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Learning a foreign language vocabulary with a companion robot

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ABSTRACT

Modern emotional companion robots can support multimodal communicative interaction with humans using speech, gestures, and facial expressions. This paper researches the potential of a social robot in the educational process: in a situation of learning a foreign language vocabulary. We have compared a classic text interface for word-learning with a companion robot, orally supporting the learning process of students (43 people, 34 women, average age 22.5years). It was shown that selection of one of the two methods does not affect the efficiency of word memorization, however, most of the students appreciate the robot as an assistant and indicate is as a preferable, or one of the possible learning tools in their future studies. The obtained results open up further prospects for using emotional companion robots in the educational process.

1. Introduction

Modern interfaces such as computers, tablets, and smartphones provide a wide range of options for first and second language learning and are increasingly integrating into educational programs for children and adults (Golonka et al., 2014; Young et al., 2012). One of the recent tools in educational technologies are social robots (van den Berghe et al., 2019). Within the area of Human-Robot Interaction (HRI), researchers work to develop autonomous social robots, able to support people in learning new skills through repeated interactions through emotional feedback and social support cues. They are used in teaching natural sciences (Shiomi et al., 2015), mathematics (Brown & Howard, 2014) and music (Han et al., 2009). It is noted that robots are effective tools for language learning (Alemi et al., 2014; Belpaeme et al., 2018; Kennedy et al., 2016; van den Berghe et al., 2019), thus, constituting a rapidly growing area – robot-assisted language learning (RALL) (van den Berghe et al., 2019).

The main advantage of robots over traditional learning materials is that robots provide more natural interaction due to their appearance, which is often humanoid or animal-like. They can return the students to the learning process, thus, providing an external source of motivation. Social robots may guide users' attention via oriented movements: gaze direction and pointing gestures (Zinina et al., 2020), they can act in physical environment and teach through manipulating real objects or pointing at them. In (Han et al., 2009), based on the example of learning English, it is shown that home robots are more effective than other types of learning tools (such as books or audio recordings): children show a higher interest in learning, concentrate better, and increase their academic performance. In (Han et al., 2008), it is shown that the robot's cheering is especially important for children: the ability to give supporting feedback increases their interest and motivation. In (Brown & Howard, 2014), a robot uses different verbal encouragement strategies when teaching math to maintain the level of student engagement. The authors assume that educational robots should monitor student involvement and apply the engaging behavioral strategies (verbal or nonverbal) when the involvement decreases. In many interaction situations, robots are shown to be perceived as more interactive and user-friendly than computers (Alemi et al., 2014; Belpaeme et al., 2018; Kanda et al., 2004). As compared to the educational applications, social robots can demonstrate greater involvement of children in learning, increase their motivation and curiosity as well the number of emotional responses (Gordon et al., 2015; Wainer et al., 2006). Robots can communicate via gestures, facial expressions and speech – although this also may apply to animated screen characters, robots are generally perceived as more helpful, trustworthy, informative, and pleasant to communicate with than the animated characters (Kidd & Breazeal, 2004; Wainer et al., 2007). In addition, robots are more often perceived as human-like partners: as teachers, peers, or friends rather than as computers – both children and adults tend to anthropomorphize robots, that is, attribute human characteristics and behavior to them (Bartneck

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Fig. 1. F-2 robot.

et al., 2009; Beran et al., 2011; Duffy, 2003). Unlike teachers, a robot can play different interactive roles, acting as a mentor, as a learning tool, or an equal partner (Kanda et al., 2004; Mubin et al., 2013) – and switching a specific role, depending on the skill being trained. For example, a robot can be used to teach some material (as a teacher) and then – to practice what has been already learned (as a friend).

It is important to note that social robots have great potential in education not only for children, but also for adults (Belpaeme et al., 2018), in this case – for students of a linguistic university. In this paper we will compare the ability of the F-2 companion robot to act as an assistant in learning a foreign language vocabulary with a traditional way of word learning screen interface.

2. F-2 robot architecture

The F-2 robot (Fig. 1), designed for human–machine interaction experiments, was used in the study. The kinematic scheme of the robot allows reproducing human emotional movements. The robot has two moving hands and a head with a monitor for face projection. It is designed as a simple and reproducible research and educational platform. Within the experiment, the robot demonstrated gestures and facial expressions. The robot's behavior was divided into (a) situations of inactivity, where it demonstrated slight random movements, and (b) communicative situations, where the robot uttered a sentence (instruction or word), accompanied by facial expressions and gestures. Although the robot has the means to react to a user's gaze and speech, we did not apply these competencies in the experiment for not to change a user's preferences depending on some other type of interaction – in this experiment we concentrated on the evaluation of its teaching competence. Also, the robot has the ability to turn its head and direct its gaze to the current location of the user's eyes, but this feature was not used in this experiment either: each subject took a static position on the chair in front of the robot, so when the robot needed to *look at the user*, it directed its gaze to the supposed location of the user's head. The robot's speech was generated by the Yandex Speech API system. Thus, we used a state-of-the-art speech synthesis system, which, of course, loses in quality to the real voice, but represents the current level of technology for real human-robot interaction.

