Journal of Convergence Information Technology
Volume 4, Number 3, September 2009

Analysis on Children's Tolerance to Weak Recognition of Storytelling Robots

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doi: 10.4156/jcit.vol4.issue3.15

Abstract

A number of studies on teaching assistant robots (or peer tutoring robots) have proven that robots can be considered effective tools for language education. Interactive storytelling, in particular, can be used for enhancing the teaching of English as a foreign language. This can be used in robot aided learning of English. However, the biggest obstacle to the interaction between human beings and robots in field studies is the robots' low-success rate of face and voice recognition. This causes some children to utterly give up interaction with robots or to just ignore them altogether. This paper explores robot storytelling elements to look at ways of generating and maintaining interaction between teaching assistant robots and children. Robot storytelling about the robot's own weak recognition was examined to see if it could address the challenge of changing children's attitudes and maintain interaction between the children and the robot. It was concluded that teaching assistant robot storytelling is effective in increasing children's tolerance towards robot weak recognition.

Keywords

Robot, Storytelling, Language Learning

1. Introduction

Recently, there have been field studies harnessing robots for educational purposes in many countries, such as Japan, Korea, and Taiwan, where English is used as a foreign language [1,7,19]. These studies have shown that while using robots as teaching assistants is highly effective for the purpose of language learning, one result is a noticeable drop in the interaction between children and robot as time passes. The discontinuation of interaction fits one of the four communication cases suggested in [5], in which the sources, or children, have the certain belief that the receivers, or robots, do not understand. According to Berlo's SMCR communication model, which is made up of source, message, channel, and receiver [3], the main reason for the gradual decrease of interaction between robots and children is that the channel, such as the optic and auditory abilities to recognize, is not accurate.

The biggest obstacle to the interaction between robots and children in the field, after the novelty effect has worn off, disappears is the robot's weak recognition [8,11,12]. This weak recognition disables robots from making proactive reactions to various situations. Since robots engage in dynamic interaction in highly varied environments, failure to recognize children's voices and faces often occurs. This causes some children to utterly give up having communication with robots and results in the children completely ignoring the un-responding automations. This imperfect, autonomic recognition function of robots may have a meaningful level of adverse impact even before interaction starts. It is also the largest discouraging factor to the purchase of robots, even though their efficiency in language education has been proven.

According to a study by Lazanov, listening to dramatic stories and creating empathy towards characters are more natural when one is in a state of comfort and relaxation [8]. Also, storytelling is used as a general tool to heighten immersion into games, and this kind of storytelling tool can be equally applied to language education. Thus, many studies on robot-aided language learning such as [7,8,9,12] have adopted storytelling to motivate children. Robot functions towards promoting positive relationships with children, such as roll call or selection of a presenter, were developed in [8]. However, these functions could not improve children's tolerance to the innately weak recognition ability of teaching assistant robots.

Berlo's SMCR model for communication considers the attitude of the source [3]. Applbaum et al.'s group communication model, made up of communicators, message, situational context, and interaction between messages and context, also contains the attitudes and

personal information of the communicators (the source and the receiver) [2]. Thus the purpose of this paper is to discover whether prior knowledge of the source (robot)'s lack of ability to recognize children affects the receiver (children)'s psychological attitude toward the robot. Prior knowledge was delivered through storytelling about the robot's birth. This internal element was hoped to improve children's tolerance and patience toward the robot despite the robot's technological limitations.

2. Related Works

2.1 Group Communication and Attitude

Berlo's SMCR model is made up of source (communication skills, knowledge, social system, culture, attitudes), message (content, elements, method, structure, code), channel (hearing, seeing, touching, smelling, tasting), and receiver (communication skills, knowledge, social system, culture, attitudes) [3]. The channel emphasizes the role of the relationship between the source and the receiver as an important factor in the communication process. Similarly, the group communication model of Applbaum et al. defines the process of communication as one in which a message acts as a linkage between people. This process consists of five factors, which are each communicator (attitudes, motivation, one's value, knowledge and information, one's personal affairs), messages between both (verbal or nonverbal), situational context (physical environment, the purpose of the communication, the social trend, structure of their group), and interaction between the message and the context (union, conformity, conflict, solution, etc).

