A Language Learning System Utilizing RFID Technology for Total Physical Response Activities

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Abstract. In this paper, we present a method of integrating a CALL system with RFID tags in a classroom in order to provide the basic support for listening activities based on the concept of Total Physical Response (TPR) Approach. We designed and developed a prototype system with the function of providing corrective feedback. The prototype system has the following three features: (1) Real objects are used as the options for responding to audio questions. (2) A considerable amount of attribute information is used to increase the variation in the questions. (3) The system has a function of providing error messages and additional questions, depending on the degree of a learner's mistakes. Results from the experiment suggest that integrating real objects into the learning system by using RFID tags has a potential impact on the language learners.

Keywords: RFID, Language learning, TPR, Corrective feedback, Interaction.

1 Introduction

Radio communication technology, such as radio-frequency identification (RFID) tags has been the focus of attention in recent years[1,3], and it is expected to be incorporated in the field of education[2,8,9,11]. With the inclusion of such technologies, the learning environment can be embedded in the real world, thus resulting in the following educational benefits. First, the real-world objects can be used as learning materials by attaching RFID tags to them; this will have a better impact on learning and will increase its potential effectiveness. Second, learners will be able to directly interact with their teachers and peers in the face-to-face environment, wherein the teachers can observe the learning processes of the learners.

In this study, we present a method of integrating a CALL system with RFID tags in a classroom in order to provide the basic support for listening activities. In this system, the learners are required to respond to the commands of a system by performing a physical movement based on the concept of the Total Physical Response (TPR) approach[7]. It is believed that the TPR approach is a method through which learners can directly understand the target language without translating the commands into their own language. By utilizing the concept of the TPR approach, we designed and developed a prototype system that provides error messages and additional questions. The prototype system developed has the following three features: (1) Real objects are

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used as the options for responding to audio questions. The respective object is linked to its attribute information. (2) A considerable amount of attribute information is also used to increase the variation in the questions. Thus, multiple target listening points are included in one question. (3) The system has a function that provides not only appropriate error messages depending on the learner's incorrect responses but also provides additional questions as supplementary exercises, depending on the degree of the learner's mistakes.

The remainder of the paper is organized as follows. Chapter2 describes the basic concept of the system. In chapter 3, the outline and features of the prototype system have been discussed. Chapter 4 presents the implementation of the system, and chapter 5 explains the experiment and its results. Finally, the conclusions as well as future suggestions are presented in chapter 6.

2 System Concept

In this chapter, the basic concept of the system has been described. This includes the concept of the TPR approach, the manner in which the questions and answer options should be arranged so as to cope with the variation in and difficulty level of the questions, and the manner in which feedback messages should be prepared in response to the learner's mistakes.

2.1 The TPR Approach

The TPR approach is a method in which teachers first provide a command in the target language, and then perform the corresponding action with the students. In this manner, the students learn not only by observing the actions but also by performing them[7]. In lessons that employ the TPR approach, teachers should avoid introducing new commands in quick succession. It is generally recommended that they present three commands at a time. As the students increase their knowledge of the target language, a longer series of connected commands can be provided. In this method, the actions clarify the meaning of the commands. Moreover, memory is also activated by connecting the actions with the language. From the teachers' perspective, they will be able to immediately determine whether or not the students understand the command by observing their actions. The prototype system designed and developed in this study is based on this method.

2.2 Question and Feedback Structure

Varying the Question Sentence Patterns and Controlling the Difficulty Level of the Questions. When creating listening exercises, it is necessary to consider the variation in the question sentence patterns and the difficulty level or complexity of the questions. The latter is related to certain aspect of language, i.e., vocabulary and phrases, grammatical structures, and length of sentences. Thus, a listening sentence that includes many new words and high-level grammatical structures will be difficult to comprehend. In addition to vocabulary and grammatical complexity, the difficulty level of a question will also be affected by the length of the sentence[10]. Therefore, vocabulary, grammatical structures, and length of sentences are the determinants of

the difficulty level of questions. However, the following can be employed to reduce the difficulty level.

