KINJIRO: Animatronics for Children's Reading Aloud Training

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Abstract. Reading aloud during childhood is fundamental to develop the necessary power of expression and imagination needed in our society, and is adopted by many elementary schools in language classes. Teaching reading aloud focuses on the ability to adjust the way one reads to improve the understanding of the listener. However, it is difficult for children not in class to correctly read aloud while being aware of the listeners. In this paper we propose a support robot that will allow children to enjoy reading aloud by themselves or with their family, and encourage them to do so while paying attention to their listeners.

Keywords: Animatronics robots, Aloud Training, Robot therapy.

1 Introduction

Reading books does not only enrich our lives but it is also said to be the foundation for acquiring the expressiveness and imagination needed to cope with the ever-changing environment and communication in our society [1]. To support such reading activities it is fundamental to start reading sentences aloud since early childhood, and for this reason elementary schools actively incorporate it in reading comprehension classes [2][3][4][5][6][7][8].

The elementary school read-aloud guidance focuses on the ability to adjust the voice volume, intonation and accent, to think about the listener while reading, and to read in an easy to understand way [5][6][7]. However, when children are not in class and without a listener it is difficult for them to read aloud as if reading for someone. In addition it has been pointed out that the embarrassment due to reading aloud in front of other people and the fear of being corrected when doing a mistake leads to developing the awareness of not being good at reading. R.E.A.D. (Reading Education Assistance Dogs) is a program conducted in the United States where children with reading difficulties read aloud with a dog as a companion, so that they can feel at ease while training regularly and improving their reading comprehension.

In this paper we propose KINJIRO, an autonomous animatronics robot for children which allows them to enjoy reading aloud with their families or by themselves, and encourages listener-aware reading. Animatronics refers to the use of robotics to imitate the appearance, motion and emotion expression of humans, animals and other characters that appear in movies and theme parks. In our system, in addition to a familiar external appearance and life-like motion generation, we added perceptive

Fig. 1. KINJIRO.

behaviors to give the feeling that the robot is listening, such as turning in the direction of the reader's voice, nodding and blinking. Thanks to an evaluation experiment with a group of elementary school children we were able to confirm the improvement of both reading span when reading by memory and listener-aware behavior.

2   Animatronics for Supporting Reading Aloud

With our reading aloud support animatronics robot (KINJIRO), not only the child can read while aware of it as a listener, but it also adopts psychological elements present in animals that relieves the child from shyness and stress (Fig.1) [11][12][13]. Parents and teachers can check how often and how long the child has been reading aloud using an application for smartphones.

2.1   Animatronics Control

When a child reads aloud, having someone willing to listen increases the motivation and the chances of continuing this activity [12]. For this reason KINJIRO reacts to the child by turning its head in the direction of the voice, nodding and showing happiness. Sound sensors in each ear of KINJIRO sample the nearby sounds at every millisecond. The neck has two degrees of freedom so that it can move up, down, left and right; ears and eyelids have one degree of freedom. When the child starts reading, if during a given interval the sensors value keeps exceeding a threshold the nodding phase begins. During this phase, if the value goes under a predicted limit it is interpreted as a pause in the sentence and triggers the execution of a nod. If the difference between left and right sensor values is sufficiently big, the head turns to face the voice. Nodding is accompanied by ear movements and blinking(Fig.2).
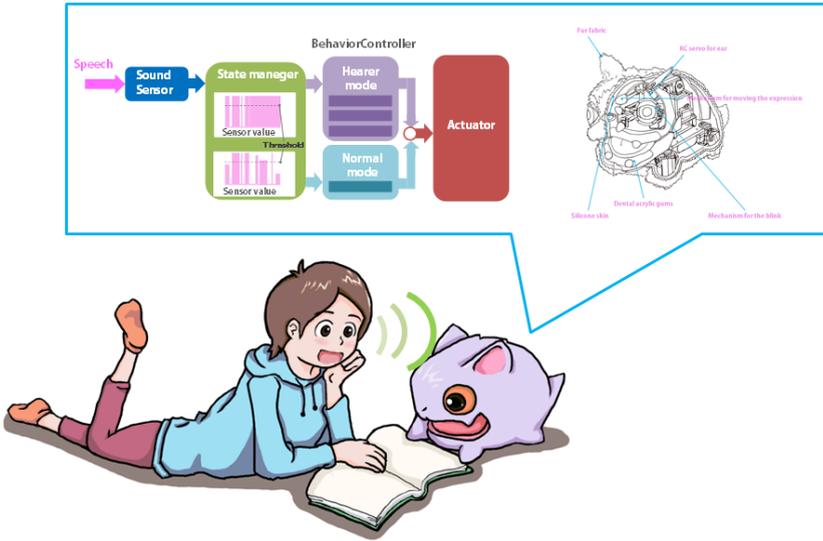
Fig. 2. Motion control of KINJIRO