The act of conversation can be classified into four cases: (1) when the source has an intention the receiver recognizes; (2) when the source has an intention the receiver is not able to recognize exactly; (3) when the source does not have any intention and the receiver also does not recognize any, and, (4) when the source does not have any intention, yet the receiver recognizes one [5]. If this process of communication is adapted to a computer without artificial intelligence, such as a robot, it can be translated into the following four cases: (1) when a man has an intention a robot recognizes, (2) when a man has an intention that a robot is not able to recognize exactly, (3) when a man does not have any intention and a robot also does not recognize any, and (4) when a man does not have any intention, yet a robot recognizes one. The last case is widely known as that of 'ascribed communication'. Cases (1) & (4) could possibly occur in the near future, when robot intelligence technology is more developed. Case (2) often occurs in current robot technology.

Berlo's SMCR model, as well as the group communication model of Applbaum et al., strongly considers the source's attitude. 'Attitude' refers to a friendly or non-friendly evaluation, or reaction tendency, toward symbols, humans, objects, and behaviors [18]. With the provision of advance knowledge to ease the second discontinuation of Burgoon & Ruffner, a patient, giving, and friendly attitude toward robots is expected to ensue.

2.2 Storytelling and Digital Storytelling

Children build their views towards the world through storytelling and form 'mental lens'' as cognitive processes to look at future happenings and to filter them [4]. In addition, Bruner emphasizes that children's desire to create a story precedes language acquisition, and that sharing stories with others motivates them to learn languages.

The American English Teachers' Committee (AETC) defines storytelling as the act of delivering stories to listeners through voice and action. Storytelling consists of "Story+ Tell + ing", which has story, presence and interaction [15]. All successful stories have five basic components, as follows: (1) the passion with which the story is told; (2) a hero who leads us through the story and allows us to see it through his or her eyes; (3) an antagonist or obstacle that the hero must overcome; (4) a moment of awareness that allows the hero to prevail; and, (5) the transformation in the hero and in the world that naturally results [14]. Our robot storytelling in Section 3.2 is based on these components.

The Center for Digital Storytelling defines digital storytelling as the modern expression of the ancient art of storytelling. Digital stories derive their power by weaving images, music, narrative and voice together, thereby giving deep dimension and vivid color to characters, situations, experiences, and insights. The seven main elements of a digital story's development are as follows: (1) point of view; (2) a dramatic question; (3) emotional content; (4) the gift of the teller's voice; (5) the power of the soundtrack; (6) economy; and, (7) pacing. In robot storytelling, the story would be delivered via multimedia content, based on economy of the display panel of the robot, with background music and text-to-sound (TTS). The elements above were considered for the design and development of the robot storytelling content in Section 3.2.

2.3 Storytelling in English Education

Storytelling has been regarded as one of the most effective ways for children to learn English. All parts of storytelling, such as listening, re-telling, role playing, and story-making, allow children to casually use language for understanding, listening, and speaking the story. The stories improve children's communication abilities through the message that they are trying to deliver and therefore are absolutely necessary for language education [6]. Stories usually repeat key words and sentence structures, and not only teach language to children, but also offer opportunities for intelligence and emotional growth as human beings. This helps children to predict what will come next and get them more engaged in the learning process.

Robot-aided English learning with games, such as 'rock, paper, scissors' and 'basic conversation,' was especially effective in motivating students[10]. Through a survey, it was found that teachers preferred using tutoring robots for language or music learning in [8]. It was indicated that the linguistic ability of children in the robot-assisted groups with storytelling robots improved significantly compared with that of media-assisted groups [7,9]. In their studies, robots told picture book stories to children. In field trials the robot, Robosapiens IV, was used to motivate students' learning activities in an English learning classroom. The robot had five models: storytelling model, Q&A model, cheerleader model, let's act model, and pronunciation leading model [19]. Lu et al. developed an authoring system of robot storytelling to motivate children's second language learning without negative emotion due to anxiety over English speaking and listening ability [16]. The robot storytelling content, 'The Ugly Duckling,' was developed as shown in Figure 1 [12], using mixed reality technology based on identification to enhance the relationship between children and the robot.