1. Give specific examples: When using terms such as “carbonated drinks” in a question, provide specific examples such as “Coke” or “Sprite.”
2. Give external characteristics: When the word “glue” is mentioned in a question, provide supplementary information about its external characteristics such as "It has the shape of stick and has a blue cap."
3. Simplify the text: Consider the following sentence, "Please give me cold lemon juice in a plastic bottle." This text can be simplified by breaking it up into two sentences, such as "I want a cold drink. A lemon juice is good, and a plastic bottle would be better."

Thus, providing examples, giving supplementary information, and breaking up the questions into manageable parts is helpful for the learners.

Controlling the Difficulty Level of the Questions by Varying the Response Options. The second factor to be considered is the response options. Typically, teachers instruct mixed-level learners, and hence, by observing the level of each learner, they need to keep changing the difficulty level of the questions. However, we can also control the difficulty level of the questions by varying the response options to the questions. For example, when a question such as "Please choose cold lemon juice which costs ¥130" is presented, the learner will attempt to listen selectively for specific information such as cold, lemon juice, and ¥130. If the learner is required to choose a response from the following four options, he/she will have to listen to the question and identify all the key words: (1) cold, lemon juice, and ¥130; (2) cold, lemon juice, and ¥150; (3) cold, apple juice, and ¥130; (4)hot, lemon juice, and ¥130. However, if the learner is given the following options, he/she will be correct even if only one key word is correctly identified: (1) cold, lemon juice, and ¥130; (2) hot, orange juice, and ¥200; (3) cold, banana juice, and ¥150; (4) cold, apple juice, and ¥150. In this manner, the difficulty level of questions can be controlled, depending on the learner’s understanding, by merely changing the response options. This method would be helpful particularly when teaching lower-level learners. Thus, when developing our system, we introduced the above-mentioned concept of changing the objects that are used in the response options.

Corrective Feedback. In general, teachers react to the mistakes made by learners in many different ways. One such manner is by providing feedback; it helps the learners in altering their outputs in a constructive manner. The typical types of corrective reactions have been described in Chaudron's research[4,5] in the following manner:

_Emphasis: Using repetition, or questions, to identify the aspect that is incorrect
_Explanation: Providing information on the different causes of the error
_Original question: Repeating the original question
_Altered question: Altering the original question syntactically, but not semantically
_Verification: Assuring that the correction has been understood

In addition, the following can be regarded as the other types of corrective reactions:

_Selecting & reviewing: Selecting & reviewing important points in order to guide the learners toward the right direction
_Breaking down: Breaking down the learning items into smaller parts/steps to ease understanding

Based on the above-mentioned works, we considered the function of providing feedback in the prototype system.

3 Prototype System

3.1 Flow of Instructions

Fig. 1 illustrates the prototype system developed in this study. When a learner scans a question card, the system reads out the corresponding message, e.g., "Please choose cold lemon juice in a plastic bottle" (Fig. 2).

Fig. 1. Prototype system

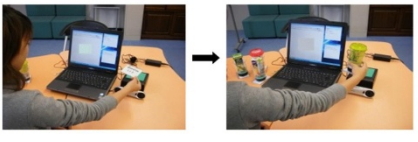

Fig. 2. Method to use the system

The flow of instructions has been presented in Fig. 3. When the learner responds to the question by choosing an appropriate object and allowing the scanner to scan it, the system will check his/her answer. For example, if the learner chooses a cold, orange juice can, the system will detect an error in the following two attributes: kind and container type. Thereafter, it will detect the degree of the error, i.e., the data pertaining to two attributes among the three targeted attributes are wrong. These errors are represented as follows: cold = cold, lemon ≠ orange, and plastic bottle ≠ can. Then, the system will read out an error message, e.g., "No, it is not lemon juice. It is not in a plastic bottle," followed by an additional question regarding the wrong response, e.g., "Please choose lemon juice." If the learner provides the correct response in this case, the system would state, "OK, good," and then read out the second additional question for another wrong response, i.e., "Please choose a plastic bottle." If the learner correctly responds to all the additional questions, the system would again read out the initial question, i.e., "Please choose cold lemon juice in a plastic bottle." At this instance, when the learner responds correctly, the system will move on to the next question.