2.2   Robot's Exterior

KINJIRO's exterior is made to let the child feel at ease and naturally induce helping behaviors in him. According to Lorenz, the characteristics of children cuteness (baby schema) activates in others the motivation to care for them [13]. Moreover, touching something fluffy like a dog's fur is considered to have a relaxing effect. For these reasons, KINJIRO is shaped to be seen as a baby animal, characterized by a big head, big mouth and small arms and legs. It is also covered in an elastic skin made of the same silicon used for special effects makeup. This makes it soft and comfortable to the touch, and allows for greater expressivity. The skin is covered with fur to resemble the touch and fluffiness of a real dog.

3   Evaluation Experiment

3.1   Goals

The goal of the experiment is to evaluate, by analyzing video recordings of children reading aloud with KINJIRO, their listener-awareness and enjoyment while reading.

Fig. 3. Internal mechanism and Production of skin.

3.2   Procedure

A child (elementary school, 2nd to 4th grade, male and female, 5 people) is made to sit in a room in front of KINJIRO and asked to read aloud. The text used for the experiment is taken from the textbook used in their respective language classes. By using a text which the child is used to, it is possible to reduce the difference among the children's reading skills. The reading experiment was repeated in three different conditions (in arbitrary order).:

- KINJIRO is present and moving (MK)
- KINJIRO is present and not moving (NMK)
- KINJIRO is not present (A)

After the experiment, children are asked to answer a questionnaire about their impressions on KINJIRO.

3.3   Video Analysis

After performing the experiment the recorded video data is analyzed. The text being read, the children's speech transcript and behavior (gaze, posture) and the behavior of KINJIRO are annotated using a timeline to examine their correspondences (Tab. 1, 2). Speech analysis is performed through ELAN, a dialog analysis tool [17].

Table 1. Description symbol of reading aloud behavior.

Transcript	content
Behavior	
B	Subjects move the eyes to book
BP	tracing books with a finger
LB	Subjects to lift the book
VR	Subjects move the eyes to the robot
Angle of head Fa	Front
Dla	down a little
Da	down

Table 2. Description symbol of the behavior of the robot.

Transcript	content
Nod	Nod
Ear	moving the ear
Blink	Blink
TF	Turn around

3.4   Questionnaire

To evaluate the impressions of the children about reading aloud and KINJIRO, a questionnaire in interview format has been carried out using a question panel. Q1, Q2, Q3 and Q5 use a five grade scale (5: Strongly agree, 4: Agree, 3: Neutral, 2: Disagree,

1: Strongly disagree), Q4 is an open question, Q6 and Q7 use a different five grade scale (5: Strongly like, 4: Like, 3: Neither, 2: Dislike, 1: Strongly dislike), Q8 has two options (with or without the presence of the robot).

—Questionnaire for a single subject—
Q1: Do you think that the robot listened to you when reading?
Q2: Do you think that the robot behavior changed in response to different ways of reading?
Q3: Do you want to read a book to the robot again?
Q4: How was reading a book to the robot?
Q5: Did you enjoy reading a book to the robot?
Q6: Do you like reading aloud?
Q7: After reading to the robot, did you start liking reading aloud more?
Q8: Which one was more interesting?

4   Evaluation Results

The results of the questionnaire are shown in Fig. 4. The overall impressions of KINJIRO are positive. Before the experiment, many participants gave neutral or negative answers to Q6; after the experiment, there was an increase in positive answers. Regarding Q8, most children reported a more enjoyable reading experience with KINJIRO than when reading by themselves.

Figure 5 shows a sample of the video analysis for test subject A, revealing the subject's behavior while reading aloud. The video analysis results for each subject are presented in Figs.4 and 5, and the results of the behavioral and speech features are presented in Figs. 6 and 7, respectively. The purple regions in Fig. 6 indicate when children are studying the book. During the periods indicated in blue, the children are shaking their bodies, touching their bodies with their hands, or performing other redundant movements. The red regions denote moments of looking at KINJIRO. When alone or in the presence of a stationary KINJIRO, all subjects showed many unnecessary movements and focused little on reading aloud. A moving KINJIRO attracted much more attention. However, even when KINJIRO was stationary, the children tended to look into its eyes. This behavior indicates that the children were aware of KINJIRO's presence, and thus better focused on reading aloud.

