# 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 year.

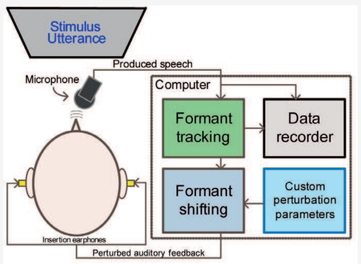
**Procedure**

- 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.

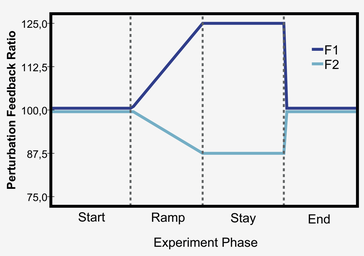
### Perturbation paradigm and analysis

- **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 result.
- **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 setup (from [4])**




**Perturbation feedback paradigm**

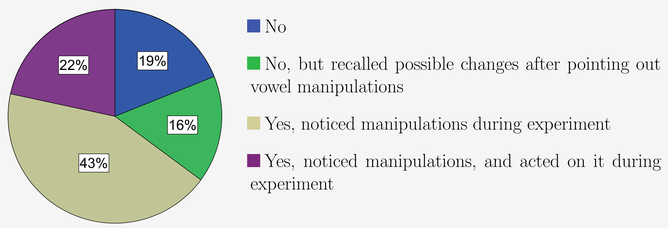



## Results

### Experiment 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?"**




- **Crosstabs analyses:** no correlation between debriefing and F1/F2 perturbation.

### Analysis of compensation and adaptation

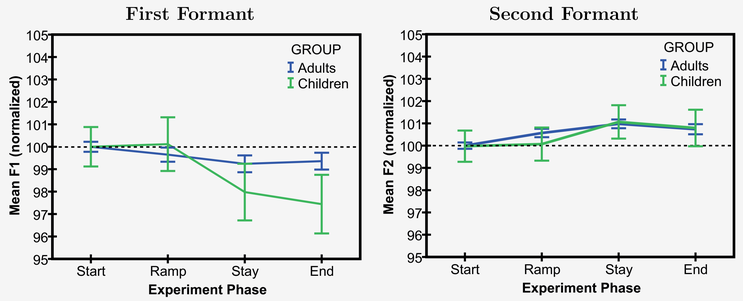
**LMM results First Formant**

- **Group:** F (1,2121) = 16.2, p < .001; **Phase:** F (2,2140) = 15.2, p < .001; **Group x Phase:** F (2,2140) = 4.0, p = .018.
- Post-hoc: Adults showed compensation (p = .005), but no adaptation (p = .093).
- Children showed compensation and adaptation (both p < .001).
- No group differences in Start phase: p = .591; children showed stronger compensation in Stay phase: p = .004, and stronger adaptation in End phase: p = .003.

**LMM results Second Formant**

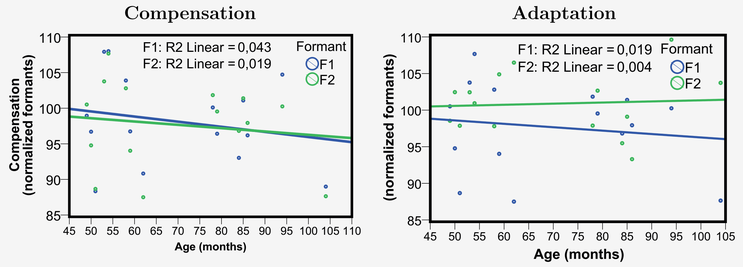
- **Group:** F (1,2132) = 2.0, p = .155; **Phase:** F (2,2147) = 18.3, p < .001; **Group x Phase:** F (2,2147) = .209, p = .811.
- Post-hoc: Adults showed significant compensation and adaptation (both p < .001).
- Children showed significant compensation (p = .003), but no adaptation (p = .063).
- No group differences in Start: p = .100; Stay: p = .354 ; or End: p = .786.

### Results of F1 and F2 productions




### Effect of age

**Is it possible to detect developmental changes with respect to compensation and/or adaptation?**




## Discussion

**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.
- Stronger/longer adaptation in F1 for children suggests that **adults revert faster to the ingrained original representation** of the speech sound.
- Absence of adaptation in F2 for children is possibly due to a **high within-group variance.**

**Developmental effects**

- Absence of age-related effects for children may be due to several reasons: lack of data; large within-group variability; or... storage and learning strategies of auditory-motor integration do not change significantly in the age span of 4-8 years?
- Within-group differences might be due to different strategies; somatosensoric vs auditory focus [6].

## References

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