Figure 1. Robot Storytelling based on Identification

This kind of content based on identification is an external element that encourages a relationship and interaction between children and the robot. This definitely increased the flow of mutual interaction, but it did not overcome the recognition failure level and un-sustainability of long-term interaction.

Most of the previous studies have focused on enhancing the motivation or reducing children's affective filter in language learning, not on interacting patiently with robots despite the robots' failures to recognize voices and faces [7,9,10]. While children expect robots to have a high ability of recognition, robots do not meet this expectation in the real-world environment, as follows:

Expectation (Ability (Robot))>Ability (Robot)

This causes children to think that robots are too stupid to teach or interact with them because the robots often fail to recognize children's voices and faces. Storytelling about the birth of the robot, including its limited ability of innate recognition, is considered to reduce the expectation of the children to be less than the ability of the robot.

3. Tutoring Robot Storytelling

3.1 Plot of Tutoring Robot Storytelling

Human storytelling starts off when the audience is ready, and the storyteller makes eye contact with the audience to keep their attention level, changes voice tone, uses exclamations, makes a pause at the climax, and makes facial expressions as well as does actions that suit the circumstance [17]. By relying on these series of acts, the storyteller can encourage the audience to predict what will come next in the story or immerse them in the story.

Robot storytelling also requires the same elements as human storytelling. The robot should start the story when there is weak noise, and should detect listeners' multiple facial images. Then, it should maintain the audience's attention by sharing eye contact with the detected facial images, with emotional TTS voice, and with exclamations. The robot should pause at the climax and make appropriate actions and facial expressions using its body hardware. However, possible errors in face and voice recognition programs, and the limited hardware for robot storytelling, hinder full facial expressions and actions. These are the real-world limitations of robot storytelling.

Although most storytelling materials are about others rather than the speaker himself/herself, robot

storytelling material is equally about others as well as the robot itself. Children want to know where the robot comes from, how old it is, who made it, and when it was born, before they listen to it or its storytelling. Thus, a story about the background of the robot that included reference of its weak innate recognition was created, and then children's tolerance toward the robot was investigated. Table 1 shows the frank and candid storytelling of the robot and its action template as if it were making a confession.

Table 1. Robot Storytelling and its Action Template

Group	Storytelling with background music	Robot Action		
		Face	Action	Display
Not Sharing Robot story	Hi! I am IROBIQ. Scientists and experts developed me. I was born two years ago and I've moved to this school to help you learn English. I hope we get along well.	Happy Talking	Looking around the classroom	(Name) IROBIQ
Sharing birth storyof robot	Hi! I am IROBIQ. I've moved to this school to help you learn English. Scientists and experts living in 2050 developed me two years ago gave me a very smart intelligence and sent me back in time. But, unfortunately, a virus attacked the time machine and impaired my intelligence. That's why I am not perfect. While I help you out with English, I hope to find the future scientists and experts who gave me my intelligence among you. Let's study English hard and I hope to get along well with you. I am eager to find who my future friends among you are.	Happy Talking Sad (Pause) Talking Normal Talking Happy Talking	Looking around the classro-om Being exhausted Looking around the classroom	(Name) IROBIQ 2050 (red colored) virus Beating a heart

While the robot itself does the storytelling, the teacher steps in to give more concrete explanations to children if the children fail to fully understand or ask more questions.

3.2 Development of the Robot Storytelling

The process of developing the content for robot storytelling is as follows:

- Design of the birth story, according to Table 1;
- Design and development of the Flash-based contents for the touch screen of the robot based on economy;
- Insertion of the robot action script in XML (Extensible Markup Language) type by eR-Author, robot script authoring tool, of Yujin Robotics; and,
- Uploading of the contents to the robot from the LMS (Learning Management System) via wireless internet.

