

Does Unconscious Anchoring in Maternal Imitation Help to Solve the Correspondance Problem between Dissimilar Bodies?

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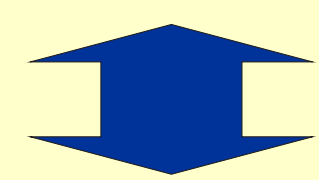
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Abstract

Due to differences in body structure between robots and humans, it is a formidable task for robots to show behaviors that correspond to human behaviors. As a simple case of this correspondence problem, this paper presents a robot that learns to vocalize vowels through interaction with its caregiver. Inspired by the findings in developmental psychology, we focus on the role of maternal imitation (i.e., imitation of a robot voice by a caregiver), which could play a role in guiding the correspondence of sounds. Furthermore, we suppose that it causes “*unconscious anchoring*” in which the imitated voice by the caregiver is approaching to one of his/her own vowels without his/her intension, and thereby works for guiding robot's utterances to be more vowel-like. We propose a method for vowel learning with an imitative caregiver under the assumption that the robot knows the desired categories of caregiver's vowels and the rough estimate of mapping between the region of sounds that the caregiver can generate and the region that the robot can generate. Through experiments with a Japanese imitative caregiver, we show that a robot succeeds in acquiring more vowel-like utterances than would be possible without such a caregiver, even when the robot is provided different mapping functions.

Introduction

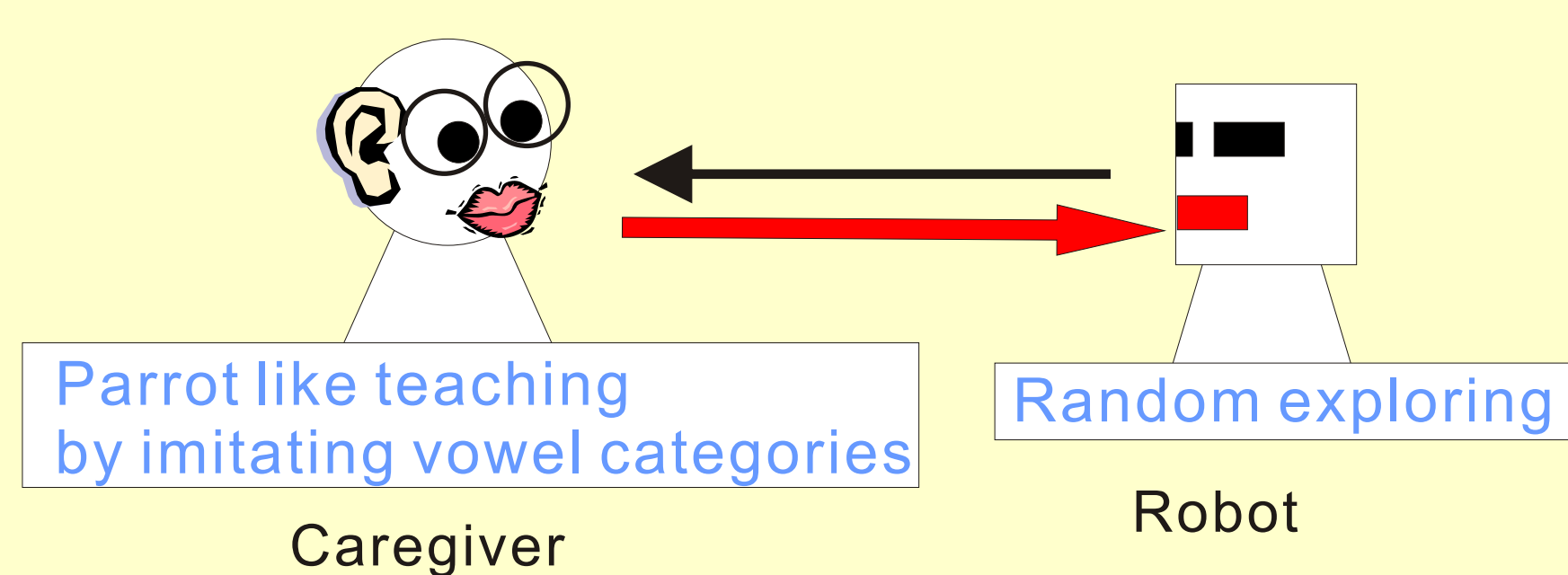
Due to the **difference in body structure between robots and humans**, it is **difficult for robots to acquire behaviors that corresponds to humans one**.



