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ABSTRACT

Previous research has shown that the presence of a human peer during a learning task can positively affect learning outcomes. The current study aims to find out how second language (L2) vocabulary gains differ depending on whether children are learning by themselves, with a child peer, or with a robot peer. Children were administered an L2 vocabulary training in one of these three conditions. Children's word learning was measured directly after the training and one week later. Contrary to our expectations, children learning by themselves outperformed children in the peer conditions on one out of four word knowledge tasks. On the other tasks, there were no differences between the three conditions. Suggestions to further study the potential benefits of a robot peer are provided.

KEYWORDS

Child-robot interaction; peer learning; L2 vocabulary learning

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1 INTRODUCTION

Human peers can positively affect learning outcomes, by transferring their knowledge onto the learner, increasing task enjoyment, or allowing for learning-by-teaching [1]–[3]. One of the advantages of robots over other forms of technology is that they can take up various roles in learning interactions, such as tutors, teaching assistants, and, crucially, peers. Perhaps robot can, similarly to human peers, enhance learning outcomes.

Present evidence in robot-assisted language learning studies on the effectiveness of robot peers is contradictory. Some studies employing a robot as a peer find that children do learn [4]–[6], while other studies find limited learning or effects for only a subgroup of the children (e.g., those who voluntarily continued playing with a robot over time) [7], [8]. In these studies, the presence of a robot peer has not always been systematically compared to children learning alone or together with a human peer, and they differ in their design (e.g., single or multiple sessions, the robot acting like a tutor versus a learner). The current study compares L2 vocabulary gains across three learning conditions: children learning by themselves, with a child peer, or with a robot peer during a single session. The findings will help develop effective robot peers.

2 METHOD

In this study, 67 Dutch kindergartners (26 girls and 41 boys) with an average age of 67 months (*SD* = 7) participated in an L2 (English) vocabulary training. They were randomly assigned to one of the three conditions: (1) the child-only condition, in which they were learning by themselves (*N*=23), (2) the robot-peer condition, in which they learned together with a robot (*N*=23), or (3) the child-peer condition, in which they learned together with a child of the same age (*N*=21).

Children were taught six L2 English target words: "heavy", "light", "full", "empty", "in front of", and "behind". As part of the training children had to manipulate 3D images of objects on a tablet (e.g., putting animals in a cage). In the child-only condition, the child performed all manipulations on the tablet screen. In the peer conditions, the target child and the robot or child peer took turns in performing actions on the tablet.

The robot used in the present study was a NAO robot, developed by Softbank Robotics. We used the Wizard-of-Oz approach. The robot's responses had been preprogrammed, such that its responses and behaviors were consistent for all children.

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To make sure the children would perceive the robot as a peer, children were instructed prior to the training that the robot also did not know the English words yet and was going to learn these as well. The robot's behaviors were: 1) manipulating the tablet; 2) repeating the target words; 3) commenting on the children's manipulations; 4) pointing to the tablet while explaining what to do, in case the child failed a task. Types 1 and 2 were the same activities as the child (and child peer) was/were asked to do, type 3 was included to increase children's motivation and stimulate interaction, and type 4 was used to provide scaffolding.

Children's word learning gains were assessed immediately after the training and one week later using four tasks: (1) a translation task in which the child had to translate the word from English to Dutch; 2) the same task from Dutch to English; 3) a comprehension task in which children had to select the picture that best represented the target word out of four options; and 4) a sorting task in which the child had to sort cards depicting one of two antonyms, e.g. "heavy" and "light", into trays depending on the word depicted on it. In addition, children were asked directly after the training whether they perceived the robot as a friend or a teacher, to assess whether our framing of the robot as a peer succeeded. Finally, a non-word repetition task in which children repeated non-existing words [9] was administered during the delayed post-test to investigate the comparability of the three groups on an important skill related to word learning: phonological memory.

The training and the tests were administered individually in a quiet room at children's schools. The first session, in which the training and the immediate post-test were administered, lasted about 50 minutes. The second session, with the delayed post-test and the non-word repetition task, lasted about 30 minutes.

In our data analyses, we included phonological memory and age as covariates, as one-way ANOVAs revealed a significant difference across the three groups in phonological memory, p = .039, with post-hoc tests showing that children in the robot-peer condition outperformed children learning alone, and in age, p = .047, with post-hoc tests showing that children learning alone were older than children in the robot-peer condition. Due to floor effects, the scores on the translation tasks were transformed into a dichotomous variable (having produced no words or at least one word correctly).

3 RESULTS

First, we assessed whether framing the robot as a peer succeeded and whether children performed above chance level on the comprehension task (25%) and the sorting task (50%). Most children (18 out of 23) saw the robot as a friend rather than as a teacher. Children performed above chance level on the comprehension task and the sorting task in both sessions (all ps <.005, 1.04 < d < 2.03).

Pearson's Chi-Square Tests indicated no effect of condition on the scores of the translation tasks in both sessions (all ps > .101, .305 < φ < .382). A repeated-measures ANCOVA showed an interaction effect between condition and time (p = .012, partial η^2 = .10), which was significant for the comprehension task (p = .010, partial η^2 = .15), but not for the sorting task (p = .091, partial η^2 = .08). For the comprehension task, children learning alone outperformed children in the child-peer condition during the delayed post-test (p = .031, d = 0.72) (with a trend for children in the robot-peer condition, p = .071, d = 0.47), while they did not differ significantly from children in the peer conditions during the immediate test (both ps >.999, 0.12 < d < 0.14).

4 CONCLUSIONS

Contrary to our expectations, we found that children learning by themselves in an L2 vocabulary training outperformed children learning with a child or robot peer on one out of four word-knowledge tasks. On the other tasks, there were no differences between the three conditions.

A possible explanation for the lack of peer benefits is that the vocabulary training did not allow for enough interaction between the learner and the peer for the learner to benefit from the peer. In addition, there were fewer learning opportunities in both peer conditions by manipulating the tablet, as tasks were divided between the target child and the (child or robot) peer. We recommend future researchers to look into more interactive learning tasks in which robots can take a more active role in supporting children's learning. Furthermore, qualitative analyses, which were beyond the scope of the current paper, would be especially valuable to assess which types of interactional patterns in child-child and child-robot dyads do or do not benefit learning in such tasks.

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