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A Social Robot to Support Children's Role-play

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Abstract

Creativity is a non-static trait that can be trained and improved from an early age. Children when they join the education system, have a decline in creativity due to the pressures of fitting in with their school peers. This decline can be countered with the help of creativity training tools, but such tools still look like tests and are not appealing to children. Robots have proven to be valuable tools to increase the engagement of children in activities, and when combined with storytelling have been demonstrated to help train creativity. Robots also have benefits when used in a shared autonomy context increasing users' performance in tasks while still retaining their trust. Shared autonomy allows the combination of human attributes with the attributes of a robot. In this dissertation, we present a study using a semi-autonomous robot that explores a simulated shared autonomy by a wizard in a storytelling activity. We measure in a storytelling activity, the impact of two different reactive strategies on creativity. These reactive strategies consisted of six autonomous behaviors that were displayed either randomly at key moments of the story or displayed according to the context and content of the story. We show that when children have lower baseline values of creativity, the semi-autonomous robot, combined with random emotional behaviors, has a positive impact on the fluency and originality of the stories.

Keywords

Shared autonomy; Creativity; Storytelling; Child-Robot Interaction.

Resumo

A criatividade é um atributo que pode ser treinado e melhorado em qualquer idade. Quando entram no sistema de ensino, as crianças sofrem um declínio dos níveis de criatividade devido à pressão de se integrarem com os seus colegas. Este declínio pode ser contrariado com a ajuda de ferramentas que treinam este atributo, mas estas são parecidas com testes e não são apelativas para as crianças. Os robôs já mostraram ser ferramentas úteis para aumentar o nível de envolvimento das crianças em diferentes tipos de atividades e quando combinados com atividades de criação de histórias já demonstraram ter um impacto positivo no treino da criatividade. Os robôs também apresentam benefícios quando usados em contextos de autonomia partilhada, aumentando a eficácia do utilizador na execução de tarefas mantendo a confiança do mesmo no sistema. Nesta dissertação apresentamos um estudo completo usando um robô semi-autónomo, que explora o uso de uma autonomia partilhada simulada por um investigador, numa atividade de criação de história e medimos o impacto que duas estratégias de reação têm nas diferentes métricas de criatividade durante a atividade. Estas estratégias de reação consistem em seis comportamentos autónomos que foram demonstrados, ou de forma randomizada em momentos relevantes da história, ou em concordância com o contexto e conteúdo da história. Concluímos esta dissertação mostrando que as crianças quando apresentam um valor mais baixo de criatividade o robô semi-autónomo quando combinado com demonstrações aleatórias de emoções, tem um impacto positivo na fluência e originalidade das histórias.

Palavras Chave

Autonomia partilhada; Criatividade; Criação de histórias; Interação Criança-Robô.

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Acronyms

TCT-DP Test of Creative Thinking - Drawing Production

BCI Brain-Computer Interface

HRI Human-Robot Interactions

1

Introduction

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Creativity is an interaction that produces a novel and useful product, and it can be applied in many different contexts providing improvements in people's everyday lives [3]. Kovac [4] showed how creativity is highly correlated with prosocial behaviors, a sense of humor, and with less aggressive behaviors. Moreover, Plucker [5] presented how communication and creativity can positively impact conflict resolution and mediation.

Since it is not static and can be improved [3], creativity has been shown to increase with tools that help enhance it. These tools have been developed by psychologists and engineers, to practice divergent and convergent thinking and have been applied with varying degrees of success [6–11]. To help children engage more when using these tools, robotic toys have been used and have been shown in past experiments to have a positive impact on children's creative processes, when programmed to stimulate that trait [2, 12–14].

These robotic toys were fully autonomous but shared autonomy allows a user to control the robot while the robot aids the user with autonomous behaviors. These behaviors have been shown to help the user increase efficiency in tasks, while still maintaining the user's trust in the system [15, 16]. These benefits from shared autonomy provide opportunities to explore them in creativity training tools.

1.1 Problem

Since creativity is not a static trait [3], it can also decrease, and this event is very noticeable in children at the age of 7 years old [3]. At this age, children have just joined the education system, and this pattern of decreased creativity can be related to the need of fitting in with their peers, by conforming to the group behaviors [3]. It can also be related to creativity being seen often as disruptive behaviors by school teachers [17]. This is a real problem and it is often referred to by the "Creativity Crises" [3] or the "Creativity Slump" [18].

Adding to that, with age increasing we get more cautious taking fewer risks which leads to less exploratory behaviors and less original ideas [3]. This pattern combined with the lack of tools to enhance creativity, and the ones that exist are very similar to tests [1], makes training and enhancing creativity a very hard and not-so-pleasing task.

1.2 Approach

In the area of children's creativity, storytelling has proven to be a valuable tool [1]. Storytelling provides the ability to create stories without imposed boundaries and guidelines that are present in other forms of story creation like writing. When robots are programmed to stimulate creativity, they can provide children with a playful and stimulating activity that helps enhance their creative processes [2, 12–14].

Since children suffer a decline in creativity at the age of 7 [3] robots can take a major part in helping increase children's creativity. These robots have features that regular toys do not usually have like programmable movements and rotations, programmable sounds, and different sorts of inputs (buttons and proximity sensors) that can also be programmed.

These features allow robotic toys to be used with shared autonomy, where a child controls the robot while telling a story, and the robot performs autonomous behaviors to trigger convergent or divergent thinking in the child. We study how shared autonomy helps children create stories, by combining the teleoperation of the robot with different emotion-related sounds, and emotion-related movements displayed by a robot during storytelling. The child using a controller, moves the robot constructing and telling the story at the same time, and the robot displays autonomous behaviors based on the content of the story.

We looked at the benefits of shared autonomy and storytelling and how we could combine them with the benefits of robots in creativity. This resulted in the first design of our system which was composed of a robot and a controller that could move the robot in discrete movements in four directions. This design was validated and suffered minor improvements in sounds and movements to allow better recognition of which emotions they were relating to.

These emotion-related sounds and movements were triggered by a wizard, that had an application where it was able to also track the total time of the experiment, pause the experiment when needed, and stop the experiment. The total amount of emotions available to trigger in the application was six: happy, sad, scared, disgust, surprise, and anger. All of these included movements and sounds.

We conducted a between-subjects experiment where a child was asked to create a story using the robot as the main character. To evaluate the impact of emotions displayed by the robot in the overall storytelling and in the child's creative process, we created three conditions: teleoperated where there were no emotions displayed during the storytelling, random where emotions were triggered in key moments of the story, but these emotions were picked randomly, and story where the emotions were triggered also in key moments of the story but were also related to the story itself. We then gathered the data from the creation of these stories and analyzed them.

1.3 Goals

The goal of this work was to provide insights into the impact of shared autonomy with reactive behaviors on a storytelling activity and a system that could be utilized to help children practice and improve their creative process. To achieve that we set the following goals for our work:

- Design and develop an application that allows the wizard to trigger emotions recognizable by the child with the robot, as well as allow a remote controller to send commands to the robot;

- Collect the data from the wizard application and the story creation process and analyze it to check the impact of the emotions and shared autonomy on the overall creative process;

1.4 Thesis Outline

This thesis is organized as follows: in Chapter 2 we will cover the background of this thesis by surveying the existent work on creativity and storytelling, and the related work by gathering the literature available on creativity stimulation with robots and storytelling with robots. In Chapter 3 we present the final version of the prototype used throughout the study and we describe in detail the design process. In chapter 4 the user study is detailed also presenting the data collected and we finish by evaluating the results. In the last chapter, Chapter 5, we write the final observations from the work done throughout this dissertation and elaborate on future work and improvements.

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Background & Related Work

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2.1 Background

To be able to conceptualize and develop a shared autonomy storytelling activity, some concepts need to be clarified regarding shared autonomy, creativity, and storytelling. In this chapter, we are going to cover each one of these background topics to better identify the existing constraints on training creativity and explore the benefits of storytelling. We are also going to look at previous work done with shared autonomy and the advances and limitations of each work. We end this chapter with a discussion of the literature collected and the existing gaps between the three topics.

2.1.1 Creativity

"Creativity is the interaction among *aptitude*, *process*, and *environment* by which an individual or group produces a *perceptible product* that is both *novel* and *useful* as defined within a *social context*.". This is the definition created by Plucker et al. [3] but it's one of many definitions created by researchers about creativity. In their work Plucker et al. [3] presented some of the problems and myths regarding creativity, as well as presenting some areas where creativity can have a positive impact and improve people's lives. These problems have been explored for many decades and can affect how creativity is perceived and how we don't explore it to its full potential. For instance, Furman [19] showed how teachers mostly use direct teaching methods which lets them control all the student's activities but leads to a lack of questions where students can be original and use their own ideas. It also showed how students are not encouraged to ask questions and how the classroom environment is set so that these questions were limited to a minimum. Torrance [18] also presented how children in the fourth and fifth grades were experiencing a slump in creativity and how some of them would not even recover from this slump. This data shows how classrooms lack methods to potentiate children's creativity and how this slump could affect children for many years.

Adding to its problems, creativity also has preconceived notions that do not align with reality, like people being born creative or uncreative [3]. These notions were refuted by studies showing how training can positively affect and foster creativity [20–22]. In the work done by Scott et al. [23], they collected 70 prior studies on creativity and found that creativity training is effective and can be used for all ages. From the data collected, divergent-thinking and problem-solving criteria were positively impacted by creativity training with the population from 14 years old and up, showing stronger effects on attitude and behavior, and the younger population (under 14 years old) showing stronger effects on performance. This study from Scott et al. [23] also shows that creativity training is not only effective in academic environments but also effective in organizational environments.

Another preconceived myth is that brainstorming in groups provides more creative ideas than brainstorming individually [3]. This has proven to be false by the work of Diehl & Strobe [24]. They conducted experiments to investigate and evaluate the differences in productivity between individual and group brainstorming and found that subjects produced more ideas when working individually. They also found that participants would censor their own ideas when working in groups due to the presence of outside observers. In the last experiment of their work Diehl & Strobe [24] also found out that the verbalization of the ideas as they occurred produced double the number of ideas than having to wait for their turn to speak.

But creativity has shown that it has many benefits, Baer [25] has shown that creativity makes life better by bringing joy, wonder, efficiency, excitement, and pleasure. Kaufman [26] also shows that creativity helps people live happier and more meaningful lives, and brings more attention to talented people who are usually overlooked by traditional measures like IQ. Creativity can also have a positive impact on conflicts when combined with communication [5].

With our fast-growing society powered by the boom of technology, people need to be more creative since creativity has shown to be a powerful tool in a response to evolutionary changes [27]. Creative people are shown to be more flexible to changes and more capable of coping with advances and opportunities that arise with change [27]. This flexibility provided by creativity also allows late-life adaptations and growth, with adults tending to rely on routines becoming unflexible [27].

Given all the benefits of creativity, many exercises were developed to try to stimulate and enhance this trait. Fink et al. [6] created an exercise to generate uses of 68 given conventional objects and conducted a study on how other people's ideas may influence the creativity of the participants. They discovered that when exposed to other people's ideas, participants were more creative but only on common and moderated creative ideas. Baer [28] observed that divergent-thinking training in children in the seventh grade, on a specific topic had a positive impact on creativity when applied to that same topic. This work combined with the work of Birdi [29], a study on how training creativity has a positive impact on employees of a government organization, shows that divergent thinking training enhances creativity. Birdi et al. [8] have also shown that the theory of inventive problem solving (TRIZ) creativity training program made a noticeable impact on the employees of an international engineering firm. The study showed that employees participating in the training program had short-term improvements in creative problem-solving skills and motivation to innovate and long-term improvements in idea suggestions in their workplace. In a university environment, Cheung et al. [30] also showed how a one semester-long course can impact positively the verbal and drawing creativity of students that participated in that course. These students also rated the course as useful and their creativity to have improved after taking the course.

To evaluate the benefits of creativity is also important to have tests that measure the levels of creativity. The Test for Creative Thinking-Drawing Production (TCT-DP) was created by Urban [31] and assesses the creativity level by evaluating a drawing on fourteen different metrics:

1. Continuations (Cn): Any use, continuation, or extension of the six given figural fragments.
2. Completion (Cm): Any additions, completions, complements, or supplements made to the used, continued, or extended figural fragments.
3. New elements (Ne): Any new figure, symbol, or element.
4. Connections made with a line (Cl) between one figural fragment or figure or another.
5. Connections made to produce a theme (Cth): Any figure contributing to a compositional theme or ”gestalt”.
6. Boundary breaking that is fragment dependent (Bfd): Any use, continuation, or extension of the ”small open square” located outside the square frame.
7. Boundary breaking that is fragment independent (Bfi).
8. Perspective (Pe): Any breaking away from two-dimensionality.
9. Humour and affectivity (Hu): Any drawing which elicits a humorous response, shows affection, emotion, or strong expressive power.
10. Unconventionality, a (Uc, a): Any manipulation of the material.
11. Unconventionality, b (Uc, b): Any surrealistic, fictional, and/or abstract elements or drawings.
12. Unconventionality, c (Uc, c): Any usage of symbols or signs.
13. Unconventionality, d (Uc, d): Unconventional use of given fragments.
14. Speed (Sp): A breakdown of points, beyond a certain score limit, according to the time spent on the drawing production.

