A comparison of kindergarten storytelling by human and humanoid robot with different social behavior

CONTI, Daniela <http://orcid.org/0000-0001-5308-7961>, DI NUOVO, Alessandro <http://orcid.org/0000-0003-2677-2650>, CIRASA, Carla and DI NUOVO, Santo

Published version

CONTI, Daniela, DI NUOVO, Alessandro, CIRASA, Carla and DI NUOVO, Santo (2017). A comparison of kindergarten storytelling by human and humanoid robot with different social behavior. In: HRI '17. Proceedings of the Companion of the 2017 ACM/IEEE International Conference on Human-Robot Interaction - HRI '17. New York, ACM, 97-98.

Copyright and re-use policy

A Comparison of Kindergarten Storytelling by Human and Humanoid Robot with Different Social Behavior

Conti Daniela
Sheffield Robotics
Sheffield Hallam University, UK
d.conti@shu.ac.uk

Alessandro Di Nuovo
Sheffield Robotics
Sheffield Hallam University, UK
a.dinuovo@shu.ac.uk

Carla Cirasa, Santo Di Nuovo
Deparment of Education
Università degli Studi di Catania, Italy
s.dinuovo@unict.it

ABSTRACT
In this paper, we present a study on the influence of different social behavior on preschool children's perception of stories narrated either by a humanoid robot or by a human teacher. Four conditions were considered: static human, static robot, expressive human and expressive robot. Two stories, with knowledge and emotional content, were narrated in two different encounters. After each story, children draw what they remember of the story. We examined drawings of 81 children to study whether the sociability of the teacher (robot or human) could influence elements and details recorded. Results suggest a positive effect of the expressive behavior in robot storytelling, whose efficacy is comparable to the human with the same behavior or better if the expressive robot is compared with a static inexpressive human.

Keywords
Storytelling; kindergarten; humanoid robot; social robot; human-robot interaction.

1. INTRODUCTION
Recent research in the area of robotics has made available numerous possibilities for further innovation in the education of children [1], [2], including those with learning difficulties and/or intellectual disabilities [3]. Educational robots are expected to facilitate children's learning and they may improve their literacy and creativity [4]. Previous research in human-robot interaction explored the use of robots as storytellers [5] and demonstrated that gazing and gestures can improve the robot's persuasiveness [6].

This paper presents results of our on-going study with pre-school age children. One of the aims of the study is to examine the effects of social behaviors (gestures, eye gaze, and voice tone) of a humanoid robot and compare them with those of a human being on the memorization of stories. To this end, we tested the following hypotheses (H1–H2) for two stories with a different type of content (emotional and knowledge):

H1. Children will have more memory of the narrated story with a robot or human showing expressive behavior.
H2. Children will report a similar level of elements and details with a robot and human with the same social behavior.

HRI '17 Companion, March 06-09, 2017, Vienna, Austria
ACM 978-1-4503-4885-0/17/03.
http://dx.doi.org/10.1145/3029798.3038359

2. MATERIAL AND METHODS
2.1 Experimental Design & Material
We designed the story using feedback from preschooler teachers to ensure that the vocabulary and difficulty levels of story comprehension were appropriate for the age.

The stories selected for the experiment were: "The ugly duckling" and "The Emperor's New Clothes", both of Hans Christian Andersen. The latter story has knowledge content (i.e. it taught the children new concepts), while the main content of the former story is emotional. Each story contains about 900 words and 150 gestures used according to the narrative situations.

The role of the human teacher was taken by one of the authors.
The robot used was the Aldebaran *Nao*, which is a small toy-like humanoid robot, very popular for child-robot interaction studies [7], [8]. *Nao* is 58 cm high and can produce very expressive gestures with 25 degrees of freedom. It can detect faces and mimic eye contact moving the head accordingly; it can also vary the color of LEDs in eyes' contour to simulate emotions. It can read text with child-like voice. The children have never seen the authors or the robot before the experiment.