Human infants acquire common vowels through interaction with his/her mother despite difference of body structure between them.



Previous work:[Yoshikawa et al'03]
Vowel acquisition for the robot based on mother-infant interaction model



The robot acquire many candidate of vowels but **cannot determine which were more vowel-like.**

Our hypothesis

Maternal imitation causes “*unconscious anchoring*” and it guides robot's utterance to be more vowel-like.

unconscious anchoring :

Imitated voice by a human is performed **unconsciously to be more similar to one of his/her own vowels.**

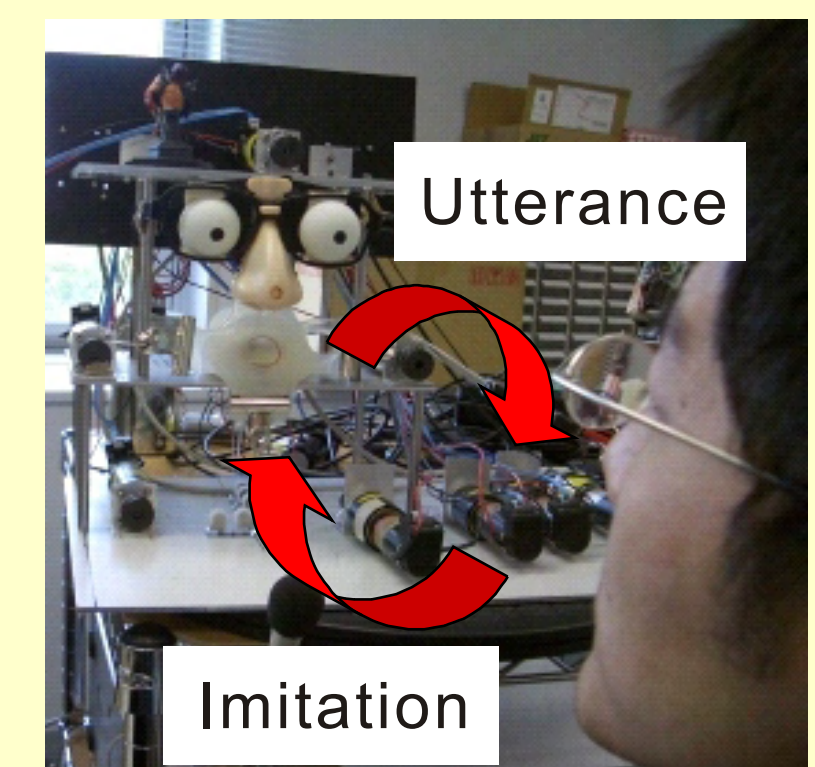
Previous work:[Miura et al'06]

