Carrot or Stick: The Effect of Reward and Punishment in Robot Assisted Language Learning

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ABSTRACT

Feedback plays an important role in language learning. However, limited research can be found on the influence of feedback in robot-assisted language learning. Therefore, this study aims to identify the effects of robot-feedback on learning gain, motivation, and anthropomorphism. In total, 60 students participated in a language learning task, with a robot using one of three feedback conditions: reward, punishment, and no feedback. The results showed that feedback only affected learning gain: students learned more with punishment, followed by reward, compared to no feedback. Thus, our results underscore the importance of feedback in RALL.

CCS CONCEPTS

• **Computer systems organization** → Robotics; • **Applied computing** → *Education*; • **Human-centered computing** → *Human computer interaction (HCI).*

KEYWORDS

Foreign Language Learning, Robot Tutoring, Feedback

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1 INTRODUCTION

Skinners' [10] operant conditioning theory states that learning is influenced by consequences from the environment. Specifically, he distinguishes two types of consequences, reinforcement and punishment. Reinforcement are aimed at increasing the likelihood of behavior, while punishment is aimed at decreasing it. This theory is often used and applied in educational contexts, to improve learning. Within language learning, reinforcement or reward has shown to increase motivation [8]. On the other hand, punishment or negative feedback has been shown to increase learning gain [12].

Robots have increasingly been used in language learning, often referred to as robot-assisted language learning (RALL) [6]. Previous studies showed mixed effects of RALL on learning outcomes, but RALL generally has positive influence on motivation [11]. Although feedback plays an important role in language learning [4], limited research can be found on the influence of feedback in RALL [11]. Two exceptions are an exploratory study that examined the effect of adult-like, peer-like feedback and no feedback on engagement and learning gain [3] and a study that looked at adaptive feedback based on children's emotions [1] who found that happy feedback (positive and negative) had an influence on the children's learning gain and their motivation. However, the influence of punishment and reinforcement as feedback from a robot in RALL is still unexplored. Moreover, previous work has shown that non-verbal robot behaviors can affect the way that people perceive a robot (also referred to as anthropomorphism) [9].

Therefore, in the current study we aim to identify the effects of reward and punishment on learning gain, motivation, and anthropomorphism.

2 METHODS

In total, 60 university students (M = 24 years, SD = 5.8; 39 female) participated in this experiment. Participants received credit for participating. All participants signed an informed consent form and were randomly assigned to a condition. The design was a between-subjects design, with three conditions:

(1) Reward (N=20). Participants received only positive reinforcement when they answered correctly. The robot randomly used one of six variations of verbal praise (e.g. 'Well done!') and one of six non-verbal positive emotions, e.g., cheering (see Figure 1a).
(2) Punishment (N=20). Participants received only negative reinforcement when they answered incorrectly. Again, the robot randomly used one of six variations of verbal reinforcement (e.g., 'Sorry, that's incorrect') and one of six non-verbal negative emotions (e.g., shaking head (see Figure 1b)).
(3) No feedback (N=20). Participants received no feedback (control condition).

The Softbank Robotics robot was placed next to a Windows Surface tablet in front of the participant (see Figure 1).

All interactions were the same except for the feedback that the robot provided. The whole interaction was in English, except for the nine target words in Vimmi, which is an artificial language designed to not look similar as other languages [5]. The lesson was based on the children's game 'I spy with my little eye' in which they practiced the Vimmi words. The interaction started with teaching the different words. During this phase, the tablet showed an animal, the robot translated the animal to Vimmi and asked the participant to repeat the word. After all words were shown, the participant and robot started the practice rounds. Each

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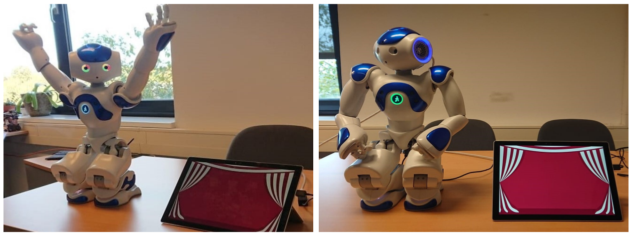

(a) Reward (b) Punishment

Figure 1: Example of the robot's non-verbal behaviors.