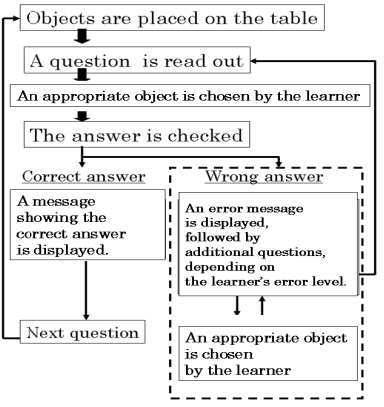

Fig. 3. Flow of instructions

3.2 System Features

The Use of Real Objects for Providing Responses. In this system, learners are required to choose an appropriate object after listening to the question. The system checks whether or not the object selected is correct. In order to realize this, real objects with RFID tags are used as the response options. The respective objects are linked to a considerable amount of attribute information that includes factual data about the object, such as kind, price, container type, and size, as shown in Fig. 4. A set of correct attribute information is also prepared in advance for each question. The system checks the responses made by the learners by comparing the difference between the attribute data of the correct response and that of the selected response.

Questions with Multiple Target Listening Points. The attribute information of each object is also used to create questions with multiple target listening points. Here, the target listening points refer to the points in a question that a learner is required to listen to. For instance, in the question "Please choose cold lemon juice in a plastic bottle," the target listening points are cold, lemon juice, and plastic bottle. As mentioned above, a set of correct attribute information is prepared for each question. Further, a question sentence pattern is also prepared in advance. For example, in Fig. 5, the attribute data—(1) cold, (2) lemon juice, and (3) plastic bottle—are set as the correct attribute information. When we frame a question using the above data, "Please choose [hot/cold] [kind of juice] in a [container type]," the following question will be read out: "Please choose cold lemon juice in a plastic bottle."

Error Messages and Additional Questions. When considering feedback messages and questions, many of the existing CALL materials, including the commercially available ones, only have a "Good-Wrong" feedback function, leaving much to be desired. In this respect, more detailed feedback and step-by-step support can be expected, depending on the learner's level of understanding. Taking the above-mentioned into consideration, the prototype system verifies the responses given by the learner and reads out corresponding error messages as well as additional questions. These error messages and additional questions are produced based on the degree of the learner's mistakes.

ID No.	hot/cold	kind	size	container type	kilo-calories	price	..
0101	hot	lemon juice	small (sized)	plastic bottle	200 kcal	130 yen	..
0102	cold	carrot juice	small (sized)	plastic bottle	250 kcal	150 yen	..
0103	cold	orange juice	large (sized)	can	350 kcal	200 yen	..
...	...	...	...	...	...	...	..

Fig. 4. Attribute information of the objects

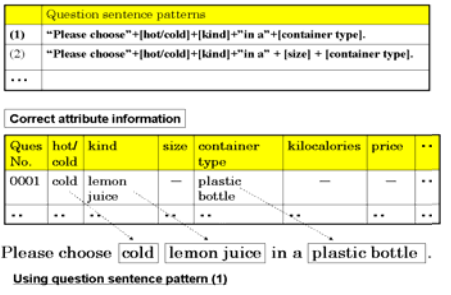

Fig. 5. Process of creating a question

Fig. 6 illustrates the manner in which error messages and additional questions are selected and produced.