The robot acquire vowel-like utterance but

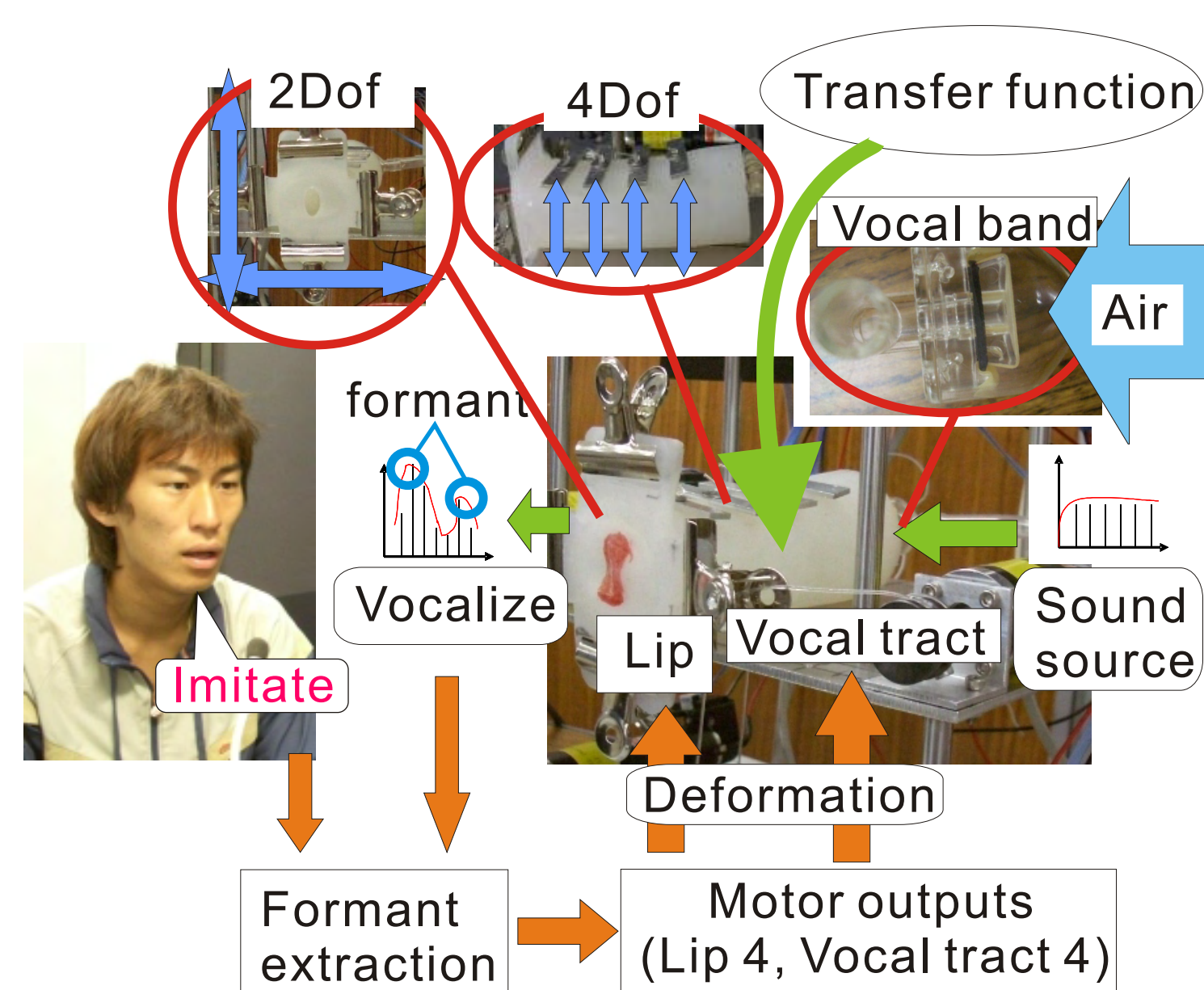
- We did not analyze the change of caregiver's imitation
- The robot were provided with a feasiably correct mapping between the caregiver's sound features and the robot's ones.