3. Experimental research

We conducted an experiment in which the robot acted as an assistant in learning the vocabulary of a foreign language. We hypothesized that personal interaction between a human and a robot can facilitate the learner's engagement and satisfaction with the learning process, compared to the more traditional means – a computer program with a screen interface.

Table 1
Examples of Latin words with the keyword.

Russian word (translated)	Latin word	Keyword (pronunciation and translation)
butterfly	papilio (pap[lĭo)	[pəpɪlómə] papilloma
swamp	stagnum (stagnum)	[stəgnátsəjʌ] stagnation
sparrow	passer (passĕr)	[pəsʌžir] passenger
crow	cornix (cornix)	[kór'en'] root

3.1. Stimulus material

Latin words with low frequency in both Latin and Russian were chosen as stimuli. 26 words were selected. The words were randomly divided into two groups for each of the experimental conditions.

Assisting procedure relied on phonetic keys: Russian words, phonetically similar to the Latin words. To choose the keywords, we presented the list of Latin words without translations to 42 Russian native speakers (mean age 22, female 28), not familiar with Latin, and asked them to suggest phonetically similar Russian words. For each Latin word, the most frequent Russian keyword had been chosen. Since the informants did not know the meanings of the Latin words, the suggested hints were usually semantically unrelated to the original words Table 1. The Latin words were then pronounced by a Latin specialist and recorded.

3.2. Subjects

The subjects were students of a linguistic university (n = 43, 34 female, average age 22.5 years). 38 (88.4 %) participants of the experiment noted that they had not studied Latin, and 4 (11.6 %) passed an introductory course of Latin in a medical institute. In spite of the fact that such examinees estimated their level of Latin language proficiency as *A1 / Beginner*, they did not know the words presented, because we used words with low frequency in both Latin and Russian. It was decided not to exclude these subjects from the sample.

3.3. Procedure

We used a within-subject experimental design: each participant of the experiment was practicing Latin words with the robot and with the computer (Fig. 2). The order of the conditions was randomized. During the experiment the participant stayed alone in the experimental room with the robot or the computer, without the involvement of the experimenter. The start of each condition and the reactions to the subject's correct answers were controlled from an adjacent room: *the Wizard of Oz* paradigm was used for the correct answers. Wrong answers were not handled, as the interfaces were programmed to suggest keywords and correct readings in standard 5 *sec* intervals, thus, supporting the learning process in case no correct answer was given. The entire experiment was recorded on video.

At the beginning of the experiment, the person sat in front of the robot or in front of the computer. The experimenter introduced the procedure of the experiment in details, showed a video of the procedure and answered the participant's questions. In each condition a subject passed two stages: (a) got acquainted with the words, and (b) was training the words.

During the interaction with the robot: (a) the subject saw a Latin word and its translation on the screen and heard its reading by the Latinist, moreover, the robot presented the keyword to help memorize the Latin word. After this general introduction, the robot (b) assisted in learning the words: it pronounced the word in Russian, allowing the person to recall the Latin word. If the person did not remember the word, the robot pronounced the keyword, and if the person again did not give the answer (was silent or gave an incorrect answer), the word was

Condition 1 – With the robot

Condition 2 – With the computer

Fig. 2. Experimental conditions for word learning.