This test was conceived to be used on all ages, simple and cheap to allow it to be widely used, and culture-independent.

2.1.2 The Benefits of Storytelling

“Storytelling is the activity of writing, telling, or reading stories” [32]. In its many forms, storytelling has different benefits that have been studied and tested. For instance, Rubegni and Landoni [33] have shown how a digital storytelling application has a positive impact on children’s ability to discuss the contents of a story. It has also shown how it can support children in being creative and organizing their work. This application consisted of an iPad application that was divided into three modules that supported children in creating their stories: the definition of the story plot and structure, the media creation and editing, and sharing the story. Yilmaz and Goktas [34] have also shown how interactive storytelling in augmented reality has a positive impact on the creation of stories. In their study, they found that students that created stories with the help of augmented reality created longer stories and better narratives.

Storytelling has also shown its benefits in stimulating creativity. Sylla et al. [35] conducted a study on how a picture card platform can promote children's creativity while supporting and guiding the construction of logical stories. This picture card platform consisted of a cardboard sheet and a set of cards that contained scenery, characters, and nature. Children would then create their stories by placing the different cards on the cardboard and telling the story as they placed the cards.

Wallbaum et al. [36] showed how a storytelling kit for exploring emotions with children had a positive impact on the recreation of scenes from a pre-constructed story and on the ability of children to create their own personal narratives. It also allowed children to better express their emotional states and react to them.

2.2 Related Work

As we can see from the background work collected, there is a need to stimulate creativity in children, especially in the fourth grade where the slump occurs. We can also see how storytelling has numerous benefits for children and can contribute positively to children's creativity. In this section, we will cover the related work done in the area of storytelling with robots, robots and creativity, and the related work done in shared autonomy.

2.2.1 Robots for Creativity

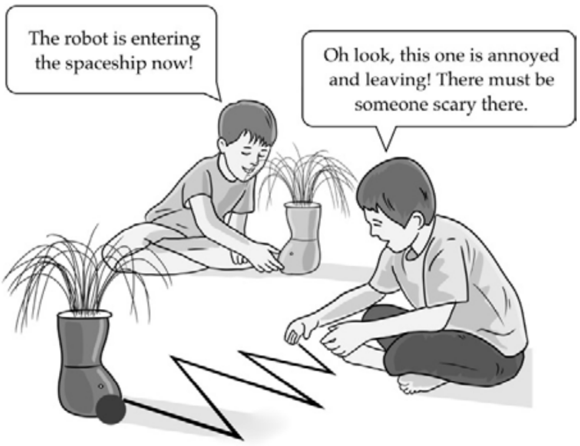
Creativity has been studied in social sciences for many decades on its benefits when trained and its drawbacks when neglected. Due to the many benefits of training creativity, it started to become a popular topic in the human-robot interactions field, with various papers covering the different aspects of the creative process and how robots can impact it positively.

Kahn et al. [37] introduced the first work on creativity and human-robot interactions by creating a task where participants were asked to produce creative ideas on a Zen rock garden. The forty-eight participants were randomly assigned to one of two conditions: the robot or the PowerPoint. On the robot condition, the authors designed 10 human-robot interaction patterns that would try to stimulate the participant's creative process. These patterns were also combined with the robot pulling relevant images and videos on the topic to help the participants. The results showed that these patterns were able to help stimulate the creative processes of the participants, by doubling the creative expressions from the control condition where the PowerPoint was used. Also, the participants would spend more time when interacting with a robot than with the PowerPoint.

Based on the results and the success of the experiment described above, Alves-Oliveira et al. [38] analyzed the impact that a robot would have on creativity in a drawing experiment. The experiment consisted of a Test of Creative Thinking - Drawing Production (TCT-DP) test that was done in two conditions: the first one where the participants interacted with a robot and the second one where the participants interacted with a tablet. The participants, and the robot or the tablet, depending on the condition, had two turns where they contributed to the drawing. The experiment found no significance in the results when comparing the robot to the tablet, however, it opened the door to expand the subject of co-creative processes between humans and robots.

When it comes to children, creativity hits different levels throughout the different stages of childhood. When children join the school system at the age of 6 to 7 years old, their levels of creativity suffer a huge decline [3]. This can be explained by the need for acceptance by their peers and by the organization and structure of the education systems.

(a) The YOLO robot



(b) Activity mock

Figure 2.1: From the work of Alves-Oliveira et al. [1]

Alves-Oliveira et al. [39] created a social robot named YOLO, co-designed with children (see Figure 2.1(a)) and showed how it could help increase children's creativity in a storytelling activity [1]. The authors compared the robot's ability to stimulate the creative process using three conditions: the simple condition where the robot would display creativity-stimulating behaviors, the enhanced condition, where the robot would display the same behaviors as in the simple condition plus social behaviors, and the control condition where the robot was turned off. The creativity-stimulating behaviors consisted of two patterns of movements when playing with the child, the mirroring and the contrasting technique. When mirroring the robot would convey the actions of the child to support the initial construction of the story, and in the end to support the conclusion of the story. The contrasting technique on the other hand serves the purpose of contradicting the movements of the child to stimulate creative processes simulating a plot twist in the story. To evaluate the efficacy of such patterns the authors measured creativity in two different ways: the creative person and the creative process. To measure the creative person, the authors measured verbal creativity using the CREA test and graphic-figural creativity using a TCT-DP test. The creative process was measured using the traditional objective scoring system of creativity composed of fluency, flexibility, elaboration, and originality. From the results, the authors concluded that there was no significant effect on the pre-test and post-test measures between the different conditions, however, on the creative process, the authors concluded that the robot in the enhanced condition was able to help increase the flexibility, elaboration, and originality. This work shed light on the ability of robots to stimulate children's creative process and provided valuable insights into the measurement techniques used to measure creativity.

Elgarf et al. [12] also tried a different technique to see if a social robot could positively impact children's creativity. Instead of using the convergent and divergent-thinking techniques present in Alves-Oliveira et al. [1], the authors used two emotional regulation techniques: promotion and prevention. In the promotion technique, the robot would express verbal and non-verbal behaviors that would suggest happiness and excitement, and in the prevention technique, the robot would express verbal and non-verbal behaviors suggesting fear and anxiety. The study was divided into two main activities: the prime activity and the story activity. In the prime activity, the child was asked to imagine themselves and the robot locked in a spaceship, where the objective was to collaborate with the robot in order to find a key and escape the spaceship. In this first activity, the game would vary depending on the condition, being a reward-seeking game in the promotion condition and a risk-avoidance game in the prevention condition. If they managed to get out on the promotion condition they would be rewarded with a gift and if they managed to get out on the prevention condition they would escape and survive an explosion.

The storytelling activity part was divided into a pre-test that happened before the priming activity and a post-test that happened after the priming activity. These tests were intended to check if the prime activity had any impact on children's creativity levels. On these tests, children were asked to create a story and tell it to the robot. These tests were then measured using four different metrics: fluency, flexibility, elaboration, and originality. From the results, the authors concluded that children in the promotion condition had higher values of creativity in fluency and average originality when comparing the two tests (pre and post).

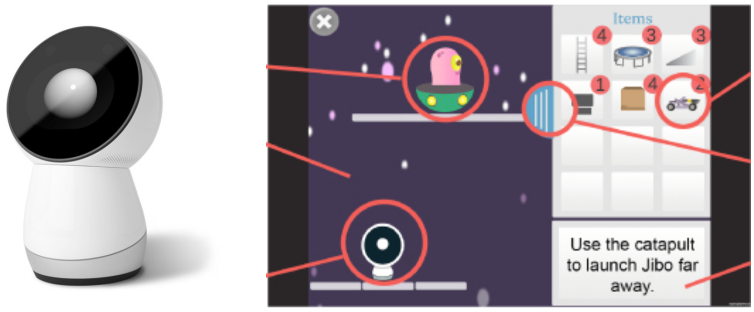
Ali et al. [13] explored how a social robot can impact children's creativity when playing the Droodle Creativity Game. This game consisted of generating creative titles for ambiguous images. The robot played the game with the child and interacted verbally and non-verbally exhibiting a curious expression in body posture and eye expression. The children were divided into two groups, the ones who participated with the non-creative robot (control condition) and the ones who participated with the creative robot. The hypothesis was that participants interacting with the creative robot would generate more ideas, explore more themes and generate more creative ideas than the ones interacting with the non-creative robot. The researchers measured the creativity from the interactions using three metrics: fluency, novelty, and value. The fluency metric was collected by counting the number of ideas generated by the participants, the novelty was collected by counting the number of unique themes explored, and the value was collected by the droodle creativity scores for each of the ideas generated. The results of the experiment showed that when interacting with the creative robot, children generated more ideas per play, explored more different themes of ideas, and also generated more creative ideas.

To explore figural creativity, Ali et al. [14] studied how a social robot, taking turns with a child on a collaborative game, could influence positively the child's creative process. In the game, one of the players would start by drawing an initial incomplete drawing without any meaning, and the other player had to complete it and make it something meaningful. The authors conducted the study with two conditions, one where the child would interact with only the tablet and the other where the child interacted with both the tablet and the robot. To evaluate and collect the data from the levels of creativity, the authors used a TTCT test as a pre-test and a TCT-DP test to evaluate the drawings from the child. They also applied a questionnaire after the end of the activity to understand children's perceptions of the robot. They concluded that the data was not statistically significant to support their hypothesis on figural creativity increasing with the presence of the robot.

The authors conducted a second study with the same game and tests, where the robot was present in both conditions but the drawings of the robot were more or less creative depending on the condition [14]. They collected the results and found that participants who interacted with the robot on the creative condition scored significantly higher on creativity than participants who interacted with the robot on the non-creative condition.

The results from both studies show that figural creativity did not increase with the embodiment of the robot, but it increased with the different drawing strategies of the robot. The authors hypothesized that the embodiment did not produce the expected results due to the expectation of a physical robot to be more creative than a digital one.

With the positive results from the second study, Ali et al. [2] also explored how a social robot could help children solve a digital creative problem-solving game called Escape!Bot. This game consisted of a sandbox-like game where players assembled contraptions to move the game's character to the goal (see Figure 2.2(b)). The participants of this study were divided into four different groups: virtual and non-creative, virtual and creative, embodied and non-creative, and embodied and creative. The virtual groups had a virtual version of the robot commenting on their different actions while the embodied groups had a physical version of the robot Jibo (see Figure 2.2(a)) commenting. Each of these two groups was then combined with two different types of dialogues, creative and non-creative. From the results, the



(a) The Jibo robot **(b)** The game interface

Figure 2.2: From the work of Ali et al. [2]

authors concluded that children that interacted with the creative type of dialogue took significantly less time to win the game and that children in the embodied and creative dialogue did more spatial planning and used various unique objects as the winning strategy. Despite the positive results, we can also see that children who interacted with the embodied condition were more likely to quit the game before ending and that they found the robot to be more creative but less helpful than its virtual version. Adding to that, the overall conclusion was that the robot's social interactions did not have a significant impact on children's creativity overall, and the authors suggest that in future work, a more reactive approach would possibly yield better results.

Other studies have focused on creative activities and how robots can positively impact them. Hoffman and Weinberg [40] created an interactive improvisational robotic marimba player, that would listen to a human musician and play simultaneously, adapting its improvisation, and McCallum and McOwan [41] added head pose and facial expressions to a drumming robot and they observed longer uninterrupted play sessions.

2.2.2 Storytelling with Robots

As we can see from Section 2.2.1 there is a lack of work done in the area of creativity using storytelling. In this section, we try to cover the work that has been done on storytelling using robots.

Chang et al. [42] studied how a robot could help children learn a second language. To accomplish this, they designed five modes for a robot to serve as a partner for teachers in the classroom. One of the modes was a storytelling mode that the robot would tell the stories using a male or female voice, perform comic actions and play sounds related to the story to increase engagement. The authors collected feedback from teachers before and after the study to understand what were their main concerns when using a robot in a classroom environment and after using the robot what feedback they had on the robot. The teachers had some concerns regarding the usability and the durability of the robot, but after the study the overall feedback was positive and the students also had positive feedback from the robot. The ability to make sounds and role-playing with different voices engaged more the children's attention.

Storytelling can also have benefits in pediatric rehabilitation, Plaisant et al. [43] conceived a storytelling robot for child patients that needed pediatric rehabilitation. The goal of the study was to create a robot to help children that needed to do rehabilitation exercises with lots of repetitions that children usually do not finish. By using the robot to create a story, children had to mimic the movements that the robot would do during the story. These movements were recorded as the child was doing them, and were used later in the story's construction. They were recorded using sensors mounted on two armbands and a hat, and these had to be wireless to avoid tangles during the exercises and movements.

