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Auditory feedback perturbation in adults and children

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INTRODUCTION

Auditory feedback important mechanism in speech production [1]
- Perturbation of auditory feedback during speech production elicits a compensatory response in the opposite direction to maintain the intended auditory outcome [2]
- Plays an important role in speech motor learning, i.e. the acquisition of speech motor programs [3]
- Auditory perturbation experiments may help to understand early development of auditory-motor integration.

Research question:
- To what extent are children able to compensate for and adapt to auditory feedback perturbation throughout their developmental trajectory?

METHODOLOGY

Participants
- 15 children: 8 female, 7 male; age range 4.1 - 8.7 y.m, mean 5.8 y.m.
- 37 adults: 32 female, 5 male; age range 19 - 29 years, mean 22.4 y.y.

Procedure
- Stimuli: CVC words /be:r/ (bear), /ve:r/ (feather), /pe:r/ (pear).
- Participants were seated in front of a PC-monitor showing pictures of the target words.
- A bird flying over one of the pictures cued the participant to say the intended word.

Perturbation paradigm and analysis

- Experimental setup Real-time acoustic tracking and shifting of F1 and F2 using Matlab based software package Audapter [5].
- F1 raised 25%; F2 lowered 12.5%.
- Paradigm with 5 phases: Practice - Start - Ramp - Stay - End.
- Length adults and children > 7 y.o. 111 words; children ≤ 7 y.o. 84 words.
- Analysis F1 and F2 were measured from steady-state portions of the produced vowels using custom PRAAT-scripts.
- Compensation differences in formant frequencies between the Start and Stay phase. This is a measure of motor learning: the ability to notice and act on the mismatch between the motor command and the corresponding auditory outcome.
- Adaptation differences between the Start and End phase. This is a measure of the after-effect of change in the motor command, followed by recovery (de-adaptation).
- Statistical analyses differences across groups and phases using Linear Mixed Model analyses with fixed factors Group and Phase; random factor Subject; repeated factors Phase, Word, Repetition.

EXPERIMENTAL DEBRIEFING

- Previous studies reported participants were unable to notice perturbations.
- In this study, around 65% indicated to have heard something (and some took action).
- “Did you hear something odd when listening to your own voice?”
  - No
  - Yes, but recalled possible changes after pointing out vowel manipulations
  - Yes, noticed manipulations during experiment
  - Yes, noticed manipulations, and acted on it during experiment

ANALYSIS OF COMPENSATION AND ADAPTATION

LMM results First Formant
- Group: F (1,212) = 16.2, p < .001; Phase: F (2,2140) = 15.2, p < .001.
- Group x Phase: F (2,2140) = 4.0, p < .028.
- Post-hoc: Adults showed compensation (p < .001), but no adaptation (p = .097).
- Children showed compensation and adaptation (both p < .001).

LMM results Second Formant
- Group: F (1,212) = 21.6, p < .001; Phase: F (2,2147) = 18.3, p < .001.
- Group x Phase: F (2,2147) = 24.9, p < .001.
- Post-hoc: Adults showed significant compensation and adaptation (both p < .001).
- Children showed significant compensation (p < .003), but no adaptation (p = .063).
- No group differences in Start: p = .100; Stay: p = .354; or End: p = .786.

RESULTS

Compensation and adaptation across groups
- Stronger effect of compensation for the group of children suggests auditory-motor properties are less ingrained compared to adult speakers.
- Presence of adaptation effects of F1 suggest ramp and stay phase lengths are adequate, even during the shorter program for children.
- Presence of adaptation of F2 suggests children can adapt to within-group variance.
- Within-group differences might be due to different strategies, semantically or to auditory focus [6].

DISCUSSION

Effect of age
- Is it possible to detect developmental changes with respect to compensation and/or adaptation?

REFERENCES


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