Purpose

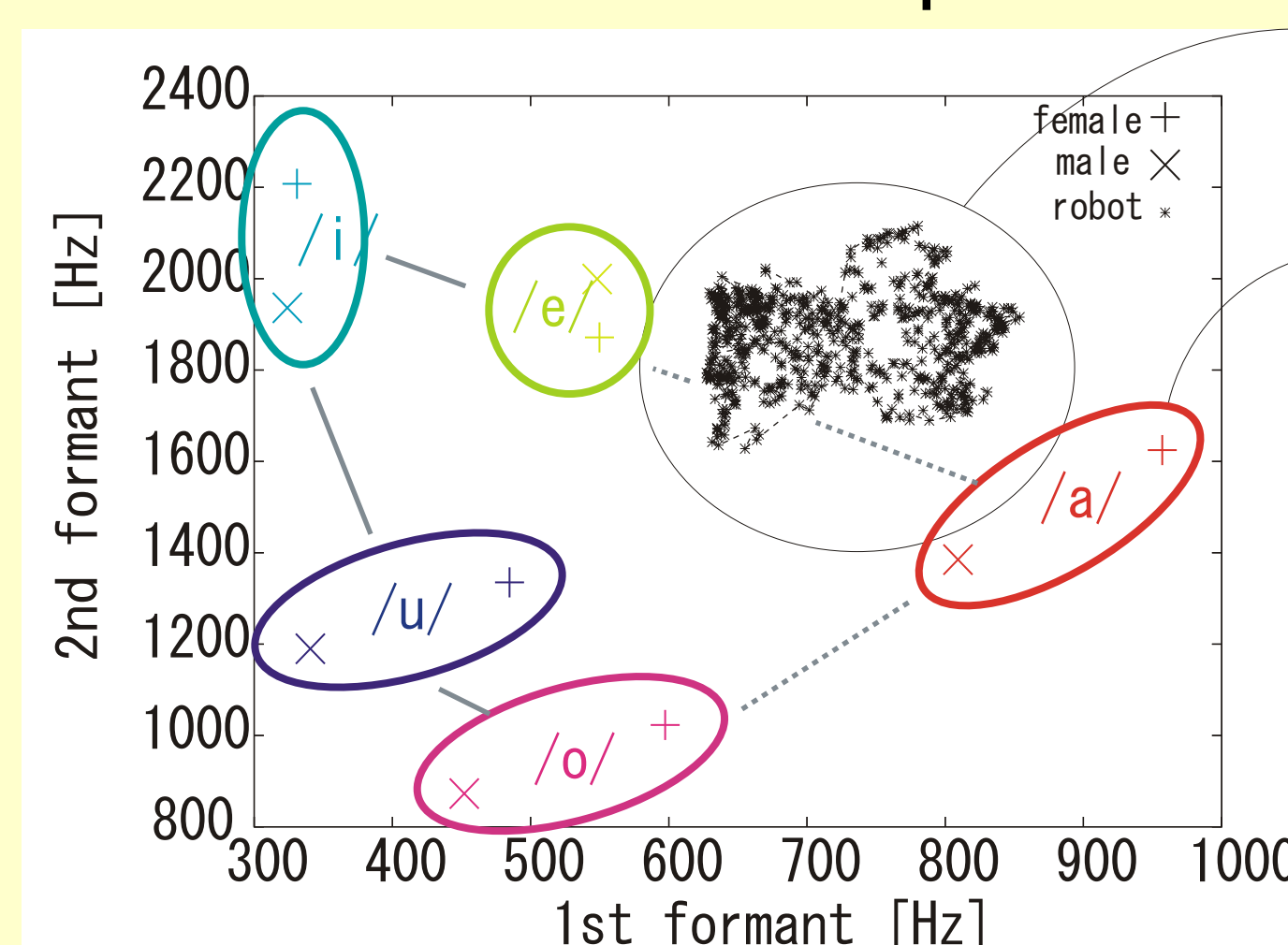
1. Examine how caregiver's imitation changes.
2. Examine whether a robot can acquire vowel-like sound even if the mapping is rough.