In the expressive mode, Nao was standing up while expressing appropriate emotions both with the body (moving arms and head, changing eyes' LEDs color) and vocally (adding sounds according to the contexts). In the static mode, Nao was sitting without moving. Fig. 1 reports pictures of the robot during storytelling.

Figure 1. Robot expressive (left) and static (right) storytelling.

2.2 Experimental procedure
The experimental procedure included 3 encounters over 3 weeks:
(i) To decrease the novelty effect, the robot was first presented to all the children involved. The robot performed a dance and autonomously interacted with group of children. The presentation lasted 15 minutes and it was repeated for each group.
(ii) a week after the first encounter, the Nao or the human teacher narrated the first story.
(iii) Finally, after another week the storytelling procedure was repeated with the second story.

Each session was approximately of 15 minutes, the robot or human initiated the storytelling procedure greeting the children, and explaining them the current activity.
At the end of each storytelling session (ii & iii), children were asked to use with colored pencils to draw all the details they were able to recall about the narrated story. We used these drawings to see what children memorized of the story.

2.3 Participants

Participants were recruited from a school in Mascalucia, Sicily, Italy. Over 100 children agreed to participate at least one session. Consent forms were signed by parents of all children.

Children were randomly assigned to either a human or a humanoid robot teacher. Then, each group was further split per teacher behavior: expressive condition, it changes gesture, eye gazing and voice following the story, or static inexpressive condition with fixed gaze, motionless body, monotonous voice.

A total of 81 children (45 males and 36 females, from 5 to 6 years old, average 5.1) could attend all sessions and only these are included in our analysis. Distribution is shown in Table 1.

Table 1. Participant distribution for teacher and modality

Storytelling	Human teacher	Robot teacher
Expressive modality	EH = 21	ER = 21
Static modality	SH = 19	SR = 20

2.4 Measures and Analysis

For each drawing, we determined how many main elements of the stories and additional details were represented by children. Main elements are plot, characters, setting, and theme, while additional details included actions, objects or descriptors that were part of a story, and we eliminate the extra story details that are references to the participant's opinions, feelings or thoughts. Parts identified as elements were not counted in the details and vice-versa. Fewer elements than details are expected to be reported by the children.

Two researchers independently coded the drawings transcriptions from sessions. Both coders first coded the drawings from the excluded participants to become familiar with the coding scheme. Once the agreement between coders was reached, coding began on the remaining data. Coding was completed for the 162 collected the drawings (81 participants for 2 sessions).

To analyze the results we performed a one-way MANOVA to compare the means, and then we applied the Tukey HSD post hoc test for multiple comparisons among the mean differences of all group and modality-measures pairs.

3. Experimental Results & Discussion

According to the MANOVA, there was a statistically significant difference in performance among the groups, $F(12, 196.08) = 13.74$, $p < .001$; Wilk's Lambda = 0.588, partial $\eta^2 = .16$.

Table 2 presents all the paired differences of means for details and elements, according to the story type. Differences with statistical significance $p<0.05$ are in bold. The mean elements and details reported are respectively: 3.06 and 5.60 for the emotional story; 2.83 and 6.52 for the knowledge story.

Table 2. Multiple comparisons of mean differences.

	Emotional Story					Knowledge Story				
Elements	E1	SH	SR	EH	ER	E2	SH	SR	EH	ER
	SH	-	0.64	**-1.35***	-0.31	SH	-	0.08	-0.41	-0.22
	SR	-0.64	-	**-1.99***	-0.95	SR	-0.08	-	-0.50	-0.30
	EH	**1.35***	**1.99***	-	1.05	EH	0.41	0.50	-	0.19
	ER	0.31	0.95	-1.05	-	ER	0.22	0.30	-0.19	-
Details	D1	SH	SR	EH	ER	D2	SH	SR	EH	ER
	SH	-	-0.28	**-5.16***	**-3.20***	SH	-	-0.77	**-2.94***	**-3.61***
	SR	0.28	-	**-4.87***	**-2.92***	SR	0.77	-	-2.17	**-2.84***
	EH	**5.16***	**4.87***	-	1.95	EH	**2.94***	2.17	-	-0.67
	ER	**3.20***	**2.92***	-1.95	-	ER	**3.61***	**2.84***	0.67	-