The authors conducted three hours of trials to assess the usability of the robot and found that children were very excited to use the prototype. They also found that the addition of random movements to the robot made the robot feel more alive and that children were jumping and dancing with the robot.

Robots can influence children to engage more in physical activities but can also influence children to engage more in theoretical activities. Munekata et al. [44] studied how robots could help autistic children or children with Down's syndrome in storytelling activities. The robot would stimulate children while they were writing an email by saying encouraging messages. The authors conducted the study for two years and collected data from the stories in the emails written by each child. The results show that the length of the stories increased with each session and that children started to produce more grammatically complex stories.

Druin et al [45] studied the process of designing a robotic pet that supported children during the storytelling process. The pet was designed to be snapped together using a modular system composed of multiple animal parts. Then the children could use the pet constructed to recreate a story they made using a custom application. The authors conducted multiple sessions with children to test and improve the prototype, collecting valuable feedback and iterating on the design of the robot and the application. After all the sessions the authors contributed with the following three design principles for building and designing robots with children: deconstructing the power structures between adults and children, giving voice to all the participants in the design process, and creating a comfortable design environment.

Sugimoto [46] created a system to enable the manipulation of a robot using a handheld projector in a storytelling activity. The activity was divided into three parts: story design, story rendering, and story expression. On the story design part, children would brainstorm about the theme, characters, and plot of their story. The story had a requirement for one of the characters to be played by the robot. After finishing the story design children would start the rendering process, where they would have to draw sketches and describe the robot's behavior. The robot's behavior had to include how it was going to move throughout the scene and what would happen if the robot collided with a virtual object. In the last part, the story expression, children would manipulate the robot's actions using a handheld projector which projects their sketches and manipulates the robot. The results from the study show that the robot supported successfully the children's storytelling activities and when interacting with the robot children engaged more in their tasks.

The novelty of robots can help capture children's attention and make them engage more in activities. Ribeiro et al. [47] used a Lego robotics kit to try to get more engagement from children in a storytelling activity. Children would construct and program the Lego robots to tell the different stories proposed by the authors. Each of the robots constructed by the participants would then be dressed accordingly to their character, and perform the story following the programmed steps. The results showed that students were able to construct and program the robot with high levels of motivation and enthusiasm.

2.2.3 Shared Autonomy in Human-Robot Interactions

Shared autonomy is the coordination between multiple agents on a task or system, where an agent remains autonomous, but respects the autonomy of other agents by adjusting its degree of autonomy [48]. To achieve shared autonomy, the agents should agree on common ground, be transparent about their goals, and communicate between them.

In assistive robots where a user teleoperates the robot, the input from the human and the autonomous assistance from the robot have to be combined to successfully reach a goal. Javdani et al. [16] proposed a solution to improve the shared autonomy between a robotic arm and the user input, by analyzing the history of user inputs and creating a distribution of user goals. This distribution is then used to predict the goal of the human based on the inputs, and provide a faster and more cost-effective solution to reach that goal. The authors conducted a study where participants were tasked with picking up an object using a teleoperated robotic arm using two different teleoperation systems. Each of the objects had to be picked up at least one time in any random order. To evaluate the efficacy of their system, the authors compared their method with a single-goal prediction method and found that their method helped users to finish their tasks faster and with less input provided.

User-driven customization can also be used to increase the efficiency and performance of assistive robots. Gopinath et al. [49] analyzed how user-driven customization performed against pre-defined optimization techniques, by conducting a study where the participant had to use a robotic arm in three different tasks. In the first task, the user was asked to use the robotic arm to reach a single object, using the system in full teleoperation mode and under three different predefined assistance levels. This task was designed to enable the user to get familiar with the control interface and the assistance system. The user would provide verbal feedback on the assistance level to a system operator who would then create a customized version and let the user test the system again. After the customization, the user was asked to perform two more tasks using two pre-defined assistance levels and the customized assistance level, and data was collected from these interactions. The results showed that when using the customized assistance level the users improved their performance on the tasks.

Nikolaidis et al. [15] tried to improve the performance of a human controlling a robotic arm by guiding the human in order to achieve an effective strategy, while still retaining his trust. To do this, the authors created an adaptation model where the system identified if the human controlling the robot was adaptable or stubborn. If the human was adaptable the robot would guide the human to achieve optimal performance in the task, but if the human was stubborn, the robot would comply with the human's orders to retain their trust. To test the system the authors conducted a study with three conditions: the robot using the adaptation model, the robot using a one-way adaptation model by always complying with the human, and the robot using a fixed policy with the objective of always reaching an optimal goal. After the activity, the authors conducted a questionnaire where the participants would rate their trust and perceived collaboration of the robot. The results showed that when using the one-way adaptation model the participants had the worst performance but would rate their trust in the robot higher. In the fixed policy model the participants would have the best performance of the three conditions but the worst levels of trust in the robot. In the adaptation model, the results were balanced between the one-way and the fixed policy, the participants had better performance than the participants in the one-way model and trusted the robot more than the participants in the fixed policy.

The teleoperation of the robot does not require the human to be at the same site as the robot, but using a remote teleoperation system presents vision challenges that impact the precision of the movements. Kofman et al. [50] created a non-contacting vision-based human-robot interface that allows the human to control a robot remotely while getting feedback on the robot's motion and environment. This interface was made using two cameras that tracked the hand of the human teleoperator and transmitted the movements parsed as commands to the robot on the remote site. After receiving the commands the robot applies them while also applying autonomous movements that help the operator. The authors conducted tests on the interface and found that the operator when using the interface was able to place an object on a target with high accuracy.

Shared autonomy has also been used to add some degree of autonomy to wheelchairs, allowing the user to reduce interactions during autonomous navigation. Chang et al. [51] created a wheelchair system that was able to navigate autonomously and choose the navigation path based on user preferences. The user would select a location and the system would try to calculate which path the user was more likely to choose. After this calculation, if the system was not able to predict the path the user had the option to choose one of the paths using a touch interface. This system only collected the user's preference from the path chosen in case of a tie in the calculation process, but there is valuable data that could be collected on user preferences based on previous manual navigations using the joystick or a simulated environment [52].

In shared autonomy systems, the interaction between the user and the robot has to be done using a controller that usually requires physical interaction from the user. Beraldo et al. [53] studied how a Brain-Computer Interface could be used by children to control a robot. This Brain-Computer Interface (BCI) allowed children to operate a robot by looking at images that would trigger brain signals, which were then interpreted and parsed as robot commands.

2.2.4 Discussion

From the papers collected, we can see that there is still a shortage of work related to creativity in human-robot interactions, but the work done has presented some insights and promising data on how social robots can positively impact creativity in adults and children. We can also see that the work done on shared autonomy explores the improvement of user experience and trust in the robot, but does not explore the benefits of shared autonomy in creativity.

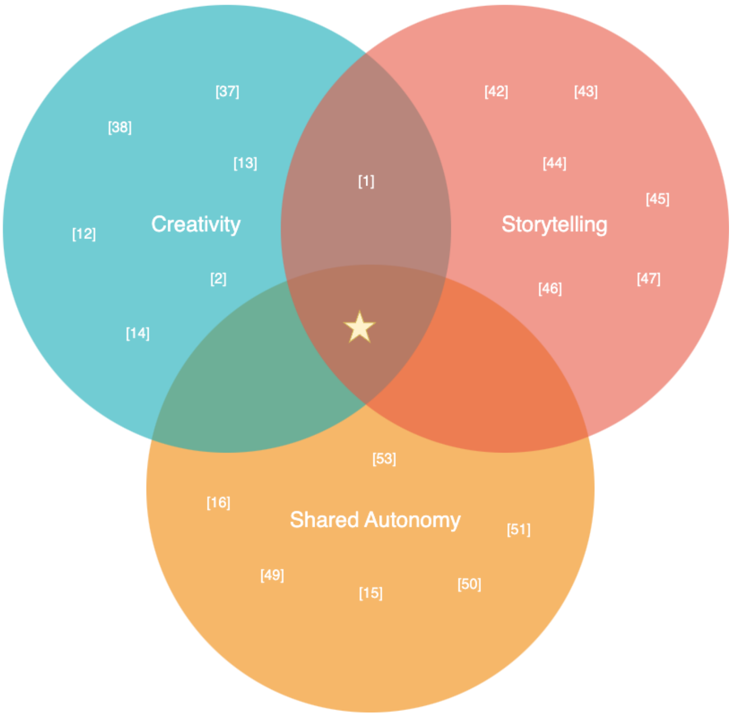


Figure 2.3: Venn diagram containing the literature reviewed

To better visualize the existing gap we created a Venn diagram (see Figure 2.3) that contains the related work done with robots on the topics of creativity, storytelling, and shared autonomy. We can see from this diagram that from our research there is no literature that covers the three topics. The work done by Alves-Oliveira et al. [1] is the only one that intersects the topics of creativity and storytelling. Our work is focused on the intersection of the three topics and its visible in the diagram as the yellow star in the middle.

To analyze the different aspects of the different studies collected we created Table 2.1. We cate-

Table 2.1: Related work on creativity

Paper	Robot Type	Robot Strategy	Type of Activity	Participants
Alves-Oliveira et al. [1]	Moving	Movements	Storytelling	Children
Ali et al. [14]	Static	Speaking & Drawing	Drawing	Children
Elgarf et al. [12]	Static	Speaking	Gaming	Children
Ali et al. [13]	Static	Speaking	Gaming	Children
Ali et al. [2]	Static	Speaking	Gaming	Children
Kahn et al. [37]	Static	Speaking	Rock Garden	Adults
Alves-Oliveira et al. [38]	Static	Speaking	Drawing	Adults

gorized the type of robot used in the studies into two types: static, where the robot was in the same place throughout the activity, and moving where the robot was changing locations during the activity. We also categorized the different robot strategies chosen to try to stimulate the participant's creativity and categorized the different types of activities. In the last column, we categorized the participants by dividing them into two groups: adults and children.

As we can see in Table 2.1 most of the work done in Human-Robot Interactions (HRI) regarding creativity has been focused on drawing or gaming activities. We can also see that the amount of work done with children on the topics of creativity in social robotics is bigger than the work done with adults but it is still a very small amount. In the work done with children, the only study done on storytelling and creativity was the work from Alves-Oliveira et al. [1]. Most of the work on children was done on gaming [2, 12, 13] and drawing-like activities [14, 37, 38]. This shows that there is a sizable gap in the literature on stimulating children's creativity with storytelling using a social robot.

Storytelling with robots has the ability to increase the engagement of children in the tasks [42, 43, 46, 47] stimulating even children with physical impairments to perform longer tasks [44]. These benefits of storytelling have shown its impacts on creativity [1] but the work done on the topic is still very residual and we could leverage more these benefits.

Table 2.2: Related work on shared autonomy

Paper	Novelty	Robot Type
Javdani et al. [16]	Goal Prediction	Robotic Arm
Gopinath et al. [49]	User-driven customization	Robotic Arm
Nikolaidis et al. [49]	Human adaptation model	Robotic Arm
Kofman et al. [50]	Remote teleoperation	Robotic Arm
Chang et al. [51]	Semi-autonomous wheelchair	Robotic Wheelchair
Beraldo et al. [53]	BCI to control the robot	Humanoid Robot

We can also see from Table 2.1 that the majority of the work done on creativity with social robots was using static types of robots that did not allow the child to have any control of the robot. Using static robots meant that the convergent and divergent thinking robot strategies were able to leverage only speech. When using a moving robot we can leverage the advantages of the speech while combining them with the advantages of the robot moving throughout the activity.

Shared autonomy allows the combination of the user controlling the robot while the robot displays autonomous behaviors. Most of the work done on shared autonomy is focused on increasing the user experience using different strategies for the autonomy of the robot or by studying different approaches to the controller type as we can see in Table 2.2.

In this dissertation, we intend to explore the benefits of a social robot with shared autonomy that displays autonomous behaviors in creativity training. This robot is going to be controlled by a child during a storytelling activity where the robot is going to be the main character.

3

System Design & Development

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The design of our system was an iterative process that started with a basic version of the system and that iterated based on feedback provided by our pilot studies. In this chapter, we intend to present the final prototype and describe the design and development process in detail, presenting the reasons behind our decisions.

3.1 Final Prototype

We created a prototype to help children create stories, by stimulating their creative process, using a semi-autonomous robot that was teleoperated by a child and had autonomous behaviors triggered by a wizard. This prototype is composed of a mat with visual cues to help create the story, a robot that is controlled by a remote controller, and an app that allows the wizard to trigger the robot's actions. We tried to always keep the prototype simple so that it has fewer points of possible failures and that is easier to assemble.

