# Effects of Pitch Gestures on Learning Chinese Orthography with a Social Robot

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## ABSTRACT
In this study, we investigate the effect of a social robot using head and arm gestures mimicking the lexical tones (i.e. pitch gestures) on learning pronunciations and translations of Chinese characters. Performance was compared between two within-subjects conditions: Gesture Observation condition, in which the robot used pitch gestures to teach six characters and the No Gesture condition in which the robot did not use gestures to teach six characters. Participants (N = 21) were tested on how well they pronounced and translated the learned characters. The study showed that a robot not using gestures was found to enhance learning, but only when participants could first familiarize with learning Chinese characters with the robot using pitch gestures. These results suggested that prior knowledge of learning Chinese attained from a robot using pitch gestures improved recall on learning the characters during a learning module with a robot not using gestures.

## CCS CONCEPTS
• Computer systems organization → Robotics • Human-centered computing → Human computer interaction (HCI) • Applied computing → Education.

## KEYWORDS
Robot tutoring, Gestures, Second language learning, Chinese orthography

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## 1 Introduction
Social robots have been becoming more popular in teaching languages, due to the more humanlike social interactions with the learner [1]. Robot gestures seem to enhance learning foreign words in children [2], although not all studies show positive effects [3]. However, there is no research yet on how learning Mandarin Chinese could be supported by a social robot and if or how gestures should be used.

Chinese is difficult to learn to speak and read since it consists of an extensive amount of characters and its usage of different tones for each character (see Figure 1) [4]. Chinese is a popular language to learn due to China’s economic growth, but learning Chinese is complicated, especially for people whose native language is non-tonal [5, 6].

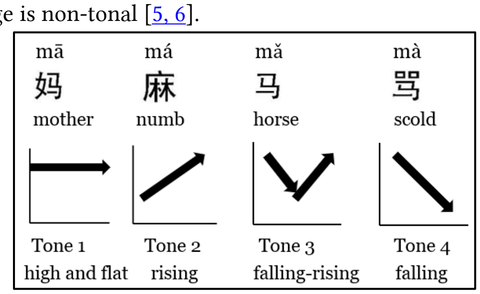


**Figure 1: Illustration of identical pronunciations differing in the four tones of the Chinese language [4].**

There is still much unknown about the usage of social robots when teaching the tonal language Chinese. While the study of [2] looked at how iconic gestures can enhance retention of foreign words, studies of gestures in humans for Chinese has mainly focused on mimicking the lexical tones with arms and hands [7]. When teaching Chinese, some studies suggest that humans using head [8] and arm gestures [7] projecting the tones of the characters facilitates the discrimination of similar-sounding characters. There are no studies on if robots as tutors using head and arm gestures (i.e. pitch gestures) could improve learning the different tones in Chinese orthography. This begs the question what the influence is of a social robot using pitch gestures portraying the lexical tones on learning the pronunciations and translations of Chinese characters. The current study will take into account musicality [6] and the hypothesis was that participants will learn more translations and pronunciations of Chinese characters when learning from a robot using pitch gestures with head and arm movements than from one without using pitch gestures.

## 2 Methods

### 2.1 Participants
In total, 21 participants (Mage = 23.35, SD = 3.12; 17 female) participated in this study. Most participants were university


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students (85.7%). The native language of most participants was Dutch (38.1%) and none of the participants had any knowledge of the Chinese language. Due to technical problems in the recordings of the audio of one participant, the audio of this participant was excluded in the analysis on pronunciation.

## 2.2 Materials

*2.2.1 Chinese characters.* Twelve Chinese characters were used, which consisted of pairs with similar pronunciations, but differing in the tones. The audio of the pronunciations were retrieved from Google Translate and programmed in the NAO robot to pronounce the characters. Characters were presented on a tablet, with the translation underneath it.

*2.2.2 NAO robot and gestures.* The NAO robot was placed in a 90-degree angle next to the tablet in a crouched position, so both the robot and the participant would be looking towards the tablet. In the Gesture Observation (GO) condition, the robot mimicked the 'flat', 'rising', 'falling-rising' and 'falling' tones, as shown in Figure 1 (see Figure 2 for an example). In the No Gesture (NG) condition, the robot did not display any gestures.