Figure 2. Major Actions of Robot in Table 1

The eR-Author gives the following features to the robot: (1) support of multimedia objects by inserting the robot scripts to the Flash Action Panel; (2) easy creation and editing of interactions between users and robots in XML type script as well as GUI (Graphic User Interface); and, (3) support of voice recognition and synthesis. The robot storytelling was stored using a robot-based format in XML type in the content server of IROBIQ. Then, IROBIQ could run the eR-Player, which is a software module running on the robot that executes physical user-robot interaction, downloads from content servers, and tells the story about its birth, as shown in Figure 2.

4. Experiments

4.1 Experimental Design

The most important task of the teaching assistant robot for language education lies in verbal communication with children. However, the language recognizing function of robots often tends not to work in class environments, causing problems in long-term interactions. To ease the second discontinuation of interaction caused by communications according to [5], knowledge and information of Berlo's SMCR model and Applbaum et al.'s group communication model support the rationale for prior knowledge of the robot's weak recognizing ability to be supplied to the receivers (children). The information was told to the receivers (children) to determine how they were affected. It was thought that if the information was provided to the children with a friendly attitude, the later relationship between the receiver and the robot would be more stable and secure. The following hypothesis was set up.

Hypothesis: *Prior knowledge of the source (robot)'s feature of weak recognition ability during the process of storytelling will positively affect the receiver (children)'s attitude, such as giving increased patience and tolerance.*

Two classes of the third grade in an elementary school that had no experience with English learning using a teaching assistant robot were randomly selected. Table 2 shows the preliminary examination of the two groups' descriptive statistics and enthusiasm toward English. The subjects were surveyed about their interest in English learning with a 5 point Likert scale questionnaire. The two groups did not have a significant difference in enthusiasm for English (p= -0.0607). It was assumed that the children's knowledge and attitude were the same in both classes.

Table 2. Descriptive Statistics of Preliminary Test

Birth story of Robot	Not Sharing Group	Sharing Group	T (p-value)
No. (male/female)	29 (13/16)	32 (16/16)	-
Average Enthusiasm to English (Stdev)	4.2069 (0.7736)	4.2188 (0.7507)	-0.0607 (0.9518)

The self-introductory storytelling scenario-based contents were developed, and the robot was asked to act in the two classrooms. Before they listened to the birth story of the robot, each class had a time for communication with IROBIQ. They experienced both success and failure of recognition, and then they listened to the birth story of IROBIQ as shown in Figure 3.

Both qualitative and quantitative data were collected to examine the change in the receiver (children)'s attitude. Qualitatively, children were asked to write a letter to IROBIQ if they wanted to. Quantitatively, the children were asked to answer a 5 point Likert scale questionnaire about how smart IROBIQ looked, how much they wanted to study English with IROBIQ, and how many times they could put up with IROBIQ when it could not recognize them through their voices.

Figure 3. Testing IROBIQ's recognition (left) and Scene of answering the questionnaire

4.2 Analysis on Children's Motivation and Tolerance

The letters that children sent to IROBIQ were used to compare each group's tolerance toward the birth story, and the survey results from the questionnaire were used to compare context. with quantitative data. In the letters, the group that did not hear the birth story

asked mostly about the robot itself, such as the meaning of the name IROBIQ, the robot's hometown, and age, whereas the group that heard the story mostly wrote down that they can understand IROBIQ even if it malfunctions, as in Table 3.