1. To count the number of incorrect attributes (n) in a question
2. To calculate the ratio (n/m) between the number of incorrect attributes (n) and the total number of attributes in one question (m), by which the degree of the learner's mistakes are graded based on the error level
3. To determine the scenario pattern (feedback pattern) of the error messages and the additional questions, which are adapted to the learner's error level
4. To produce error messages and additional questions in the decided scenario pattern

For example, when the learner listens to the question "Please choose cold lemon juice in a plastic bottle" and chooses a cold, orange juice in a can, the system detects that the attributes of kind and container type are incorrect. It then calculates the degree of the error, i.e., two of the three targeted attributes are wrong, represented as cold = cold, lemon ≠ orange, and plastic bottle ≠ can. In this case, the error level is determined to be Level B, and the scenario pattern decided is S3. The system then reads out the error message, "No, it is not lemon juice. It is not in a plastic bottle." Thereafter, it reads out an additional question for the wrong answer, "Please choose lemon juice." If the learner provides the correct answer, it reads out the second question, "Please choose a plastic bottle." If the learner answers all the additional questions correctly, the system reads out the initial question again.

4 Implementation

The prototype system is outlined in Fig. 7. The system consists of a PC, an RFID tag reader unit (RFID-RS232C READ/WRITE BOARD), and question cards and real objects with RFID tags (Philips, Hitag2). The tag unit can read data from and write data into the RFID tags within a distance of about 5 cm. The system is implemented using Java and JavaScript. The PC functions as a local web server in the system. As shown in Fig. 7, two threads, i.e., the thread of detecting the scanning activity of the RFID tags and that of observing the clipboard, are developed by Java; the question sentences, response checking, error messages, and additional questions are developed by JavaScript. JavaScript is used because the patterns of the questions and feedback messages can easily be added.

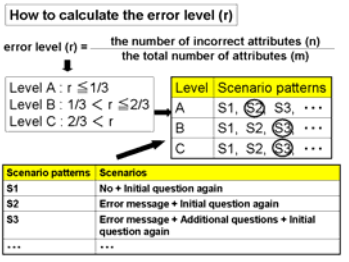

Fig. 6. Process of producing feedbacks

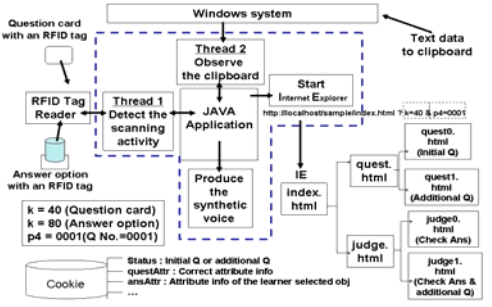

Fig. 7. Outline of the prototype system

The process of how the system works is described in Fig. 7. Here, one question sentence pattern and one feedback message pattern are implemented in the prototype system. The information about the question number and the kind of card (a question card or an answer option card) is transferred by using the method of "get." The information representing whether the system produces an initial question or an additional question, correct attribute information for each question, and attribute information of the object that the learner chose as the response object, are transferred by using a "Cookie." First, when a question card with an RFID tag is scanned, the related information is read by using the "get" method in Thread 1 of the Java application. The information about the kind of card and the question number are obtained and embedded into a URL. Then, Internet Explorer is activated with the URL (http://localhost/sample/index.html?k=40&p4=0001) in which the query string is added. In Fig. 7, k represents the kind of card, and p4 represents the question number. The file index.html provides a question or checks a response based on the information of the kind of card that is scanned. If a question is provided, the file quest.html is activated; on the other hand, when an answer is provided, the file judge.html is activated. Further, the file quest.html provides an initial question or an additional question based on the information maintained in the "Cookie." If the initial question is to be produced, quest0.html is activated, and if the additional question is to be produced, quest1.html is activated. Similarly, with regard to the file judge.html, the "Cookie" determines whether the response is for the initial question or for the additional question. If it is for the initial question, judge0.html is activated, and if it is for the additional question, judge1.html is activated. In Thread 2, the system observes the clipboard, and produces questions or feedback messages in synthetic voices.