The green regions in Fig. 7 represent times of normal verbal reading. In the gray regions, the voice was small and difficult to hear, and white regions denote times of unnatural interruption or silence. Orange, red, and yellow represent various voice intensities. Subjects 1, 4, and 5 lowered their voices and lapsed into long silences when KINJIRO was stationary. Overall, KINJIRO's presence enriched the expressiveness of the subjects' speech The exception was subject 3, whose reading was fluent but expressionless regardless of whether KINJIRO was present or not, or (if present) whether moving or stationary. This subject was unaffected by KINJIRO even after a longer trial. From this result, we understand that perceptions of KINJIRO are subjective and can vary.
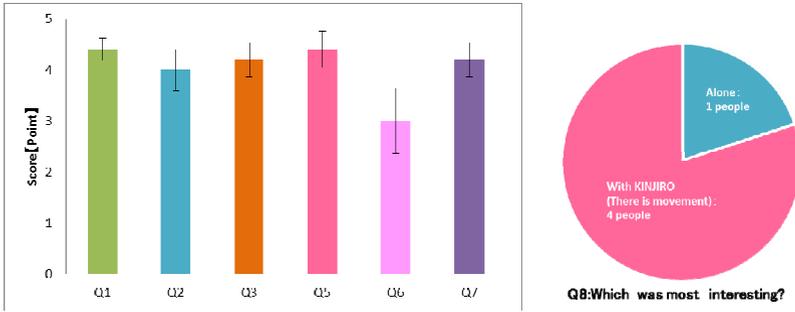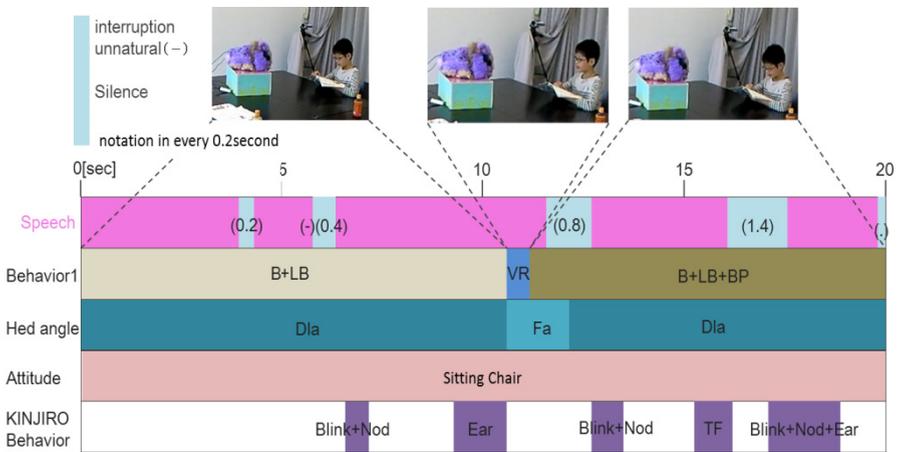
Fig. 4. Questionnaire results.

Fig. 5. Appearance of the experimental and Description of reading aloud behavior example

Overall, children who experienced difficulties in reading aloud by themselves or in the presence of a stationary KINJIRO developed clearer speech patterns when KINJIRO was present and active. The children also injected emphasis into their reading, spoke longer, and increased their expressiveness. Consequently, their reading was more easily understood. When KINJIRO was present and moving, the unnecessary movements almost disappeared, and children focused on their reading task. Moreover, the children frequently raised the book when reading and looked at the robot. According to the questionnaire results, the children felt that KINJIRO was listening to them and reacting to their reading.

