	0.43	0.50
Anger	0.00	0.36	0.46	0.20	0.43
Fear	0.12	0.25	0.27	0.33	0.47
Surprise	0.00	0.29	0.10	0.19	0.27
Generic emotion	**0.13**	**0.26**	**0.27**	**0.27**	**0.41**

5.3 Interaction

The facilitator observed that interacting with Emoty using natural language was perceived as more natural and intuitive than traditional touch or keyboard-based interactions. This aspect is one of the factors that contributed to producing engagement in the participants.

Unfortunately, as already discussed above, limitations of the currently existing technology did not permit everybody to be easily understood through the voice. For example, Giulia did not catch the imperfect mechanical nature of Emoty and tried to make herself understood as she usually does in human-human interaction: she moved the head and made gestures to reinforce the idea expressed by babbling. It was not clear for her that the machine in front of her could not cross-compare inputs from many communication channels but was considering just the oral one.

The mechanical nature of Emoty was perceived more easily by others, who commented: "Sometimes it takes so long to answer!" (Peter) or "I should try to speak slowly and use a simple language to make me understood by the PC..." (Giorgia). Eleonora has some difficulty pronouncing her Ss, and consequently, she was not understood by the system every time she said "si", that means "yes" in Italian. After several attempts, she finally got that she could express it in alternative terminology (e.g., "certo", that means "of course"). Afterward, she told us happy: "It took me a while to understand how to speak to Emoty, but now it is fine!".

The use of the mouse to wake-up the system was non-natural as well. During the first session, it seemed a difficult practice for almost all participants (18 out of 19 could not interact autonomously with the app). This issue, as discussed with the caregivers, is probably related to the fact that the actions of pointing and clicking with the mouse are completely uncorrelated from speaking. For those people, the facilitator clicked with the mouse in their place. Fortunately, the interaction with the application became smoother session by session for some of them, and in the last session, 7 participants out of 19 played autonomously. From another point of view, some users appreciated the sense of agency offered by the mouse. For example, Julia commented: "I like that I can decide when I am listened to and when I am not by using the mouse".

5.4 Sensitivity

We noticed that Emoty was perceived with feelings, exactly as a real human. This fact probably happened because Emoty was presented at first as "the game of emotions", and it introduced itself as "an emotion expert". As a consequence, some participants behaved as if they were facing a real human. For example, as a joke, a participant insulted and threatened Emoty to throw the computer away if he would not have been correctly understood. Other subjects, on the contrary, tried to reassure Emoty that following time, it would have understood their speech better and that they would have helped it by expressing emotions with more drama. When in the first part of the session Emoty asked them how it was going, they opened up themselves telling about personal events and thoughts (e.g., the fear of the dentist on the next day, how was the Easter holiday, the nephew's birth, the defeat of the favorite team).

It is important to mention that even speaking about sensitivity, the mechanical nature of Emoty came out: according to the facilitator, some users tended to be more eager to interact with our device rather than to speak to other people. Francesca e Giorgia admitted that they felt more comfortable practicing with Emoty rather than to act in the theater lab with their friends.

6 Conclusion and future works

In this study, we observed 19 people with NDD interacting with Emoty for five times. From our qualitative observations, we detected a twofold nature of Emoty perceived by the participants of our study: in some respects, it was human-like, but in some others, it was machine-like. More in detail, it was perceived as a human

- as they listened to her feminine voice,
- as they spoke to her in natural language.
- as they worried about her feelings,
- as they confided personal facts to her,
- as they got angry with her when she did not understand them,

– and as they asked about her after a long time from the end of the experimentation.

On the contrary, it was perceived as a machine

– as they were asked to adapt their way of communicating in order to be understood,
– as they felt more comfortable acting in front of it rather than in front of their friends,
– as they saw it as infallible.

With this study, we paved the ground towards a better understanding of the anthropomorphic perception of people with NDD concerning Conversational Technology.

The natural follow up will be to explore their perception of commercial Conversational Agents (e.g., Google Home, Alexa, Siri) and to compare results. Also, we want to iterate the design process of Emoty again starting from the findings of this study: we want to increase the human-like, natural, and engaging perception of the system by the target user. To do so, we will explore the impact on the user's perception of a virtual character anthropomorphizing the agent Emoty.

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