3.1.1 Workspace

We chose a mat[1] that looked like a city map, that the robot could navigate through, with visual cues that would help to create the story. This mat had a length of 130 cm and a width of 133 cm, which gives it enough space for the robot to move around. It was also a thin mat with a thickness of 2 cm allowing it to be easily rolled and folded.

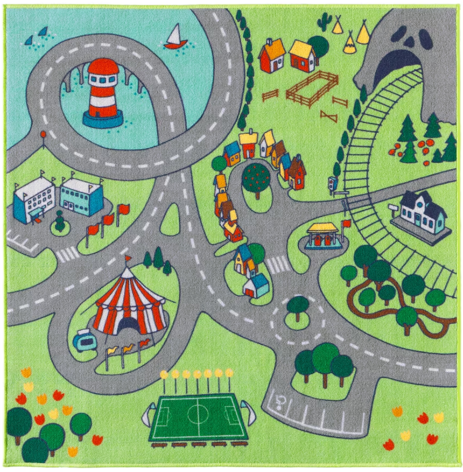


Figure 3.1: Prototype's mat

These visual cues included a lighthouse surrounded by the sea with a boat and some sharks, a circus, a football field, a train track, a farm, a cave, and some other buildings like houses, schools, a gas

[1] https://www.ikea.com/pt/pt/p/stadsdel-tapete-30361910/

station, and a train stop (see Figure 3.1).

3.1.2 Robot

The Dash[2] robot was chosen to be used on this prototype since it provided out-of-the-box many features like real-time Bluetooth, programmable LEDs, potentiometers, and dual motors that allowed position precisely the robot's head, two powered wheels, and a set of speakers. It was also capable of storing sounds, which were recorded and uploaded on the manufacturer's provided app.

3.1.3 Controller

The remote chosen for the final prototype was a PlayStation 4[3] remote and was chosen because of the long-lasting battery and its proven durability. Since we wanted the child to be focused on the story, we chose the movements of the robot to be discrete. This would also allow us to save to a CSV file, each discrete movement the child did throughout the story as well as the direction of each movement (forward, backward, left, and right).

3.1.4 Behaviors

We developed multiple functions with a set of custom movements and sounds for each behavior of the robot. We created a list below to show the different sounds and movements that were made on each of the functions:

Table 3.1: Robot's sounds

Behavior	Movements
Happy	”Wowoo”
Sad	”Ohh” + Sniffing sound
Scared	”Aiaiai”
Disgusted	”Ewww”
Surprised	”Woww”
Angry	”Hmm”

- **Happy behavior:** The robot would play the happy sound (see Table 3.1) twice followed by a 360 degrees rotation.
- **Sad behavior:** The robot would pitch its head down, play the sad sound (see Table 3.1) twice, and pitch the head back to its starting position.
- **Scared behavior:** The robot would play the scared sound (see Table 3.1), rotate its head twice from right to left, play the scared sound again, and move back.

[2] https://www.makewonder.com/robots/dash/
[3] https://www.playstation.com/pt-pt/accessories/dualshock-4-wireless-controller/

- **Disgusted behavior:** The robot would move back and play the disgusted sound (see Table 3.1).

- **Surprised behavior:** The robot would play the surprised sound (see Table 3.1), turn its entire body from right to left twice, with an interval of one second, and play the surprised sound again.

- **Angry behavior:** The robot would move forward, play the angry sound (see Table 3.1), turn its body from right to left, and play the angry sound again.

3.1.5 Shared Autonomy

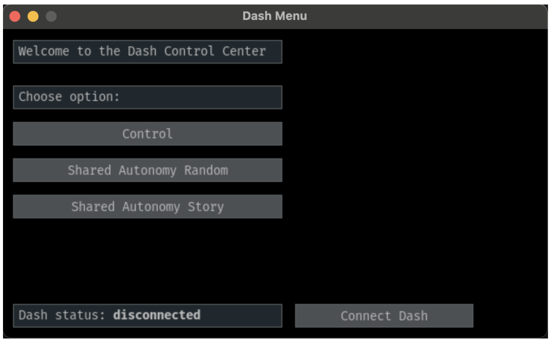
The commands sent to the robot were made using an open-source library[4], that provided an abstraction layer for the hexadecimal values, which represented each possible action of the robot. We created a function for each of the behaviors that would follow a pattern between them. When a behavior was triggered, a command to change the robot's LEDs color to purple was sent to the robot, and when all the movements and sounds from the behavior were finished, a command to change the color of the robot's LEDs to blue was sent to the robot. This provided for the child, a visual cue signalizing that the robot was starting and ending an autonomous action.

We developed an app with a graphical user interface, that allowed the wizard to connect to the robot, and trigger the behaviors smoothly as the storytelling activity was happening. When the wizard initialized the app, a screen with three buttons regarding the different reactive strategies was presented (see Figure 3.2(a)). Choosing the Control option would make a timer appear and a button to start the activity. After pressing start, a CSV file was generated and opened, and a button with pause and stop would appear on the screen (see Figure 3.2(b)). The pause button was intended to pause the activity by disabling the remote, but keeping the current CSV file open, the stop button, on the other hand, was intended to stop the activity, by disabling the remote and also closing the file. The wizard also had a back button to return to the initial menu and these buttons were present on all three screens.

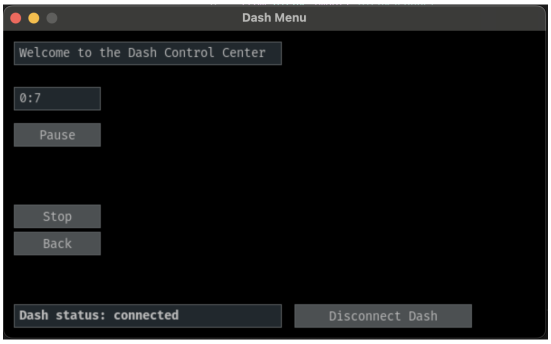
Choosing the Shared Autonomy Random option the same timer, timer controls, and back button as presented above, would appear, but it would also show a button that was able to trigger the different robot behaviors randomly (see Figure 3.2(c)). Choosing the Shared Autonomy Story option would show the timer and the other buttons present in the previous conditions, except the Random Behavior button, and it would also present six other buttons, that would allow the wizard to trigger the different behaviors (see Figure 3.2(d)).

The CSV generated after clicking start on all three screens, would have the same three columns: author, movement, and time. The author column had two options, child and wizard, which the first appeared when a child sent a command using the remote, and the second appeared when the wizard triggered a behavior. In the second column, movement, the options would vary depending on the first

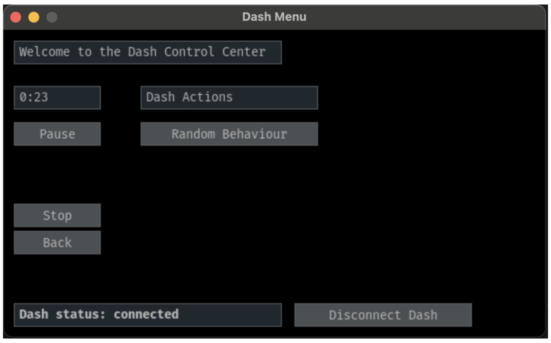
[4] https://github.com/IsabelCanicoNeto/DashRobot



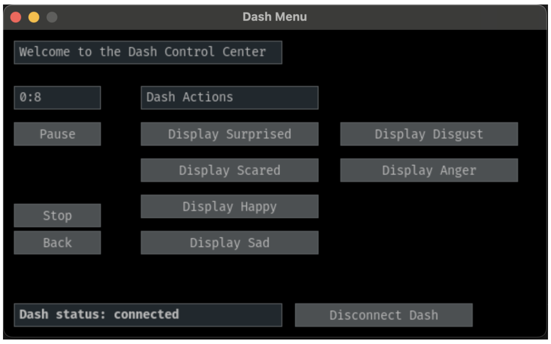
(a) First menu screen



(b) Control screen



(c) Shared Autonomy Random screen



(d) Shared Autonomy Story screen

Figure 3.2: The different screens present on the app

column. If in the first column the author was the child, then in the second column the only options available would be up, down, left, and right. If in the first column the option was wizard the only options available would be happy, sad, scared, disgusted, surprised, and angry.

3.2 Architecture

The architecture behind our prototype was designed to keep the system simple and less prone to failure, and because of that, we opted for a robot that had all the desired features described above and it also had a couple of different libraries available to program it. The overall system was composed of a PlayStation 4 remote, a computer running a python script with a user interface, and the robot.

The computer, running macOS, was essential to connect all the parts of the system. It provided a bridge between the controller, paired with the computer via Bluetooth, and the robot, and it also provided the wizard with a user interface, that would allow it to send the commands to the robot in real time. All the commands sent to the robot and the user interface were made using the Python language combined with two libraries: one that had all the smaller libraries to connect to the robot and send the commands,

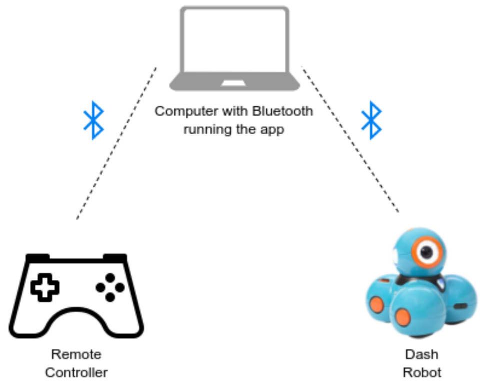


Figure 3.3: System architecture

and the other that was able to retrieve the keys pressed on the remote and also generate the interface with all the labels and buttons.

After running the app, the wizard had the option to connect to the robot using a button that would create a Bluetooth connection between the laptop and the robot. If the connection was successful a message saying *"Dash status: connected"* was displayed to the user. At this stage and with the user choosing one of the conditions from the menu and pressing start (see Figure 3.2) the robot was ready to receive the commands from the remote or from the wizard. These commands were stored in a CSV file that would be named after the condition chosen by the wizard and the time that it was created.

3.3 Development Process

One of our goals with this dissertation was to design an easy-to-use and robust system that allowed the teleoperation of a robot using a controller, and an application that allowed the wizard to trigger the robot's behaviors. To start we designed and implemented a very raw version of the system to test the controller and the wizard application. With this first version of the system, our idea was that the computer would be at the center of all the operations. The USB remote would send the commands to the computer, and the computer would interpret these commands, and send the appropriate movement commands to the robot. Sending the commands to the computer instead of directly to the robot would also allow the wizard application to block the commands issued by the remote, and trigger the behaviors of the robot. These behaviors were a combination of the robot's movements and sounds combined under a function on the wizard application and triggered by a shell command.

Our first version of the wizard application was a shell application that would connect to the robot when it was initiated. After that, it would ask the wizard to enter an option for the reaction strategy that was going to be used and the three options available were control, random, and story. Once one of the options was selected, a CSV file was created to store all the key presses sent from the controller and the behaviors triggered by the wizard. On the control option, the application would not display anything to the wizard and would enable the remote to start controlling the robot. On the random condition, the application would display a message to the wizard explaining how to trigger the random behaviors by typing "random" on the shell. On the story condition, the application would also display a message to the wizard explaining how to trigger the different behaviors by also typing them into the shell.

The first behaviors supported by our application were only four:

- Happy: The robot played a tire squeal sound followed by a 360 degrees rotation of the entire body.
- Sad: The robot played a sad sound from the list of existing sounds shipped with the robot and lowered his head.
- Scared: The robot also played a scared sound from the list of sounds shipped with the robot and do a 360 degrees rotation of the entire body.
- Surprised: The robot would play a surprised sound from the same library of sounds as the other behaviors and rotate his body left and right one time.

For the robot, we chose the Dash[5] robot from Wonder. It was an inexpensive, robust robot that allowed sending commands via Bluetooth to move it, change its LED colors, rotate its head and body, and reproduce sounds. It also had an already-developed API that would allow us to send all these commands to the robot.

We conducted a pilot study on the first version of the system and our goal was to test the wizard shell application as well as get feedback on the usability of the remote. With the feedback received from this study, we created a second version of our prototype and conducted a second pilot study.

3.3.1 Feedback Collected

From the first pilot study with the first version of the robot, we collected feedback from the participants and improved upon what we analyzed as valuable feedback. In the first session we collected the following feedback:

- Controller: The participant liked the controller but had a complaint about the cable of the controller being too distracting.
- Wizard application: The participant perceived beforehand the wizard triggering the robot's behaviors because of the keystrokes on the computer.
- Behaviors: The participant perceived correctly 3 of the 4 behaviors being the scared behavior sound mistaken for a pain sound.