These results affirm that a lifelike robot that reacts to reading aloud can improve children's verbal reading, because the children become aware of the robot's presence. Therefore, the robot can stimulate training even in children who lack the natural talent for reading aloud.
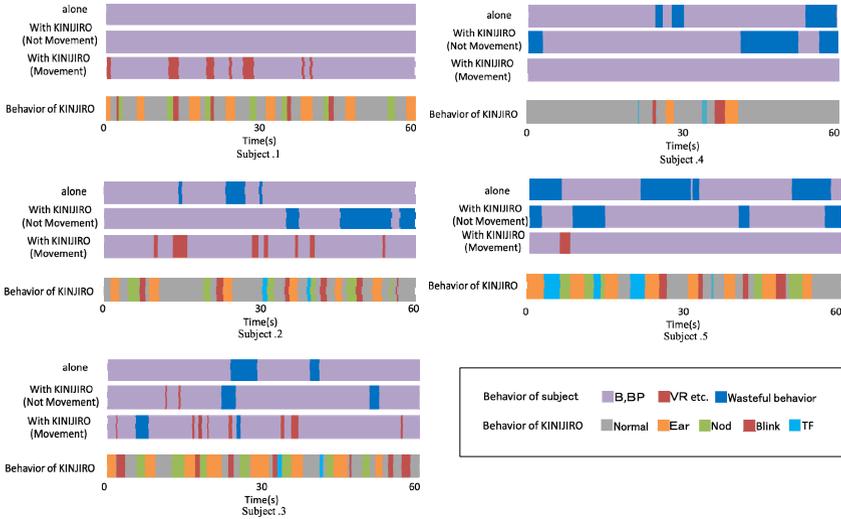
Fig. 6. Reading aloud Behavior of each subject.

5   Considerations

In Fig. 5 about subject 1, it can be observed how when reading with KINJIRO present there are numerous silences and interruptions, and the voice becomes difficult to understand. Near to when the interruptions happen, the subject looks at KINJIRO or takes up the book from the ground. Since the subject cannot follow the text when speaking while looking at the robot, it is necessary to memorize the text once and then proceed to speak. The increase in interruptions and silences when reading with the robot are probably due to this reason.

The amount of text one is able to correctly recall is called reading span, and is strongly related to one's reading comprehension capability [1][23][24]. From the data obtained from our experiment we are lead to believe that KINJIRO has a good influence on the reading span. Regarding the questionnaire, subject A's results were positive about enjoying reading aloud with KINJIRO and in Q4 answered that felt interested in the book when reading it to the robot. These results show how the subject pays attention to KINJIRO as a listener and enjoys reading aloud while looking forward to its reactions.

About subject 4, when KINJIRO is present parts of the text difficult to understand decreased and irrelevant behaviors too disappeared. In Q1 subject B answered that he thinks that KINJIRO is listening when reading aloud, thus confirming the fact that he is conscious of the robot as a listener. However, in Q8 he answered that he enjoyed reading by himself more than when with the robot. This suggests that reading with KINJIRO indeed improves reading aloud, but for the subject it may have been a source of nervousness.
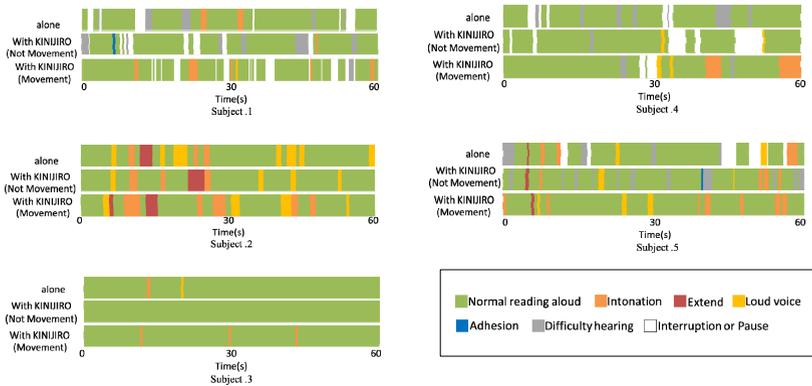
Fig. 7. Reading aloud state of each subject.

6   Conclusions

In this paper, we constructed an animatronics robot that acts as a listener, borrowing psychological elements from pets named KINJIRO. The aim was to instill enjoyment in reading aloud to a perceived listener whether alone or with family. To evaluate the efficacy of the robot as a learning tool, we recruited children to read aloud to the robot and analyzed the results using videos and questionnaires. All subjects increased their voice volume in the presence of an active KINJIRO, and their focus on the reading task and awareness of the listener was improved. Eighty percent of the subjects reported an enhanced reading experience. Since children widely differ in their personalities and capabilities, we will recruit more test subjects and extend the length of our experiments in future work. From the results, we will elucidate how a robot listener influences the verbal reading skills of children.

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