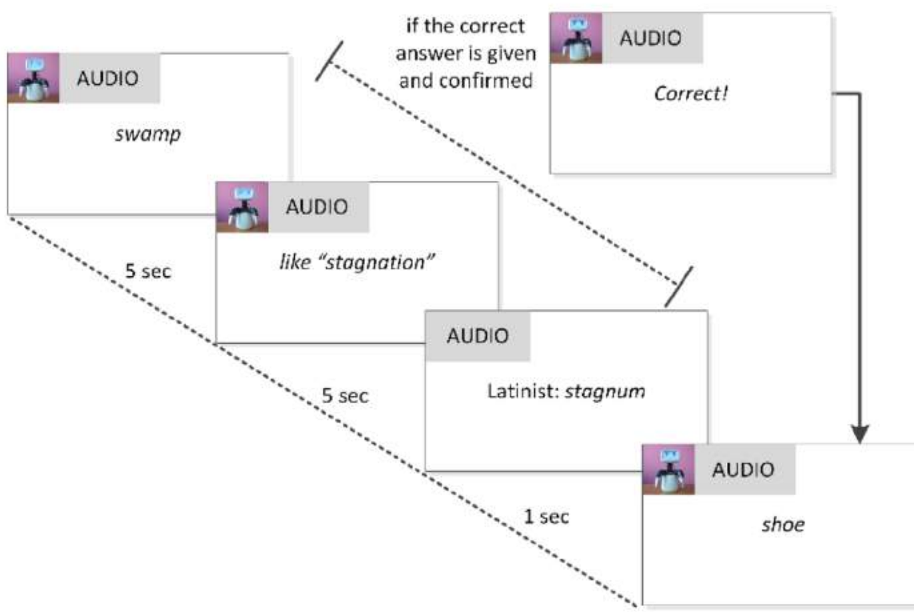

Fig. 3. Learning phase with the robot.

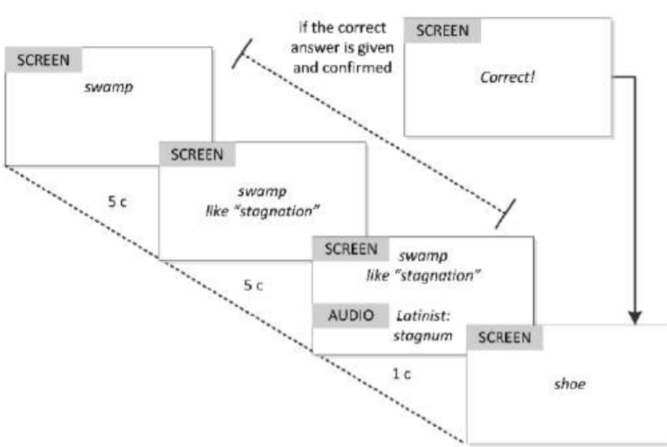

Fig. 4. Learning phase with the computer.

pronounced by the Latinist. The monitor was not used at this stage. All the hints (keyword and Latin reading) have been presented in fixed 5 *sec* intervals. Words were presented in random order but each word was presented twice (Fig. 3).

In the control condition, the same word-learning procedure was reproduced on the computer. During the first state (a) a Latin word with its Russian translation had been presented on the screen with the Latin pronunciation. Then – the keyword was added to the screen. During the training phase (b) a Russian word appeared on the screen. In case the student replied with the correct Latin word a word *Correct!* appeared on the screen and the procedure continued to the next word. In case the correct answer was not presented, a keyword appeared on the screen, and in case the correct answer still was not presented – the Latin word was pronounced by the Latinist (Fig. 4).

After the training of words with the robot and the computer, the subject was invited to the next room, where the experimenter checked the words learned in both experimental conditions (with the robot and with the computer). The oral form of verification was chosen because it corresponded to the oral form of responses in the experiment. The test was performed in two stages:

(a) Subjects were asked to recall all the possible pairs: Latin words with their translations.
(b) The experimenter announced to the subject all the remaining Russian words and asked to recall the corresponding Latin words.

After testing, the subject filled out a questionnaire. An adapted *User satisfaction questionnaire* (Degtyarenko et al., 2010) was used to evaluate user's experience during training. Based on the questionnaire four