The vocal robot



Vocal ability of the robot and humans in formant space



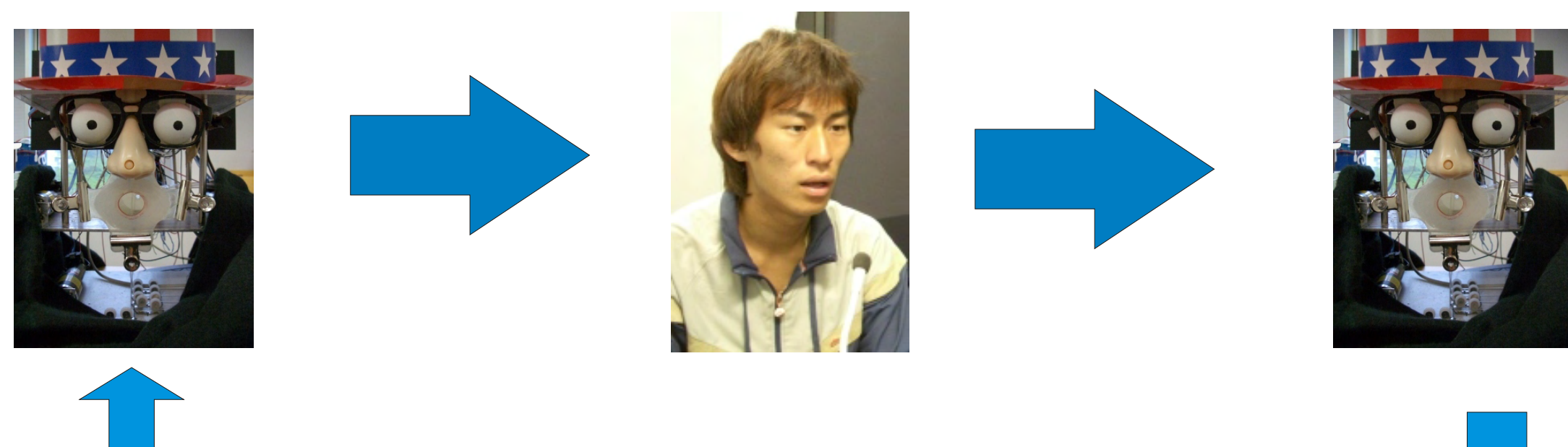
Robot's generable area

Sample distribution of Japanese vowels

Since formant area which the robot can vocalize is different from one of humans, desired vowels for the robot must be adjusted.

Learning process

Vocalize to match the desired vowels Imitate the robot's utterance Update the desired vowels



The desired vowels are updated through interaction with an imitative caregiver.

Number of turn taking is 20 for each vowels.

Rough mapping functions and updating desired vowels

We provide the robot with a linear transformation as a mapping function from the region of generable sounds by the caregiver to that by the robot.

The robot's desired vowels are updated as follows:

$$r_{d/v}(k+1) = r_{d/v}(k) + g(\Delta h)$$

$r_{d/v}$: desired vowel
 g : mapping function
 Δh : difference between the imitated voices by the caregiver and his/her corresponding usual vowel
 k : "k"-th interaction
 $/v/$: one of vowels ($/v/ = /a/, /i/, /u/, /e/, \text{ or } /o/$)

In the experiment, we use four types of mapping function "g"

$$g(h/v/; \alpha, \theta, s) \equiv r_c + \alpha R(\theta)(h/v/ - h_c) + s$$

- 1) Translation to match the centroids
 $\alpha = 1.0, \theta = 0, s = (0, 0)$
- 2) Translation plus scaling
 $\alpha = 0.24, \theta = 0, s = (0, 0)$
- 3) Translation plus offset
 $\alpha = 1.0, \theta = 0, s = (-100, 200)$
- 4) Translation plus rotation
 $\alpha = 1.0, \theta = 30, s = (0, 0)$

r_c and h_c : centroids of robot's and caregiver's generable area.
 Initial desired vowels $r_{d/v}(0)$ are provided as follows:
 $r_{d/v}(0) = r_c + \alpha R(\theta)(h/v/ - h_c) + s$