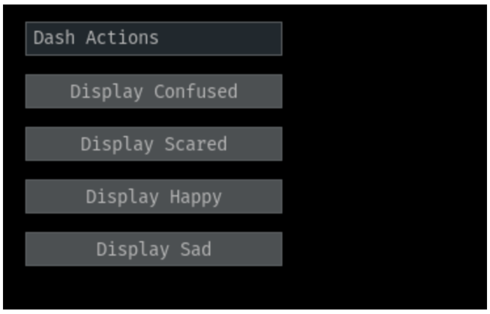


Figure 3.4: First version of the wizard application

After collecting the feedback from the session we made improvements to the overall system. We changed the cable remote with a Bluetooth remote, and we moved from the shell application to a graphical application with buttons to trigger the behaviors (see Figure 3.4). We then conducted the second session and gathered the following feedback:

- Controller: The participant felt that the robot was difficult to steer and that the robot had a big delay between commands.
- Wizard application: When we prepared the session the robot was not able to connect on the first attempt to the application and the researcher had to kill the app and start it again.
- Behaviors: The scared behavior was not perceived correctly.

This feedback collected from the sessions allowed us to improve the overall usability of the system for the participant, and the researcher controlling the wizard. We still had improvements that needed further testing so we created a second version and conducted a second round of pilot testing.

In our second version of the system, we changed the turning angle of the robot from 60 degrees to 50 degrees to improve the precision of changing directions. We also changed the robot's movements to be more responsive by increasing the motor speed and reducing the length of the movement.

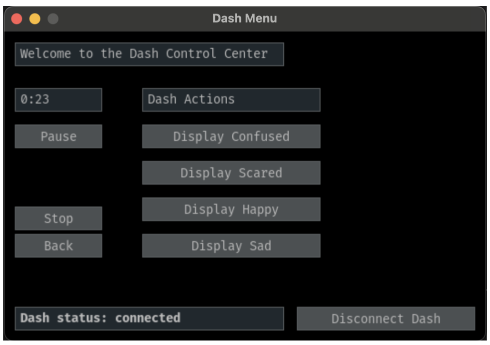


Figure 3.5: Second version of the wizard application

[5] https://www.makewonder.com/robots/dash/

Our wizard application also suffered some improvements (see Figure 3.5), we added a timer on the application with start, pause, and stop buttons. The start button allowed the wizard to only start the experiment when everything was ready, also allowing the remote to be disabled while the task was being explained to the participant. The pause button allowed the wizard to momentarily pause the session when there were unexpected events mid-session. When clicked the CSV file would remain open, the controller would be disabled and the timer paused. To finish the session the wizard had the stop button which disabled the remote, closed the CSV file, and reset the timer. We also added the option for the wizard to connect the robot at any time by adding a connect button and a label that reflected the status of the current connection of the robot.

Figure 3.6: Open day setup

After implementing all of these changes and improving the overall reliability of the system we conducted a second round of pilot studies and collected feedback. In our second pilot study, we added the mat to the sessions and conducted the studies on an open day at Instituto Superior Técnico (see Figure 3.6). Our sessions were smaller than the first sessions due to the time constraints of the event but we collected valuable data that we used to improve the system and create the final version of our prototype.

From the sessions conducted on the open day, we collected valuable insights into the behaviors of the robot and the wizard application. The feedback was positive on the controller, the robot was easy to move around but the participants complained about how the robot was not fast enough. The behaviors were also understandable but due to the noise of the environment, some passed unnoticed during the sessions. We also observed that the speed of the robot was not mentioned in every session and that there were no complaints about the controller.

There was also positive feedback from the sessions on the wizard app, having minor crashes during the sessions and the overall feedback was that the researcher triggering the behaviors passed unnoticed. Even a participant that had done previous work on robotics had trouble recognizing what was triggering the robot's behaviors.

After finishing the sessions we did some improvements to the overall stability of the system by fixing some bugs on the wizard application that popped up during the pilot study sessions. Since we noticed from the sessions that some of the behaviors were unnoticed we added a visual layer to the robot to visually cue the participant that the robot was displaying a behavior. We changed the LED lights of the robot to blue when it was being remote-controlled and to purple when the wizard triggered the behaviors.

We also redesigned the behaviors and added two more: disgusted and angry. From the sessions, we felt that the four behaviors weren't covering all the aspects of the story. We also noticed that some of the existing sounds were not relatable to certain emotions and to overcome this limitation we added new sounds to all the behaviors. We used the mobile application provided by the manufacturer of the robot to record and upload new sounds to the robot. After finishing the changes we were left with the following behaviors:

- Happy: We replaced the tire squeal sound with a recorded happy-like sound and maintained the 360 degrees rotation of the entire body.
- Sad: We replaced the existing sound with a recorded sad-like sound and we kept the robot pitching his head down.
- Scared: We replaced the existing sound with a recorded scared-like sound and changed the rotation of the entire body by rotating its head from right to left twice and moving back.
- Surprised: We replaced the existing sound with a recorded surprised-like sound and doubled the 180 right to left rotation from his body.
- Disgusted: We added the disgusted behavior with a recorded disgusted-like sound and a move back.
- Angry: We added the angry behavior with a recorded angry-like sound combined with a 180-degree left-to-right turn and a move forward.

After implementing all the changes from the feedback collected from the pilot sessions, we had our final version of the prototype ready to be used. We ran some tests before the start of the study to test the overall stability of the system and found no existing bugs.

4

User Study

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The goal of our work was to investigate the impact of shared autonomy on children's creativity in a storytelling activity. We designed two types of reactive strategies: random and story. These reactive strategies were the type of autonomous behavior that the robot would display depending on the story contents. We also wanted to examine whether these different types of reactive strategies can impact the creative process differently. To reach that goal we conducted a between-subjects user study with three conditions: a random condition, where the robot would use the random reactive strategy and display random behaviors in key moments of the story; a story condition, where the robot would use the story reactive strategy and display behaviors in key moments of the story and based on the content of the story; and a control condition, where the robot would not display any emotions. In this chapter we will present our user study and its findings, ending with a discussion of the results.

4.1 Research Questions

The goal of our study was to answer these questions:

- **RQ1:** Does shared autonomy affect creativity in children during a storytelling activity?
- **RQ2:** Can different types of reaction strategies have a different impact on the creative process during storytelling?

4.2 Participants

The user study was conducted at two different places, an out-of-school study club - "Sala do Futuro", and a primary school - "Escola Básica Bolembre", both in Lisbon. Before starting, a consent form (Appendix A) was handed to the parents of the children who wanted to participate in the study. After signing and giving consent, this form also allowed parents to choose if they want the face of their child hidden during the video recording. The user study was approved by the Ethics Committee of Instituto Superior Técnico.

In total, we had 54 children participating in the activity ranging from 5 to 13 years old, 23 females and 31 males. The average age of the participants was 9.130 years old ($SD = 0.272$).

4.3 Procedure

We chose to conduct a between-subjects study in order to compare the differences between the different types of reactive strategies of the robot. Each child participated in only one session, and the goal throughout the study was to have an equal amount of subjects per condition.

The sessions were conducted in a quiet room provided by the employees of the club and the school. Two researchers were present in all the sessions and were responsible for preparing the setup before the child arrived and guiding the child throughout the study. The session was divided into three main parts: the TCT-DP part, where the child was asked to complete a drawing, the activity part where the child was introduced to the activity and was asked to create a story using the robot, and the questionnaire part, where the child would finish the activity by responding to questions regarding the robot and the researchers.

Figure 4.1: Study layout

In the first part of the activity, the child was introduced to both of the researchers, one of whom would guide the child to seat next to the mat and the robot (see Figure 4.1). The other researcher would hand the TCT-DP form A (see Appendix B) and a pen to the child, explaining how an artist started the drawing but was unable to finish it, and that we needed a complete drawing. At this time the robot was turned off to avoid distractions and the controller was hidden from view.

When the drawing was finished the researcher would explain, that the goal of the activity was to create a story, where the robot was the main character. Throughout the story, the child would be required to try to visit the different places on the mat, with the robot. Then the researcher would explain how the controller works by demonstrating how to move the robot up, down, left, and right and would hand the remote to the child. During this demonstration, the second researcher independently of the condition was sited on a chair with a laptop with the wizard software.

In the control condition, the robot was controlled by the child and would not display any behaviors. One of the researchers would guide the child to help avoid early withdrawals from the activity and would ask the child to give a name to the robot. The purpose of the researcher interacting with the child was also to encourage the child to tell the story out loud since the activity was being recorded for later coding. In the random and story conditions, the researcher would also introduce the activity the same way, and would not give any hints that the robot would do any sort of unexpected behavior. The difference between conditions was that in the random condition, the wizard, which had an app where it could trigger the actions of the robot, would click on the button random behavior when a key moment of the story was happening. These key moments were any emotions or actions that were relevant in the context of the story.

(a) Room Layout **(b)** Final Questionnaire

Figure 4.2: Room Layout and Final Questionnaire

For the story condition, the key moments would be the same as for the random condition. The wizard would be sitting in the exact same spot as the other two conditions, with the laptop facing away from the child's face (see Figure 4.2(a)). The behaviors of the robot would be triggered by a set of buttons, that allow the robot to express 6 kinds of behaviors: happy, sad, scared, disgusted, surprised, and angry. The wizard was able to trigger these behaviors without being spotted because the laptop and the position of the researcher to the child would hide the hands of the researcher. Throughout the 54 subjects the wizard was always controlled by the same researcher, since key moments of the story can always be interpreted differently by listeners. Also, the researcher that was issuing the behaviors would avoid participating in guiding the child, to avoid bringing attention to the laptop.

When the child finished the story the researcher guiding the child would complement the story and retrieve the controller. The researcher controlling the wizard would hit stop to finish the data collection from the controller and the robot. At this point, the child was introduced to the last part of the activity where they had to respond to a questionnaire regarding the robot and the researchers. The researcher would hand a graph with 5 bars starting from completely disagree all the way to completely agree as seen in Figure 4.2(b). This graph served to help children respond to verbal questions. For every 5 verbal questions (see Appendix C), the child was asked to respond to a secret question by drawing on a piece of paper and inserting it into a box. When the questionnaire was finished the researchers would thank the child for their participation and guide the child back to the playground.

4.4 Measures and Data Analysis

The data collected from the activity was quantitative, being extracted from the CSV file export of the wizard app, combined with the data extracted from the video recordings of the interaction, from the TCT-DP test, and from the questionnaires at the end of the activity. To analyze all this data one of the researchers coded the results from the TCT-DP test, leading to a final result on the baseline creativity, and the second researcher coded the videos and audio from the sessions.

Table 4.1: Levels of originality

Originality	Description
1	Very short and non-invested clauses about the locations present in the mat and repetitions of traditional story plots.
2	Creative ways of using the locations on the mat and surprising uses of characters and actions that can have a background of traditional story plots.
3	Creation of new locations not present on the mat, acting and first-person narrative, and rare story plots.

All the sessions were transcribed and coded in 4 metrics inspired by the work of Elgarf et al. [12]: fluency, flexibility, elaboration, and originality. Fluency was coded using a 0 to 5 score composed of the sum of the different story elements expressed throughout the story: character creation and description, describing the setting or location of the story, the plot, the conflict, and the resolution of the conflict. Fluency served to analyze the basic structure of the story since creativity should produce a perceptible product [3]. Flexibility was coded by counting the total different number of characters, actions, scenarios, and affective expressions present in the story. These characters, actions, and scenarios would only count the first time they appeared in the story and repetitions of these were ignored. Elaboration was coded using the videos and audio from the sessions and consisted of the number of seconds the child was speaking about the story. The last metric coded from the transcriptions was originality, which consisted of the overall originality of the story measured from 1 to 3, where 1 was low originality and 3 was high originality, using the coding scheme present in Table 4.1.

From the wizard app, we extracted from the CSV the total time interacting with the robot, the total number of movements issued with the remote by the child, and the number of interactions from the wizard. These interactions from the wizard consisted of the 6 behaviors displayed by the robot.

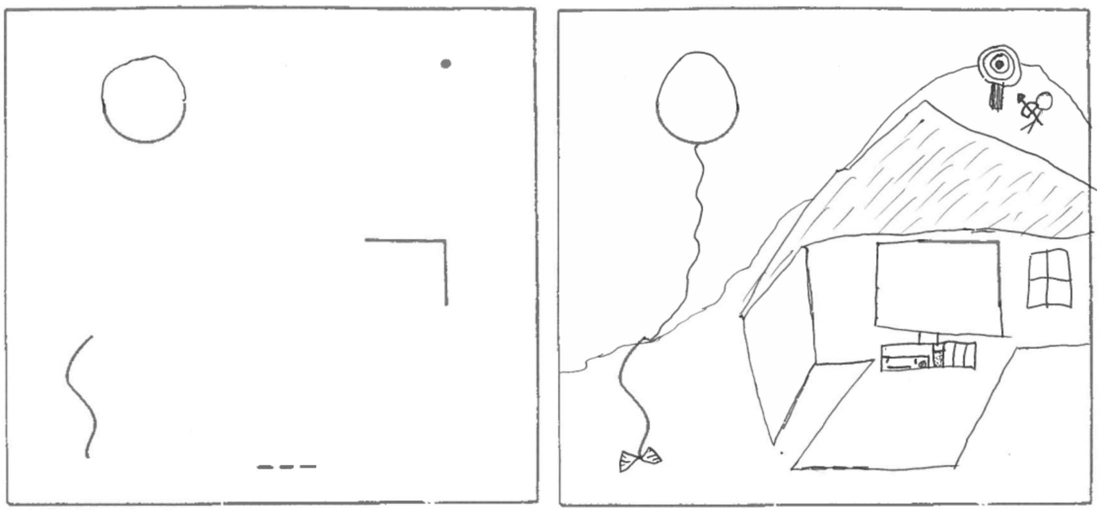
Regarding the questionnaire, we extracted data related to the researchers by asking questions to ensure the researchers were nice and that the activity was well explained. We also extracted metrics related to the perception of the robot by the child and the overall perception of the activity itself.