Table 3. Sample Letters of Two Children

Birth Story	Letter
Not Sharing Child (Boy)	Hi, IrobiQ. Nice to meet you. Wow, I'm very nervous. Can you play soccor? Your legs are wheels. You have tiny hands. Can yu understand what I say? It's okay if yu don' understend because you are a robot. You are OK to not to not understend me.
Sharing Child (Girl)	Hello, IrobiQ. I don't have a broder. I wan you to be my younger broder. I want to sing with you and speak English with you. I don' speak English well. So…. How did you ea virus? I mean... you lost your memories. Bu it's OK. I'll help you. Let's speak English with me. It will be nice if I can be your master So, are you a boy or girl? What's your IQ? Can you dance and sing?

Letters were written by all members of the two groups, , with the exception of only three boys. The contents of each letter were divided into three parts, the history of robot, future life with the robot, and tolerance toward innate recognition, in order to analyze and search for frequency as shown in Table 4. The χ^2 analysis was held to test homogeneity between the two groups, in which the result turned out to be very meaningful as χ^2 = 12.132 (*p*-value=0.0069). The result suggests that the background story would play a positive role in enhancing tolerance toward the weak recognition of the robot, thus the background story might improve the mutually interactive long-term relationship between humans and the robot.

Table 4. Quantitative Comparison on Two Groups

Letter	Not Sharing Group	Sharing Group	χ^2 (*p*-value)
About history of robots	17	12	12.132 (0.0069)
About my future life with robot	13	11	
My generosity toward an innate recognition	2	17	
Total	32	40	

Table 5 shows *T*-test statistics for quantitative analysis in our hypothesis. The two groups were identical on presumed intelligence for robots and expectations for robot-aided English learning. However, the two groups' tolerance of how much they can put up with the robot when it sometimes fails to recognize them or what they say (failure to recognize facial image or voice) differed with *T*= -1.981 (*p*-value=0.054) at the significance level α=0.1. The storytelling group had a higher level of tolerance towards the robot's imperfect intelligence. Another noteworthy point is that while the group with no knowledge of the birth story was highly dispersed indicating wide declination of tolerance towards the robot, the other group aware of its birth story had a more stable level of tolerance.

Table 5. Quantitative Comparison on Two Groups

Birth story	Not Sharing Group	Sharing Group	*T* (*p*-value)
Robot looks smart (stdev)	4.4643 (0.5079)	4.5625 (0.5644)	-0.7044 (0.484)
I want to study English with the robot. (stdev)	4.5862 (0.6823)	4.6563 (0.6016)	-0.4261 (0.6716)
I can put up with the stupid robot sometimes (stdev)	3.9655 (1.2096)	4.4688 (0.6713)	-1.981 (0.054)

5. Conclusion

Digital storytelling frequently used in games and language education was applied to a teaching assistant robot for language education purposes. Since most robots have weak recognition as channels of Berlo's SMCR model in the real environment, such as a classroom or museum, children may become disappointed with the robots soon after they start interacting. It can be referred to as the second case specified by [5], when a man has an intention a robot is not able to recognize exactly.

To overcome this issue, Berlo's SMCR model and Applbaum et al.'s group communication model were assumed. The models include the attitude and personal information of the communicators (sources and the receivers). An experiment was set to discover if prior knowledge of the source (robot)'s limiting feature affects the receiver (children)'s psychological attitude toward robot treatment. Robot storytelling, by

considering the elements of storytelling and digital storytelling, was designed to deliver background information on the robot and then developed using an authoring tool with robot action script, such as facial expressions, actions, and multimedia displays on the touch screen of the robot. The quantitative and qualitative analyses were conducted to compare the motivation and tolerance level of children's interaction with robots between two groups, one which had shared the robot's birth story and the other that had not. It was found that the robot's birth story worked to increase children's tolerance toward it. In particular, the difference is more obvious in the qualitative data than in the quantitative data. However, this might have been caused by the children's characteristic to answer kindly rather than sincerely to such questions as 'I can put up with the stupid robot sometimes'. This suggests that we cannot be certain of children's sustained tolerance when robots do not give back the right response and recognition. This is a grave challenge in the long-term application of teaching assistant robots in the classroom. Future studies are needed to investigate the impact of prior knowledge of a robot's innate weak recognition in long-term interaction with children.

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