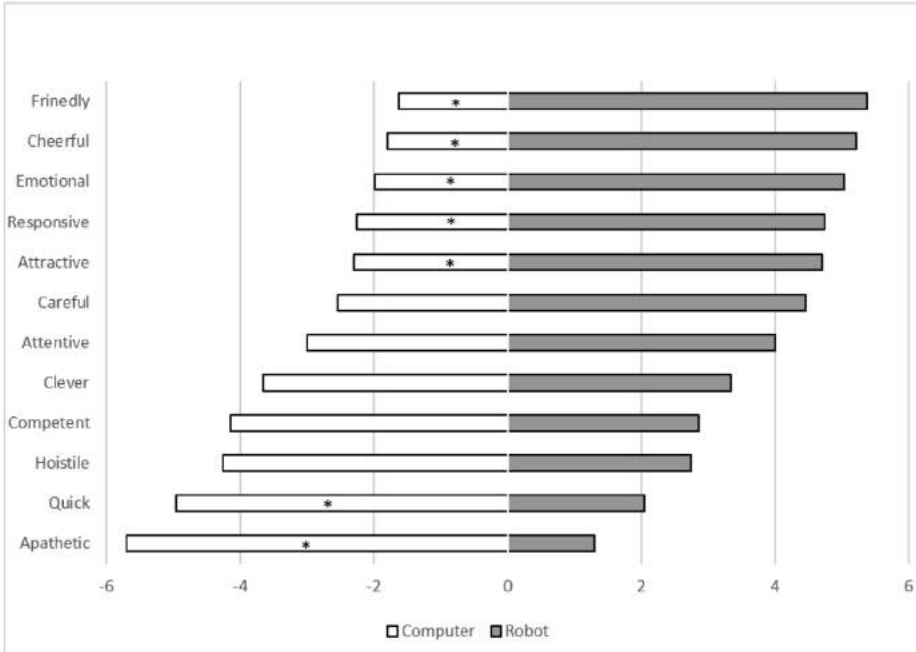

Fig. 5. Perception of the robot and computer on semantic differential scales (0 – neutral, negative values – preferences of the computer, positive values – preferences of the robot).

factors related to user satisfaction are evaluated: *Efficiency* (reliability and functionality), *Usability*, *Utility*, and *Emotional attractiveness*. We also evaluated respondents' perception of the robot using a modified *Godspeed methodology* (Bartneck et al., 2009), where five key dimensions in HRI concepts were taken as the basis: *anthropomorphism, animation, attractiveness, perceived intelligence*, and *safety*. Previous studies have shown that the level of emotional intelligence (EI) is correlated with the perceived features of the robot, so it was decided to evaluate the EI of the subjects in this experiment. For this purpose, D.V. Lusin's *Emotional Intelligence Test* (EmIn) was used (Lyusin, 2006, 2009). The test is based on the interpretation of emotional intelligence as a person's ability to understand and manage his or her own emotions as well as the emotions of others.

3.4. Results

According to the results, 25 people (59.5 % of the entire sample) indicated that they more enjoyed learning words with the robot, 10 people (23.8 %) definitely preferred the computer, and 7 people (16.7 %) equally rated the two methods. Interestingly, the participants who preferred learning words with the robot or with the computer rated the comfort of interaction with the corresponding device significantly higher (t-test, $p < .05$). According to the semantic differential scales, the participants described the robot as compared to the computer as *more friendly, cheerful, emotional, responsive*, and *attractive*, while the computer was more *apathetic* and *quick* in the respondents' evaluations (Fig. 5).

In addition, groups with different preferences for foreign language learning (either robot or computer) differ significantly (Mann-Whitney U Test, $p < .05$) in evaluating the robot's *attentiveness*. Test takers who preferred the robot also attributed *hostility* and *apathy* to the computer.

According to the modified *User satisfaction questionnaire* (Degtyarenko et al., 2010) such factors as *emotional attractiveness* and *usefulness* of the robot make a crucial contribution to the preference for one or another mode of interaction (Mann-Whitney U Test, $p < .05$). Groups with different preferences also differ on key dimensions in the HRI concepts of Godspeed (Bartneck et al., 2009). For example, respondents who prefer the robot are significantly more likely to describe the robot as *natural, interactive*, and generally more *enjoyable* than the computer (Mann-Whitney U Test, $p < .05$).

The groups with different preferences did not differ in the degree of the subjects' emotional intelligence, hence, we can conclude that this characteristic is not interrelated with the choice of the preferred method of learning.

After the experiment, we asked the subjects which words they remembered in two ways. We underlined that their personal ability to memorize foreign words was not intended to be tested – this was necessary in order to decrease the general level of anxiety of the subjects. According to the results, the subjects were equally successful in learning Latin words in both experimental conditions.

According to the post-experiment interview, we can conclude that respondents tend to like the robot as a means of foreign language learning. Even those examinees who preferred learning words with the computer noted that personal interaction with the robot could be effective for learning a foreign language: 37 examinees (86.1 %) said yes, 5 people (11.6 %) doubted the effectiveness of the robot for language learning, and only one examinee (2.3 %) said, the robot is not likely to be effective.

4. Conclusion

According to the results we can conclude that the robot within the suggested procedure has good perspectives to be used as an assistant to learn a foreign language. The robot gives a positive impression, and increases motivation and desire to use this method of learning in the future. Students of the linguistic university highly evaluate the applicability of the robot in this task. At the same time, this method demonstrates equal learning efficiency with the state-of-the-art learning technics, but can also apply to the situations of free oral interactions with the robot – as subjects do not need to face a computer screen during training. The obtained results open up further prospects of using the F-2 robot in the educational process.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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