Analyzing the results in Table 2, with regards to H1, we can see that the expressive social behavior of the robot positively impact the number of details reported by the children with a median increase of 3 items drawn for both stories. But the storytelling modality seems not significantly affect the memorization of main elements. Indeed, in this case there is mostly no difference (mean less than 1) except for the human teacher in the emotional story.

Regarding H2, we found no statistically significant differences between human and robot teachers with the same social behavior. However, the expressive robot can facilitate the children in memorizing more details than the static inexpressive human teacher with an effect comparable with that found for the robot.

4. Conclusion

Experimental results presented in this paper show that pre-school children can memorize more details of a story if it is narrated with an expressive social behavior. The positive effect has been discovered for two types of stories, with emotional and knowledge content, and for both human and humanoid robot teachers.

In comparison, the humanoid robot performed as well as the human, indeed, results show a comparable number of main elements and details reported by the children in all condition tested. Furthermore, the expressive social robot made children to recall more details of stories than an inexpressive human teacher.

5. Acknowledgments

The authors gratefully thank all children and parents, the head teacher Dr Pettinato and teachers for their precious cooperation. Dr Conti and Di Nuovo have received support from European Commission (grant n. 703489 – MSCA-IF CARER-AID).

6. References

[1] J. Kennedy, P. Baxter, E. Senft, and T. Belpaeme, "Social robot tutoring for child second language learning," in *2016 11th ACM/IEEE International Conference on Human-Robot Interaction (HRI)*, 2016, pp. 231–238.

[2] A. Jacq, F. Garcia, P. Dillenbourg, and A. Paiva, "Building successful long child-robot interactions in a learning context," in *2016 11th ACM/IEEE International Conference on Human-Robot Interaction (HRI)*, 2016, pp. 239–246.

[3] D. Conti, S. Di Nuovo, S. Buono, and A. Di Nuovo, "Robots in education and care of children with developmental disabilities: a study on acceptance by experienced and future professionals," *Int. J. Soc. Robot.*, pp. 1–12, 2016.

[4] S. Serholt, W. Barendregt, A. Vasalou, P. Alves-Oliveira, A. Jones, S. Petisca, and A. Paiva, "The case of classroom robots: teachers' deliberations on the ethical tensions," *AI Soc.*, pp. 1–19, 2016.

[5] G.-D. Chen and C.-Y. Wang, "A survey on storytelling with robots," in *International Conference on Technologies for E-Learning and Digital Entertainment*, 2011, pp. 450–456.

[6] J. Ham, R. H. Cuijpers, and J.-J. Cabibihan, "Combining Robotic Persuasive Strategies: The Persuasive Power of a Storytelling Robot that Uses Gazing and Gestures," *Int. J. Soc. Robot.*, vol. 7, no. 4, pp. 479–487, 2015.

[7] D. Conti, S. Di Nuovo, G. Trubia, S. Buono, and A. Di Nuovo, "Use of Robotics to Stimulate Imitation in Children with Autism Spectrum Disorder: A Pilot Study in a Clinical Setting," in *Proceedings of the 24th IEEE International Symposium on Robot and Human Interactive Communication, ROMAN*, 2015, pp. 1–6.

[8] A. Coninx, P. Baxter, E. Oleari, S. Bellini, B. Bierman, O. B. Henkemans, L. Cañamero, P. Cosi, V. Enescu, and R. R. Espinoza, "Towards long-term social child-robot interaction: using multi-activity switching to engage young users," *J. Human-Robot Interact.*, vol. 5, no. 1, pp. 32–67, 2016.