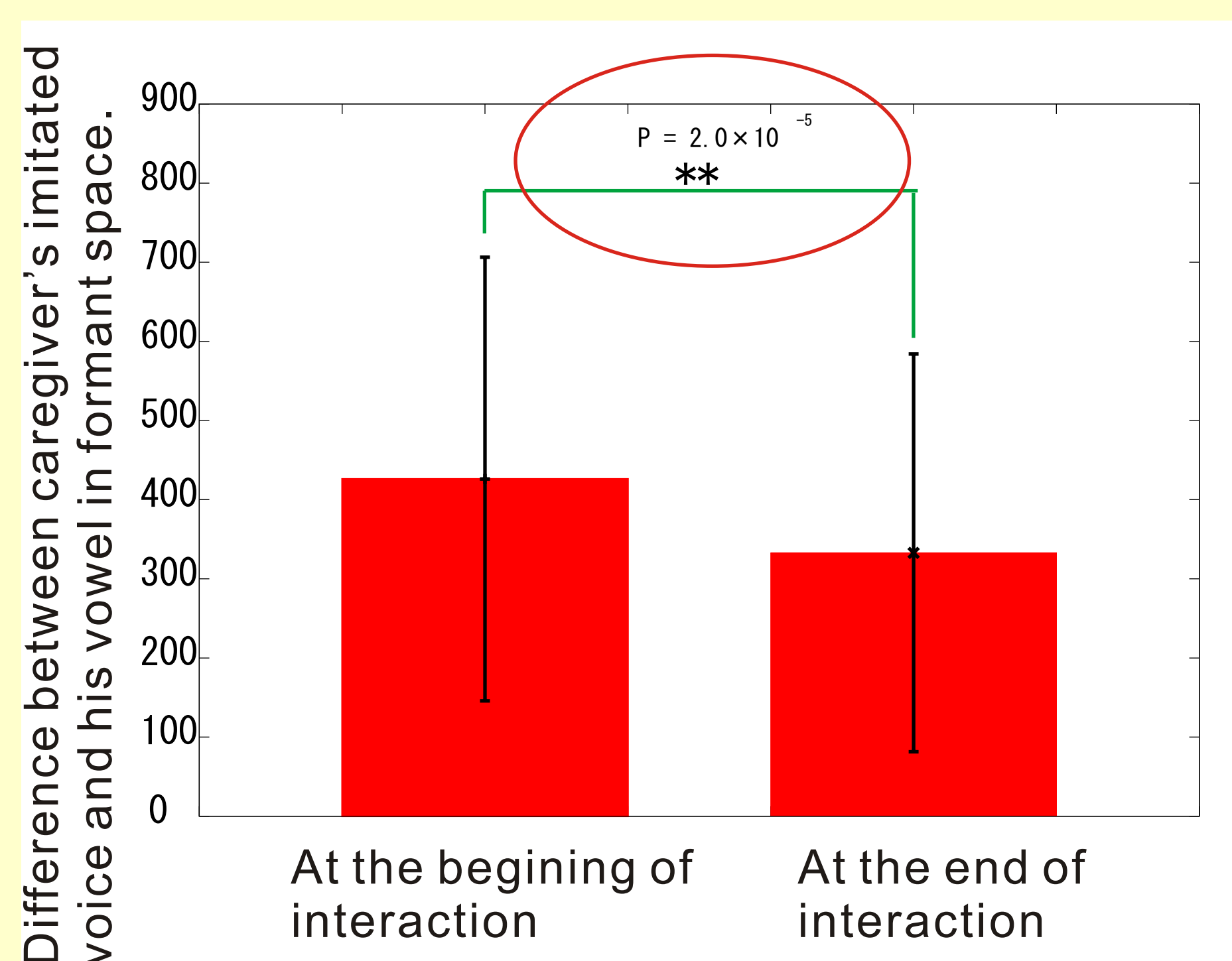
Expectation

- Through the experiment,
1. Caregiver's imitated voice will be unconsciously approaching to his/her own vowels.
 2. The robot succeeds in acquiring more vowel-like utterance than without such an interaction.

Results

Whether a caregiver's imitation come close to his/her own vowels through interaction?