5 Experiment

5.1 Participants and Procedures

Thirteen students were selected to evaluate the system; their evaluations were assimilated with the help of a questionnaire. There were seven undergraduates, five graduates, and one postgraduate. Two exchange students from the U.S. whose native language was English were among the seven undergraduates. They worked as

teaching assistants in the free conversation room at the University. After providing them with the necessary instructions on how to use the system, each student attempted to use the system with two different feedbacks: (1) only with "OK, good", and "Wrong, Once again," without detailed error messages or additional questions, and (2) with detailed error messages and additional questions. Subsequently, they were required to complete a questionnaire on the usability of the system, the use of real objects as response options, and the feedback messages and additional questions depending on the degree of the learners' mistakes.

5.2 Results and Discussion

System Usability and the Use of Real Objects as Learning Materials. According to the results of the questionnaire, as shown in Table 1, all the participants were of the opinion that the system with RFID tags was easy to use. Further, twelve of them agreed to the question "Is using real objects as learning materials useful for learning vocabulary." The results suggested that the system does have a potential impact on language learners, albeit further empirical studies are required.

Detailed Feedback, Depending on the Degree of the Learner's Mistakes. Participants were required to choose the statements that best described what they observed from among the options presented in Table 2, on the basis of the two above-mentioned feedback functions. According to the results, (1) 70%–80% of the participants stated that when they used the system with detailed error messages and additional questions, they could follow the exercises by themselves; further, they found that the error messages were effective in identifying their mistakes. (2) Half of them believed that this function could enhance the interaction between the system and the learner. In fact, some of them also commented that the "Good-Wrong" feedback function was monotonous and that the detailed error messages and additional

Table 1. Results of the questionnaire on system usability and use of real objects

Questionnaire	Yes	No
Is the system with RFID tags easy to use?	13 (100%)	0 (0%)
Is using real objects as learning materials useful for learning vocabulary?	12 (92%)	1 (8%)

Table 2. Results of the questionnaire on the two feedback functions

Statements with regard to the two feedback functions	"Good-Wrong" feedback	Detailed feedback
We can identify our mistakes with the help of error messages.	3 (23%)	**10 (77%)**
We can follow the exercises with the help of feedback messages.	4 (31%)	**9 (69%)**
This function can enhance the interaction between the system and the learner.	2 (15%)	**6 (46%)**

questions, depending on the degree of the learner's mistakes, were good because each learner's mistake is different from the others. Based on these results, it appears that the participants showed positive responses toward detailed error messages and additional questions, depending on the degree of the learner's mistakes. At the same time, they also stated that variation in the feedback messages should be increased.

Additional Questions. Finally, the participants were required to choose the statements that best described their opinion from among the options presented in Table 3, with regard to additional questions. In Table 3, the results are classified into two groups—native speakers (NS) and nonnative speakers (NNS). According to the results, the two exchange students (NS) agreed that one additional question was sufficient for multiple errors, while the seven NNS believed that one additional question was required for every error.

Table 3. Results of the questionnaire on additional questions

Statements regarding additional questions	NS (two participants)	NNS (eleven participants)
One additional question is sufficient for multiple errors.	**2**	0
It is better to provide an additional question for the error.	0	**7**
We can check each mistake with the help of additional questions.	**0**	**6**
Additional questions are short and easy to understand.	1	**5**

This result is consistent with the result that about 50% of the NNS felt that they could check each error with the help of additional questions. Further, five NNS agreed that the additional questions were short and easy to understand. Based on these results, it can be stated that feedback messages and short question sentences are helpful for learners who are unfamiliar with listening to a foreign language. It is expected that feedback comprising one additional question for an error is sufficient for helping foreign language learners.

6 Conclusion

In this study, we proposed a CALL system with RFID tags in order to provide the basic support for listening activities in a classroom. Results from the experiment suggest that integrating real objects into the learning system by using RFID tags has a potential impact on language learning. Further studies on the variation in the feedback messages and additional questions are required to improve the system. It is assumed that the present prototype system can only be used by one user at a time. The individual user is not authenticated, and the learning history data are not saved. Using an RFID tag card as an identification card and saving history data on the RFID tags would help cope with these issues.

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