*2.2.3 Test on pronunciations and translations.* Participants were tested on the amount of recalled characters on pronunciation and translation. They saw a character on the screen and were asked to write down the translation and pronounce the pronunciations. The audio of the pronunciations were recorded and were rated by 'comprehensibility' (overall understanding) and 'accentedness' (nativeness) [9].

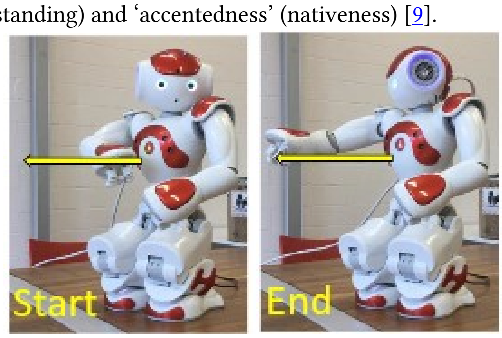


**Figure 2: The start and end position of tone 1.**

## 2.3 Procedure

The module began with an introduction and the first 6 Chinese characters were learned for 10 minutes (in the GO or NG condition). Participants then received the test on memorization of pronunciation and translation of the 6 characters. After the first module and test, the participant started with the second module of the next 6 characters in the GO or NG condition, depending on which condition they received first. After the second learning module, the participant received a test again on the learned characters. Lastly, the participants were thanked and debriefed. Total duration of the experiment was 30 minutes.

## 3 Results

Three Repeated Measures ANCOVA's were done to control for the effect of musicality and the effect of the order of the conditions between the GO and NG condition. The within-subject factor was condition (GO and NG), the between-subject factor was the order of conditions (GO-NG or NG–GO order) and the covariate was musicality (score of 1-4; quantitative). The dependent variable was either translation (score of 0-6; quantitative), comprehensibility (score of 0-30; quantitative) or accentedness (score of 0-30; quantitative). There were no significant main effects, but there were significant interaction effects between condition and order of conditions on translation ($F(1, 18) = 9.81$, $p = .006$, $\eta_p^2 = .35$), comprehensibility ($F(1, 17) = 10.74$, $p = .004$, $\eta_p^2 = .39$) and accentedness ($F(1, 17) = 14.91$, $p = .001$, $\eta_p^2 = .47$).

**Table 1. Mean scores and standard deviations of correct translations of the conditions and the orders**

| Order | Translations | | Comprehensibility | | Accentedness | |
|---|---|---|---|---|---|---|
| | $M_{GO}$ (SD) | $M_{NG}$ (SD) | $M_{GO}$ (SD) | $M_{NG}$ (SD) | $M_{GO}$ (SD) | $M_{NG}$ (SD) |
| GO-NG | 4.27 (1.19) | 5.36 (.92) | 5.90 (3.76) | 10.10 (5.17) | 4.60 (2.91) | 8.60 (4.45) |
| NG-GO | 4.20 (1.40) | 3.50 (2.17) | 7.20 (4.73) | 4.20 (3.65) | 6.40 (4.27) | 3.60 (2.95) |

One-way ANOVA's were done to study these interactions. Analyses showed significant differences in the NG condition between GO-NG and NG-GO order on translation ($F(1, 19) = 6.77$, $p = .018$, $\eta_p^2 = .26$), comprehensibility ($F(1, 19) = 6.77$, $p = .018$, $\eta_p^2 = .26$) and accentedness ($F(1, 18) = 8.76$, $p = .008$, $\eta_p^2 = .33$), in which the NG condition was higher in the GO-NG order than in the NG-GO order by 1.86 for translation, 5.90 for comprehensibility and 5.00 for accentedness.

## 4 Discussion

we studied the effect of social robots using pitch gestures on learning Chinese characters. Results showed a learning effect in which participants performed better on recall of pronunciation and translation in the NG condition after participants had to learn characters in the GO condition. It is possible that first learning Chinese with a robot using pitch gestures helps attaining prior knowledge and familiarization with Chinese resulting a learning effect. Prior knowledge reduces cognitive load, which enhances learning [10].

A possible explanation is that participants were less able to understand or hear the pronunciations produced by the robot in the GO conditions, due to the noise of the motors of the robot. This could have impaired learning in the GO condition. Future research should take this into account and use better articulated audio. More research on how the interaction between robots and learners of the Chinese language can be improved is important, since learning Chinese is complicated and it is important to design learning material in a proper manner that maximizes learning [11].

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