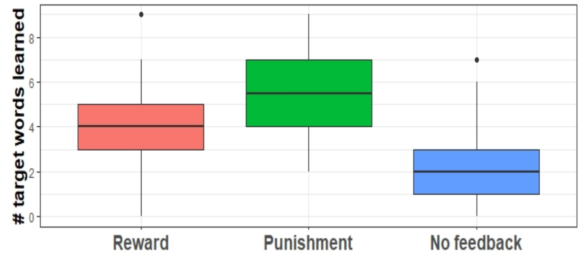

Figure 2: Boxplot of learning gain per condition

Table 1: Average scores per condition, $M(SD)$

	Reward	Punishment	No feedb.
Learning gain [0-9]	3.80 (2.09)	5.45 (1.90)	2.35 (1.87)
Task motivation [1-7]	5.23 (1.54)	5.17 (1.17)	4.92 (1.15)
Anthropomorphism [1-5]	2.58 (0.66)	2.70 (0.70)	2.67 (0.86)
Likeability [1-5]	4.32 (0.57)	4.06 (0.62)	4.26 (0.73)
Perc. intelligence [1-5]	3.54 (0.63)	3.79 (0.71)	3.77 (0.70)
Incorrect answers	23.4 (5.31)	16.4 (4.79)	24.1 (6.19)
Amount of feedback	12.6 (5.45)	16.4 (4.79)	0 (0)

round, the robot asked 'I spy with my L E D eye and it is a <target word>' after which the participant needed to search for the target. Depending on the condition, participants received either positive feedback, negative feedback, or no feedback. They then continued to the next animal. When the participant answered ten consecutive trials correctly, the practice rounds stopped (n = 3, after 30, 34, and 35 rounds), otherwise, there were a maximum of 36 rounds. After these practice rounds there was a post-test. During this post-test all nine animals were displayed on the screen and the participant had to feed the animal that the robot named. Each time the participant fed an animal, the order of the animals was shuffled on the screen. The learning gain was calculated by the number of correct answers in the post-test. After the post-test, the participants were asked to fill-out a short questionnaire on demographics; three questions on task motivation ($\alpha = .82$) from the motivated strategies for learning questionnaire [7]; and three scales (fifteen questions) from the Godspeed questionnaire [2] on the participants' perception of the robot, including anthropomorphism ($\alpha = .77$), likeability ($\alpha = .87$), and perceived intelligence ($\alpha = .77$). The descriptive statistics can be found in Table 1.

3 RESULTS

A one-way ANOVA showed there was a significant difference between the learning gain of the three different feedback strategies ($F(2, 57) = 12.54, p < 0.01$, $\eta_p^2 = 0.31$). A Tukey post-hoc test revealed that participants learned more when they received punishment ($M = 5.45, SD = 1.90$) than no feedback ($M = 2.35, SD = 1.87; p < 0.01, M_{diff} = 3.10$) and than reward ($M = 3.80, SD = 2.09; p = 0.03, M_{diff} = 1.65$). However, there was no difference between reward and no feedback ($p = 0.07$). Figure 2 shows the boxplots of the learning gain for each of the feedback strategies.

No significant differences were found for task motivation between the three feedback strategies ($F(2, 57) = 0.32, p = 0.72$). Likewise, no significant differences were found for any of the scales related to the impression of the robot. Thus, no differences were found in terms of anthropomorphism ($F(2, 57) = 0.14, p = 0.87$), likeability ($F(2, 57) = 0.89, p = 0.42$, and perceived intelligence ($F(2, 57) = 0.85, p = 0.43$) between the feedback strategies.

During the experiment, we noticed that some students in the reward condition received little feedback as they picked only a few animals correctly. Therefore, this condition was rather close to the no feedback condition. Accordingly, the results might be affected by the amount of feedback the participants received. Therefore, we also ran ANCOVAs with the number of times the participant received feedback, and the interaction effect as covariates. The ANCOVA showed a significant effect of the feedback strategies on the learning gain, while controlling for the amount of feedback received ($F(2, 55) = 5.00, p = 0.01$, $\eta_p^2 = 0.15$). However, a Tukey post-hoc test revealed that no significant differences in learning gain between punishment, feedback, and reward (all p's > 0.07). For task motivation, anthropomorphism, likeability, and perceived intelligence, again no significant effects were found of the feedback strategies, while controlling for the amount of feedback received (all p's > 0.23).

4 DISCUSSION AND CONCLUSION

In the current study we aimed to identify the effects of positive reinforcement and punishment on learning gain, motivation, and anthropomorphism, when learning the artificial language Vimmi, while receiving robot-feedback. The results showed that participants learned the most words when receiving only punishment, and the fewest words without feedback. These results seem to indicate that negative feedback has a larger effect on learning than positive feedback, which is in line with human studies [4] who describe that negative feedback enhances learning with simple tasks, especially when the task is novel. Future work should examine whether a combination of positive and negative feedback would result in even higher learning gains.

Moreover, contrary to our expectation that positive reinforcement would have a larger effect on task motivation, we did not find a difference between conditions on task motivation. This might be because the negative feedback was not perceived as negative as intended. Future work could examine the perceived valence of the two conditions. Additionally, it is possible that the effect of the robot's novelty has a larger influence on task motivation than feedback. It should be investigated whether this effect remains on the long-term when motivation becomes more important. To conclude, our results underscore the importance of feedback in RALL.

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