4.5 Findings

The data gathered from the activity was collected and we performed a statistical analysis to try and answer our research questions. We present the findings in this section.

4.5.1 Baseline Creativity

Baseline creativity levels were not different between the conditions. To analyze the baseline creativity levels among children we compared the different results of the TCT-DP tests. We expected the levels of creativity between the condition's groups, not to be statistically significant. From our analysis, we found no statistically significant difference between control $(M = 21.667, SD = 8.568)$, random $(M = 22.833, SD = 9.811)$, and story $(M = 19.944, SD = 7.780)$, as determined by one-way ANOVA $(F(2, 51) = 0.495, p = 0.612)$. This goes in line with what we expected, confirming that neither of the condition's groups started with more or less creative children than the others.



(a) Lowest Score (2) **(b)** Highest Score (40)

Figure 4.3: Highest and lowest scores on the TCT-DP test

4.5.2 Story Creation

The difference in time interacting with the robot was not statistically significant between conditions. This metric was retrieved from the CSV file and since it wasn't normally distributed we conducted a Kruskal-Wallis Test. We were expecting that the total amount of time could be bigger in the random and story conditions but from our analysis, this did not happen. The test showed that there was no statistically significant difference in the time spent storytelling with the robot between control $(M =$

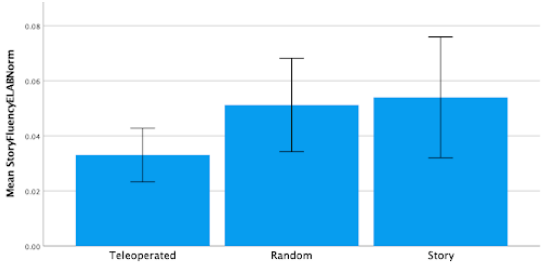
$303.444, SD = 270.667)$, random $(M = 321.944, SD = 344.677)$, and story $(M = 236.500, SD = 171.783)$ groups $X^2(2) = 0.846, p = 0.655$ with a mean rank duration of 30.28 for control, 26.28 for random and 25.94 for story.

One of our concerns initially was that the researcher that was operating the wizard would perform a different amount of emotions between the random and story conditions. **The number of emotions triggered by the wizard was not different between the random and story conditions.** We conducted a Mann-Whitney U Test and found no significant differences between random $(M = 9.667, SD = 8.275)$ and story $(M = 6.111, SD = 3.428)$ conditions $(U = 129.5, p = 0.301)$.

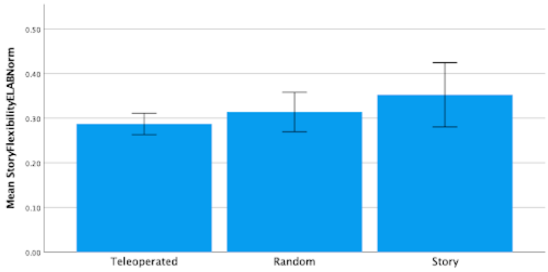
The number of instructions sent by each child from the controller during the activity was not different between conditions. The results from the Kruskal-Wallis Test show that the number of key presses on the remote was not statistically significantly different between control $(M = 206.611, SD = 135.061)$, random $(M = 278.389, SD = 222.818)$, and story $(M = 193.667, SD = 138.924)$ conditions $X^2(2) = 0.680, p = 0.712$. We can also observe that the mean rank of the random condition was 29.92, the mean rank of the control condition was 26.83, and the mean rank of the story condition was 25.75. This shows how the interactions of the robot in the random and story condition were not affecting the total number of movements issued by the child. This is both positive and negative because we would hope that the agency from the robot would stimulate the child to make more movements but at the same time, it also presents that the robot was not affecting negatively the number of movements issued by the child.

The TCT-DP test was significantly and positively correlated with fluency, flexibility, and elaboration. We ran a Spearman's rank-order correlation and found a strong, positive correlation between the metrics of fluency $(M = 3.815, SD = 1.375)$ $(r_s(54) = 0.383, p = 0.004)$, flexibility $(M = 39.259, SD = 37.484)$ $(r_s(54) = 0.397, p = 0.003)$, and elaboration $(M = 136.390, SD = 138.768)$ $(r_s(54) = 0.459, p = 0.001)$ with the TCT-DP test results, but we did not found a correlation between originality $(M = 1.926, SD = 0.797)$ and the TCT-DP test results $(M = 21.482, SD = 8.676)$ $(r_s(54) = 0.262, p = 0.055)$.

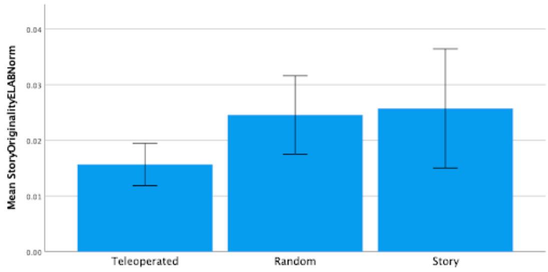
With the activity having no time limit some of the metrics could increase with time. Knowing this we normalized the story metrics, fluency $(M = 0.046, SD = 0.035)$, flexibility $(M = 0.318, SD = 0.104)$, and originality $(M = 0.022, SD = 0.016)$, by the story elaboration. We then ran a Kruskal-Wallis Test and found no statistically significant differences between conditions with the metrics of fluency $(X^2(2) = 3.573, p = 0.168)$, flexibility $(X^2(2) = 1.402, p = 0.496)$, and originality normalized $(X^2(2) = 4.225, p = 0.121)$. We can see clearly a pattern when we normalize by the story elaboration (see Figure 4.4).



(a) Fluency Normalized by Elaboration



(b) Flexibility Normalized by Elaboration



(c) Originality Normalized by Elaboration

Figure 4.4: Fluency, flexibility, and originality normalized by elaboration

4.5.3 Analysis Clustered by the Initial Creativity Levels

One of the goals of this study was to find out if the robot had any impact on children's creativity during storytelling, so we had to compare the baseline of the levels of creativity to the levels of creativity during storytelling. Since we used 3 levels of originality, one of the most important metrics of creativity [3], we decided to create 3 clusters from the baseline levels of creativity (TCT-DP test results): a cluster for the test results with low creativity $(N = 14)$ with an average age of 8.786 years old $(SD = 1.762)$, a cluster for the test results with average creativity $(N = 20)$ with an average age of 8.450 years old $(SD = 1.932)$, and a cluster for the test results with high creativity $(N = 20)$ with an average age of 10.050 years old $(SD = 1.959)$. The low creativity cluster had 4 participants in the control and random conditions and 6 participants in the story condition. The average creativity cluster had 8 participants in the control condition, 6 participants in the random condition, and 6 participants in the story condition. The high creativity cluster had 6 participants in the control condition, 8 in the random condition, and 6 in the story condition.

Using these clusters we ran a Kruskal-Wallis Test and found that in the low baseline creativity cluster, there was a statistically significant difference in fluency normalized by the elaboration $(M = 0.068, SD = 0.050)$ (time spent telling the story), between the different conditions $X^2(2) = 6.157, p = 0.046$ and that there was also a statistically significant difference in originality normalized by the elaboration $(M =$

$0.032, SD = 0.024)$, between the different conditions $X^2(2) = 6.019, p = 0.049$. However, the flexibility normalized by the elaboration $(M = 0.387, SD = 0.152)$ was not statistically significantly different between conditions $X^2(2) = 0.424, p = 0.809$.

On the medium creativity cluster, we didn't find any significant differences between conditions for fluency $(M = 0.038, SD = 0.024)$ $X^2(2) = 3.904, p = 0.142$, flexibility $(M = 0.292, SD = 0.077)$ $X^2(2) = 1.205, p = 0.548$, and originality $(M = 0.019, SD = 0.011)$ $X^2(2) = 2.921, p = 0.232$, when normalized by the elaboration. As for the children in the high creativity cluster we also didn't find any significant differences between conditions for fluency $(M = 0.039, SD = 0.024)$ $X^2(2) = 0.262, p = 0.877$, flexibility $(M = 0.296, SD = 0.058)$ $X^2(2) = 0.123, p = 0.941$, and originality $(M = 0.018, SD = 0.010)$ $X^2(2) = 0.123, p = 0.941$, also when normalized by the elaboration. **With these results we can see that children with lower baseline creativity levels benefited from the behaviors of the robot.**

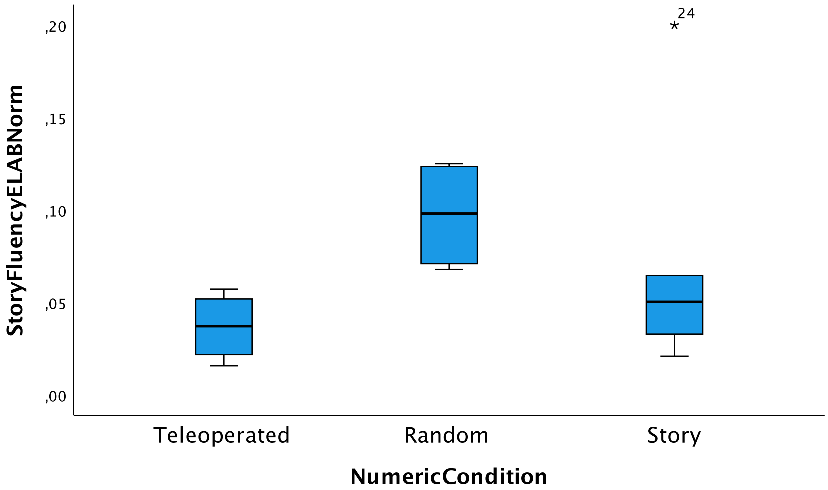


Figure 4.5: Fluency when normalized by elaboration on low creativity baseline levels

To identify which of the conditions had a significant difference from the others on the low creativity cluster, on story fluency when normalized by the elaboration, we ran three sets of Mann-Whitney U tests to compare them. We found that the teleoperated condition $(M = 0.037, SD = 0.019)$ was not statistically significantly different from the story condition $(M = 0.070, SD = 0.066)$ $(U = 7, p = 0.286)$ but was statistically significantly lower than the random condition $(M = 0.097, SD = 0.030)$ $(U = 0, p = 0.021)$. When comparing the story and random conditions on the story fluency, when normalized by the elaboration, we found no statistically significant difference between the two $(U = 4, p = 0.088)$. **The results from these tests show us that children with lower baseline creativity levels, benefited more in the fluency of the stories, from the behaviors of the robot when using the random condition.**

We also analyzed which of the conditions had a significant difference from the others, on story originality when normalized by the elaboration. We ran three sets of Mann-Whitney U tests to compare them on the cluster of low baseline creativity. From the results of the tests, we found that the teleoperated

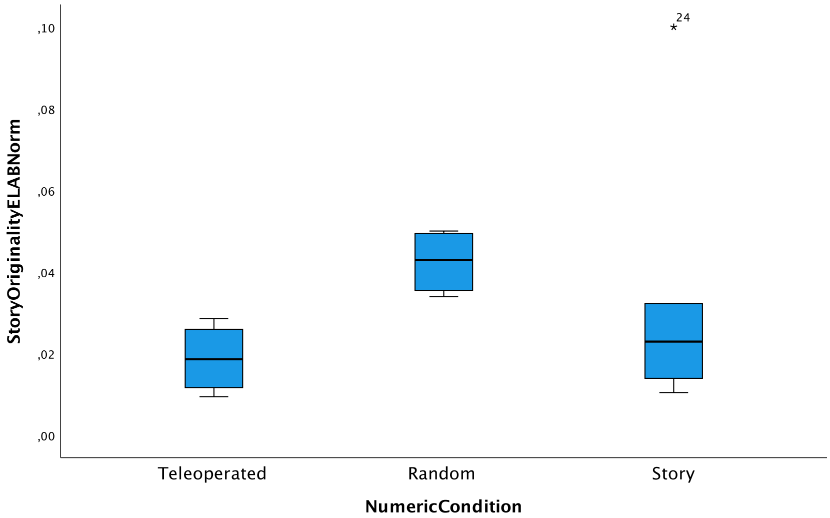


Figure 4.6: Originality when normalized by elaboration on low creativity baseline levels

condition $(M = 0.019, SD = 0.009)$ was not statistically significantly different from the story condition $(M = 0.034, SD = 0.034)$ $(U = 7.5, p = 0.336)$ but was statistically significantly lower than the random condition $(M = 0.042, SD = 0.008)$ $(U = 0, p = 0.021)$. When comparing the story and random conditions on the story originality, when normalized by the elaboration, we found no statistically significant difference between the two $(U = 4, p = 0.088)$. **The results from these tests show us that children with lower baseline creativity levels, benefited more in the originality of the stories, from the behaviors of the robot when using the random condition.**

4.5.4 Questionnaire Findings

Children perceived equally the investigators between conditions. We ran multiple Kruskal-Wallis Tests that showed that there was no statistically significant difference in how nice the researchers were between control $(M = 4.882, SD = 0.485)$, random $(M = 4.778, SD = 0.428)$ and story $(M = 4.824, SD = 0.393)$ conditions $X^2(2) = 1.572, p = 0.456$ and that there was no statistically significant difference in how the researcher explained the activity between conditions $X^2(2) = 0.206, p = 0.902$ with control with an average score of 4.824 $(SD = 0.529)$, random with an average score of 4.778 $(SD = 0.548)$, and story with an average score of 4.824 $(SD = 0.529)$.