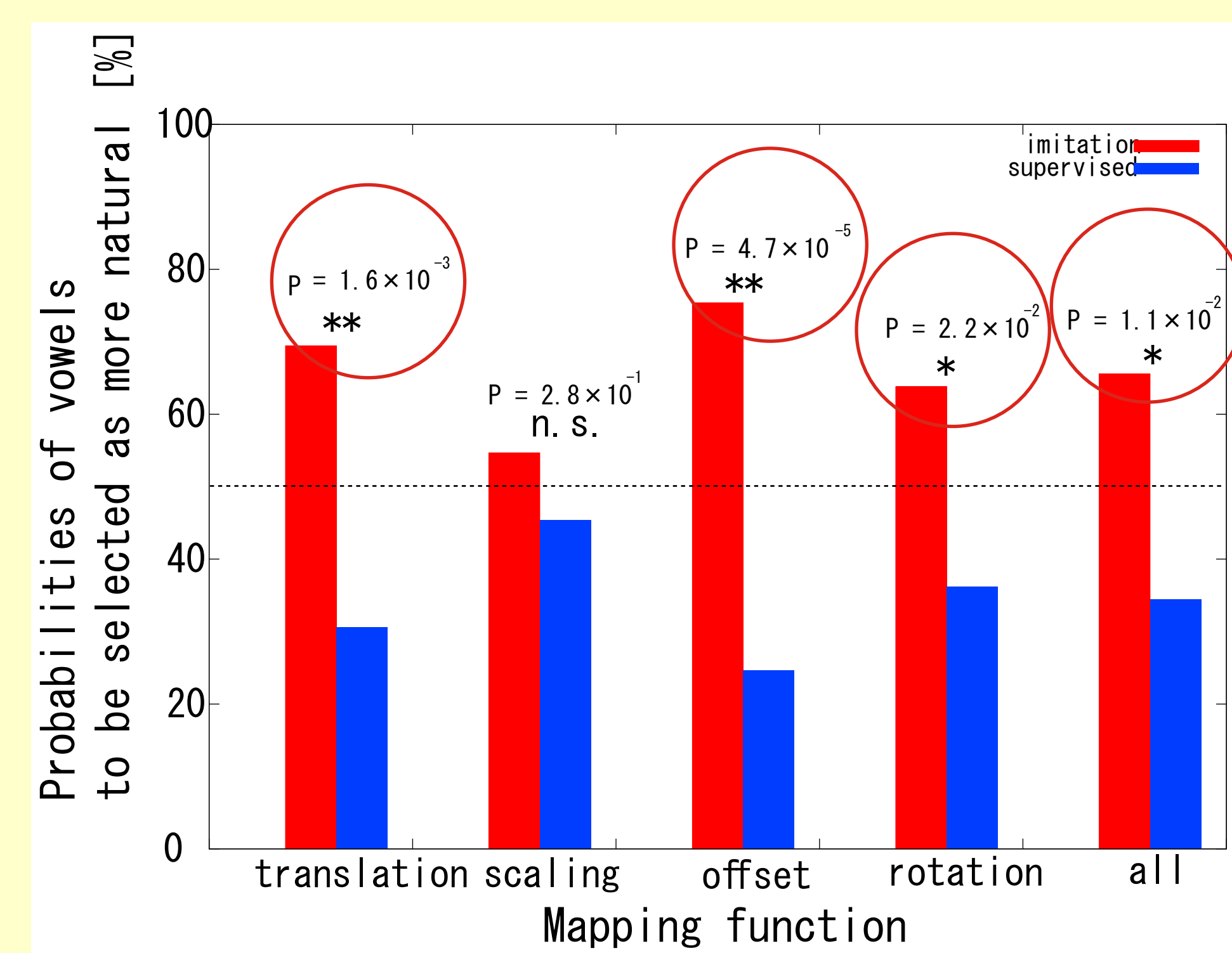
We compare differences between the imitated voices by the caregiver and his corresponding usual vowel **at the begining of and the end of interaction.**



Caregiver's imitated voice is unconsciously approaching to his/her own vowels.

Whether The robot succeeds in acquiring more vowel-like utterance?

15 subjects compare the **vowels acquired through interaction and acquired without such an interaction**, and judge which is more vowel-like sound.



The robot succeeds in acquiring more vowel-like utterance.

Reference

Y. Yoshikawa, M. Asada, K. Hosoda, and J. Koga. A constructivist approach to infants' vowel acquisition through mother-infant interaction. *Connection Science*, Vol. 15, No. 4, pp. 245-258, December 2003

K. Miura, M. Asada, K. Hosoda, and Y. Yoshikawa. Vowel acquisition based on visual and auditory mutual imitation in mother-infant interaction. *In The 5th Interactional Conference on Developmental and Learning (ICDL'06)*, 2006