From the questionnaires, we also tried to perceive if there was any significant difference in children liking the activity between the conditions. **Children liked to do the story with the robot equally between conditions.** We ran a Kruskal-Wallis Test that showed no difference in likability between control $(M = 4.706, SD = 0.470)$, random $(M = 4.222, SD = 1.166)$, and story $(M = 4.647, SD = 0.606)$ conditions $X^2(2) = 1.417, p = 0.492$. This was common, children that weren't participating in the activity were excited to participate, and children that finished the activity would talk positively about the activity with their peers.

We expected that children would rate the robot more intelligently when the robot was in story condition. This was not the case, we ran a Kruskal-Wallis Test and found no statistically significant difference between conditions $X^2(2) = 1.139, p = 0.566$ with control with an average score of 4.324 $(SD = 0.983)$, random with an average score of 3.778 $(SD = 1.478)$, and story with an average score of 4.353 $(SD = 0.702)$. **Children rated equally the robot's intelligence.**

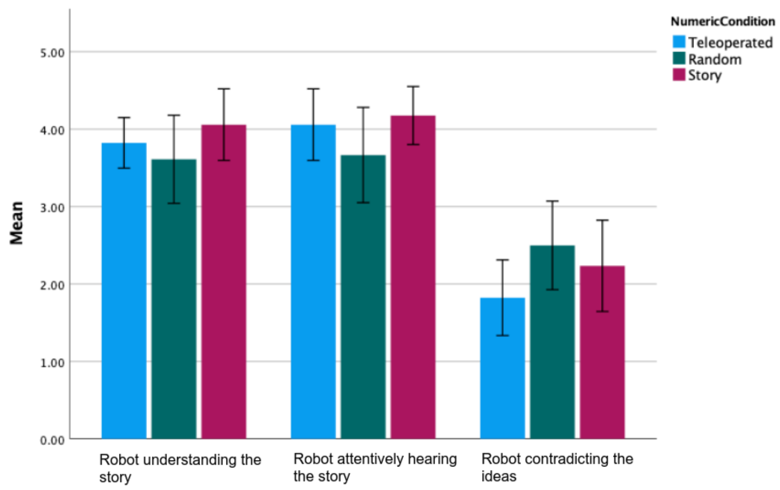


Figure 4.7: Answers on the perception of the robot during the storytelling

Children's perspectives on the robot were also important to understand. We ran a set of Kruskal-Wallis Tests and found no statistically significant difference between conditions on the question about the robot understanding their story $(M = 3.827, SD = 0.923)$ $X^2(2) = 1.755, p = 0.416$ with a mean rank of 25.320 for control (N=17), 24.140 for random (N=18), and 30.180 for story (N=17), no statistically significant difference between conditions on the question about the robot hearing attentively their story $(M = 3.962, SD = 0.989)$ $X^2(2) = 1.353, p = 0.508$ with a mean rank of 27.500 for control (N=17), 23.440 for random (N=18), and 28.740 for story (N=17), and no statistically significant difference between conditions on the question about the robot contradicting their ideas $(M = 2.192, SD = 1.103)$ $X^2(2) = 3.276, p = 0.194$ with a mean rank of 21.680 for control (N=17), 30.530 for random (N=18), and 27.060 for story (N=17). Even though this data is not conclusive, we can see a clear pattern in Figure 4.7. **Children rated equally the robot understanding their stories, hearing them attentively, and contradicting their ideas.**

We also analyzed the perception of children on the robot's autonomy, anthropomorphism, animacy, trust, closeness, similarity, and helpfulness on a scale of 1 to 5. The average results for autonomy in the control condition were 2.589 $(SD = 0.976)$, in the random condition 2.870 $(SD = 1.011)$, and in the story condition 3.275 $(SD = 0.775)$. For anthropomorphism, the average results in the control condition were 3.397 ($SD = 0.923$), in the random condition 3.000 ($SD = 0.947$), and in the story condition 3.603 ($SD = 0.673$). As for animacy, the average results in the control condition were 2.784 ($SD = 1.040$), in the random condition 2.778 ($SD = 1.120$), and in the story condition 3.098 ($SD = 0.941$).

The average results for trust in the control condition were 4.216 ($SD = 0.716$), in the random condition 3.833 ($SD = 0.752$), and in the story condition 4.137 ($SD = 0.472$). For closeness, the average results in the control condition were 4.221 ($SD = 0.637$), in the random condition 4.097 ($SD = 0.713$), and in the story condition 4.118 ($SD = 0.662$). As for similarity, the average results in the control condition were 2.961 ($SD = 1.053$), in the random condition 2.389 ($SD = 0.842$), and in the story condition 2.843 ($SD = 0.657$). The last metric we analyzed was helpfulness with an average of 4.589 ($SD = 0.507$) for the control condition, 4.167 ($SD = 1.150$) for the random condition, and 4.412 ($SD = 0.618$) for the story condition.

We ran a set of Kruskal-Wallis Tests and didn't find any statistically significant difference between conditions on autonomy $X^2(2) = 4.145, p = 0.126$, trust $X^2(2) = 3.221, p = 0.200$ or helpfulness $X^2(2) = 0.976, p = 0.614$. We also didn't find any statistically significant difference between conditions on anthropomorphism ($F(2, 49) = 2.239, p = 0.117$), animacy ($F(2, 49) = 0.534, p = 0.590$), closeness ($F(2, 49) = 0.167, p = 0.847$), or similarity ($F(2, 49) = 2.145, p = 0.128$) using the one-way ANOVA.

4.6 Discussion

At the beginning of this chapter, we defined two research questions that we ought to respond to with our collected data and our analysis of that data. We present in this section the responses to our initial research questions.

RQ1: Does shared autonomy affect creativity in children during a storytelling activity?

During the storytelling activity, we collected different types of data regarding the robot's movements and the story itself. To compare the differences in creativity levels, we had to compare to a baseline level of creativity which was provided by the pre-test. We found out that the baseline creativity test was highly correlated with a couple of metrics extracted from the story (fluency, flexibility, and elaboration), which gave us the confidence to compare the results from the pre-test to the metrics collect during the storytelling.

We created three clusters containing children with low, average, and high levels of creativity and compared the different metrics. For the average and high levels of creativity clusters, we did not find any statistically significant differences between conditions in the results. However, for the low level of creativity cluster, we found statistically significant differences between conditions for fluency and originality.

These results could be explained by looking at the different factors that affected the outcome of the activity. For instance, we can see that each condition on each cluster only had a maximum of 8 participants, and this is a relatively small sample since the differences between groups can sometimes be very small. We didn't also enforce a minimum time length for a story which meant that children with shorter stories from the shared-autonomy conditions had almost no actions triggered by the wizard.

To give a final answer to our research question, we can say that shared autonomy has a direct impact on the creative process of a storytelling activity in children with low creativity levels when using the random reactive strategy.

RQ2: Can different types of reactive strategies have a different impact on the creative process during storytelling?

We found out that when using the random behavior, the story fluency and originality suffered a significant positive impact on children from the low creativity cluster. This could be explained by the fact that when using the random reactive strategy, the robot would display emotions not related to the story, sparking more divergent thinking in children that were less creative from the start.

The data collected from the questionnaires didn't provide any conclusive data, on the impact of the different types of reactive strategies. Even though no statistically significant data was found, we can see a pattern between the two. Children seem to think that the robot understands better their story when using the story condition and that the robot contradicts more their story on the random condition. This pattern that we can see in Figure 4.7, gives us a hint that the questionnaires used were possibly not the best suited for children since children often try to not give low grades on answers [54].

To give a final answer to this research question, we found that in children with lower baseline creativity levels, the random reactive strategy had a significant positive impact on the creative process in a storytelling activity (fluency and originality) when compared to the story reactive strategy. We also found that for children with average, and high creativity levels the reactive strategies despite not having a positive impact also did not have a negative impact.

5

Conclusion

Contents

5.1 Limitations and Future Work 51

Throughout this dissertation, we presented a complete system to measure the impact of a simulated shared autonomy on the creative process during a storytelling activity. To design our system we first reviewed previous studies that were successful in stimulating children's creativity. We iterated through multiple versions of the system until we reached a final prototype that worked flawlessly throughout all the sessions. The system was robust and easy to use and made the activity easy and pleasing to children. It also provided solid data on the interactions of the child and the wizard with the robot.

We conducted a between-subjects study on 54 participants that aimed to compare the impact of shared autonomy between 3 different conditions: teleoperated where the robot was solely controlled by the child, random where the robot was controlled by the child and had random behaviors triggered by the wizard at key moments of the story to simulate semi-autonomy, and story where the robot was also controlled by the child but displayed behaviors that were also triggered by the wizard, that would better fit in the story at its key moments.

Our work provided the following contributions:

- We designed and conceived a system to test the impact of shared autonomy on creativity in a storytelling activity.
- We collected and analyzed data on the impact of shared autonomy and different reactive strategies, in creativity in a storytelling activity.
- We found that randomizing the emotions during the storytelling activity increased fluency and originality in children with lower baseline creativity scores.
- We found promising patterns in the data collected and provided suggestions for future studies.

As the first work combining the topics of shared autonomy, storytelling, and creativity, it provided valuable insights into the area. It also provided concrete data on how the different types of reactive strategies in a simulated semi-autonomy environment, have impacted the different aspects of the storytelling activity. Despite these promising results further studies should be conducted to evaluate them in the longer term.

5.1 Limitations and Future Work

Our study had some limitations and because of that, it might have impacted negatively our results. With the data collected, we were able to trace and pinpoint some aspects of our study that could be improved. In this section, we describe them in detail suggesting some improvements for future work.

We conducted a between-subjects study with three groups with 18 children per condition. When we created the three clusters, each condition was left with a small number of children. To collect more valuable data we would have to either increase the number of participants or decrease the number of conditions. Time was also a big factor that we did not take into account when we designed the study. We were not expecting the disparities in story lengths, with some children making very short stories and others very long stories. In the shorter stories, the wizard was not able to trigger the necessary number of behaviors to have a clear impact on the story outcome, which had a negative impact on our collected data. One improvement to take into account in future studies would be to create a maximum and minimum story size. This could be enforced by creating a set of tasks parallel to the story, that requires the robot to navigate through the different places on the mat.

In our study, we used the key moments of the story to trigger the robot's behaviors but these were sometimes very rare and even on the story condition, the behaviors of the robot were not suitable for certain key moments of the story. For example, a child communicating that the robot is playing a football game leaves the wizard to choose a behavior that would best fit the story, but the wizard's interpretation could differ from the child's interpretation and the emotion triggered can seem unrelated to the child. In future work with the suggestion of a fixed time span for the activity, the behaviors of the robot could be triggered based on time instead of the key moments from the story. That would allow children with lower descriptive stories to be exposed to the same amount of behaviors as children with more descriptive stories. In a future study, it could also be interesting to try and increase the time of each behavior to try and catch better the attention of the child.

The behaviors were also too simple, more complex behaviors could have a different impact on creativity. In future studies, speech could be added to better express the behavior of the robot, and more expressive movements could also be explored.

Regarding the questionnaire we could improve on the type of questionnaire used since the answers from 1 to 5 seemed to not have the desired effect. We could change the questionnaire to a 5 Smile Likert Scale to get a better perception of the impact of the robot. We also felt that the questionnaire was too long and one improvement could be to reduce the overall size of it, to improve the quality of each answer.

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A

Consent Form

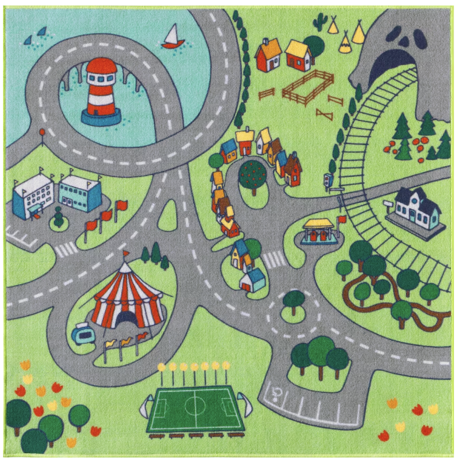
Consentimento Informado

Estimular a criatividade em crianças interagindo com um robô no contexto de criação de histórias

O meu nome é Miguel Azinheira e faço parte de uma equipa de investigação associada ao Instituto Superior Técnico composta pelo Professor Hugo Nicolau (Investigador Responsável), uma investigadora doutorada (Filipa Correia) e um aluno de mestrado (Miguel Azinheira).
A minha tese foca-se na aplicação de robôs sociais no contexto de criação de histórias de forma a estimular a criatividade das crianças.
Venho assim por este meio pedir-lhe autorização para que o sistema desenvolvido no âmbito da minha tese possa ser utilizado pelo seu filho/a. A atividade poderá decorrer durante os meses de Junho, Julho e Agosto e estarão presentes monitores do centro de actividades educativas do seu educando.
Peço que leia este documento cuidadosamente e que procure esclarecer quaisquer questões que possa ter. Para o fazer pode utilizar os seguintes contactos: Miguel Azinheira, miguel.pereira520@gmail.com, 914979103.

Em que consiste o estudo?

Este estudo foca-se no planeamento e desenvolvimento de um sistema que estimula a criatividade das crianças enquanto estas criam uma história. As crianças devem criar uma história interagindo com o robô que será controlado por um comando bluetooth. O robô apresentará alguns comportamentos como excitação, confusão, tristeza e medo à medida que a história se vai desenrolando ou o robô vai circulando no mapa. O objetivo deste estudo é perceber se estes comportamentos influenciam positivamente os níveis de criatividade das crianças que participem nesta atividade.




O que vamos pedir ao seu filho?

Se autorizar o seu filho a participar neste estudo e caso este esteja confortável com o mesmo no momento, ser-lhe-á pedido que crie uma história usando o robô. O sistema consiste num robô de pequenas dimensões que é controlado por um comando. Para a criação da história, o robô será colocado num pequeno tapete colorido com elementos e espaços conhecidos pelas crianças. O seu filho poderá usar o sistema para controlar o movimento do robô e criar a sua própria história. A atividade decorrerá numa das salas das instalações do ATL com todas as precauções necessárias e impostas pelo centro de atividades educativas relativamente às normas de segurança e higiene associadas à pandemia COVID-19. Para facilitar a recolha dos dados relativos à experiência esta será gravada na forma de áudio e vídeo. Será necessário que a gravação capture o tapete, o robô e os gestos feitos pelo seu filho para criar a história, de forma a conseguirmos analisar a criatividade. Opcionalmente, poderemos realizar a gravação numa perspectiva frontal de forma a podermos adicionalmente analisar as expressões e reações do seu filho aos comportamentos do robô. No entanto, o anonimato das crianças será sempre garantido pela equipa de investigação. Caso as gravações sejam usadas em publicações científicas, a imagem e voz das crianças serão distorcidas de forma a impedir o seu reconhecimento.

Riscos e benefícios

Não existe nenhum potencial risco nem benefício para os participantes.

Confidencialidade dos dados

Todos os dados captados relativamente à experiência acima referida serão confidenciais e apenas serão analisados pela equipa de investigação associada a este projeto. Como referido anteriormente, os dados poderão ser utilizados em contexto científico desde que devidamente anonimizados. A responsável pelo tratamento dos dados será a investigadora responsável, a investigadora Filipa Correia.

Caso necessite de entrar em contacto com o Encarregado de Proteção de Dados da Universidade de Lisboa, poderá fazê-lo através de comunicação escrita dirigida a: Encarregado de Proteção de Dados (DPO, Data Protection Officer) para rgpd@ulisboa.pt. Como responsável pelo participante tem direito a solicitar ao DPO o acesso aos dados pessoais que digam respeito ao seu filho. Tem também os direitos de retificação, remoção, limitação e oposição do tratamento, incluindo o direito de retirar consentimento em qualquer altura, sem prejuízo da licitude do tratamento eventual e previamente consentido. Adicionalmente, tem também o direito de apresentar uma reclamação à Comissão Nacional de Proteção de Dados.

Importa reiterar que a participação do seu filho é voluntária e este poderá sempre optar por não responder ou mesmo desistir a qualquer momento sem qualquer penalização ou consequência.

TÉCNICO LISBOA

inesc id lisboa

Interactive Technologies Institute
LARSyS

Declaração de consentimento

Eu, ____, encarregado de educação do aluno(a) ____, declaro que li a informação acima e que recebi resposta a todas as questões que coloquei. Ao assinar este documento autorizo a participação do meu educando no estudo e consequente gravação para fins acadêmicos e de investigação. Declaro ainda que autorizo a gravação do seguinte modo:

- ☐ Perspectiva frontal de modo a capturar o tapete com o robô e a cara do(a) seu(ua) educando(a).
- ☐ Perspectiva posterior de modo a capturar o tapete com o robô e o seu educando ligeiramente de costas.

O Encarregado de Educação

____

Data: ____/___/______

Investigador condutor do estudo

____

Data: ___/___/______

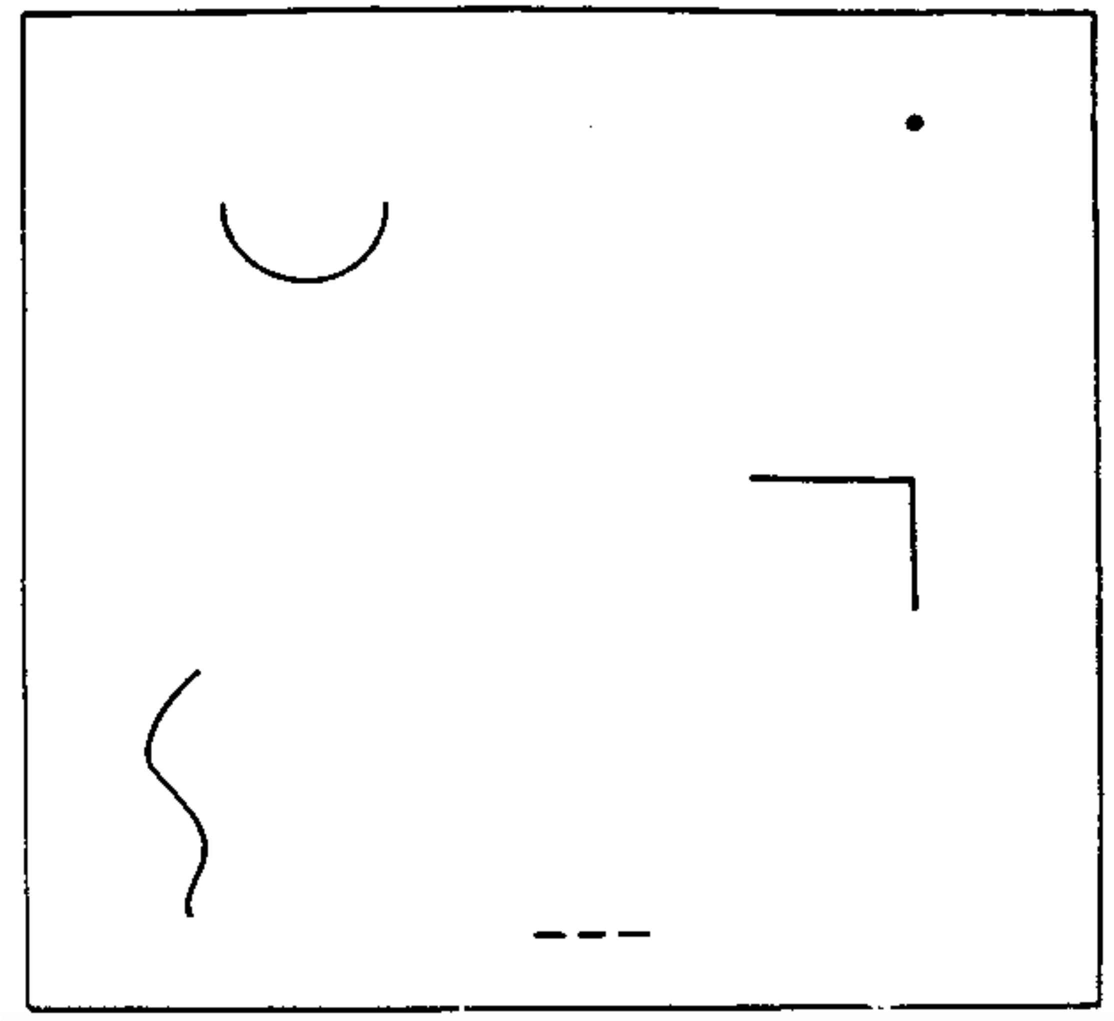
Investigador responsável:
Prof. Hugo Nicolau
Professor Auxiliar do Departamento de Eng. Informática do Instituto Superior Técnico, Universidade de Lisboa
Investigador do ITI/LARSyS
hugo.nicolau@tecnico.ulisboa.pt
http://web.tecnico.ulisboa.pt/hugo.nicolau/

Este documento será guardado pelo investigador por pelo menos três anos após o final do estudo

B

TCT-DP Form A

Um artista começou este desenho mas não conseguiu acabar.
A tua tarefa é terminar o desenho como quiseres.



C

Questionnaire

ID: Cond: Age: Gen:

*___ “O robô ajudou-me a fazer a história” [Age1]
___ “Eu e o robô formamos uma boa equipa” [Clo4]
___ “Eu sinto que posso confiar no robô” [Tru1]
___ “O robô faz coisas sem a ajuda de pessoas” [Aut2]
___ “O robô é um ser vivo” [Ani1]
___ “O robô faz coisas de forma independente” [Aut4]
###
___ “O robô pode morrer” [Ani3]
___ “Eu sinto que o robô é de confiança” [Tru4]
___ “O robô faz o que quer” [Aut1]
___ “O robô pensa por ele próprio” [Ant4]
___ “Eu e o robô estamo-nos a tornar amigos” [Clo3]
###
*___ “O robô ouviu com atenção a minha história” [Man2]
*___ “O robô estava a perceber a minha história” [Man1]
___ “O robô é como eu” [Sim2]
___ “O robô sabe que é um robô” [Ant3]
___ “O robô é algo vivo” [Ani2]
___ “O robô parece-se comigo” [Sim3]
###
*___ “O robô às vezes contrariava as minhas ideias” [Man3]
___ “O robô pode estar feliz ou triste” [Ant2]
___ “Eu sinto que o robô é honesto” [Tru3]
___ “Sinto-me confortável perto do robô” [Clo2]
___ “O robô escolhe o que ele próprio pode fazer” [Ant1]
###
___ “O robô está vivo” [Ani4]
___ “O robô é como um amigo para mim” [Clo1]
___ “O robô pensa como eu” [Sim1]
___ “Eu sinto que o robô consegue guardar um segredo meu” [Tru2]
___ “O robô é culpado se fizer algo errado” [Aut3]

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___ “O robô pode morrer” [Ani3]
___ “Eu sinto que o robô é de confiança” [Tru4]
*___ “O robô estava a perceber a minha história” [Man1]
___ “O robô faz coisas sem a ajuda de pessoas” [Aut2]
___ “Eu sinto que posso confiar no robô” [Tru1]
___ “O robô é algo vivo” [Ani2]
##
___ “O robô faz o que quer” [Aut1]
___ “O robô pode estar feliz ou triste” [Ant2]
___ “O robô é como um amigo para mim” [Clo1]
*___ “O robô ouviu com atenção a minha história” [Man2]
___ “O robô faz coisas de forma independente” [Aut4]
##
___ “O robô é um ser vivo” [Ani1]
___ “O robô é como eu” [Sim2]
___ “O robô escolhe o que ele próprio pode fazer” [Ant1]
___ “O robô pensa como eu” [Sim1]
___ “O robô está vivo” [Ani4]
___ “Eu sinto que o robô é honesto” [Tru3]
##
___ “Eu e o robô estamo-nos a tornar amigos” [Clo3]
___ “Eu e o robô formamos uma boa equipa” [Clo4]
___ “O robô sabe que é um robô” [Ant3]
___ “O robô parece-se comigo” [Sim3]
___ “Sinto-me confortável perto do robô” [Clo2]
##
___ “O robô é culpado se fizer algo errado” [Aut3]
*___ “O robô ajudou-me a fazer a história” [Age1]
___ “O robô pensa por ele próprio” [Ant4]
___ “Eu sinto que o robô consegue guardar um segredo meu” [Tru2]
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