

# Analysis of “s” and “sh” in Children with Cochlear Implants

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## Introduction

- Children with cochlear implants (CI's) exhibit delays in speech production relative to normally hearing (NH) children.
- The contrast of /s/ and /S/ may be difficult for children with CI's because the concentration of energy characteristic of /s/ is above 4000 Hz, while the filter bands in CI's assigned to frequencies above 4000 are wide.
- The current study used transcription and spectral analysis to describe the production of /s/ and /S/ by children with CI's.
- The current study compares children with CI's to NH children of similar chronological ages (CA's) and to NH children of similar hearing ages (HA's).

## Questions

- Do children with CI's show less distinction between /s/ and /S/ than NH children?
- Do children with CI's show more variability in their production of /s/ and /S/ than NH children?

## Method

### Participants

- Eighteen 4- to 9-year old children with bilateral CI's
  - Average age of implantation 1;6
  - From a larger study
- Twenty-six 2- to 5-year old NH children
  - Passed a hearing screening
  - From a larger study
- All children spoke English as a first language

The children with CI's were compared to NH children of similar hearing ages (HA). A subset of children with CI's were also compared to NH children of similar chronological ages (CA).

Group	Mean age	Mean hearing age	Males/total
CI	5;8	4;1	6/18
HA	4;1	4;1	6/18

Group	Mean age	Mean hearing age	Males/total
CI	4;10	3;7	1/11
CA	4;9	4;9	1/11

## Stimuli

	/a/	/i/	/u/
/s/	soccer sauce sun	seashore sister seal	super soup suitcase
/ʃ/	shark shop shovel	sheep shield ship	chute shoe sugar



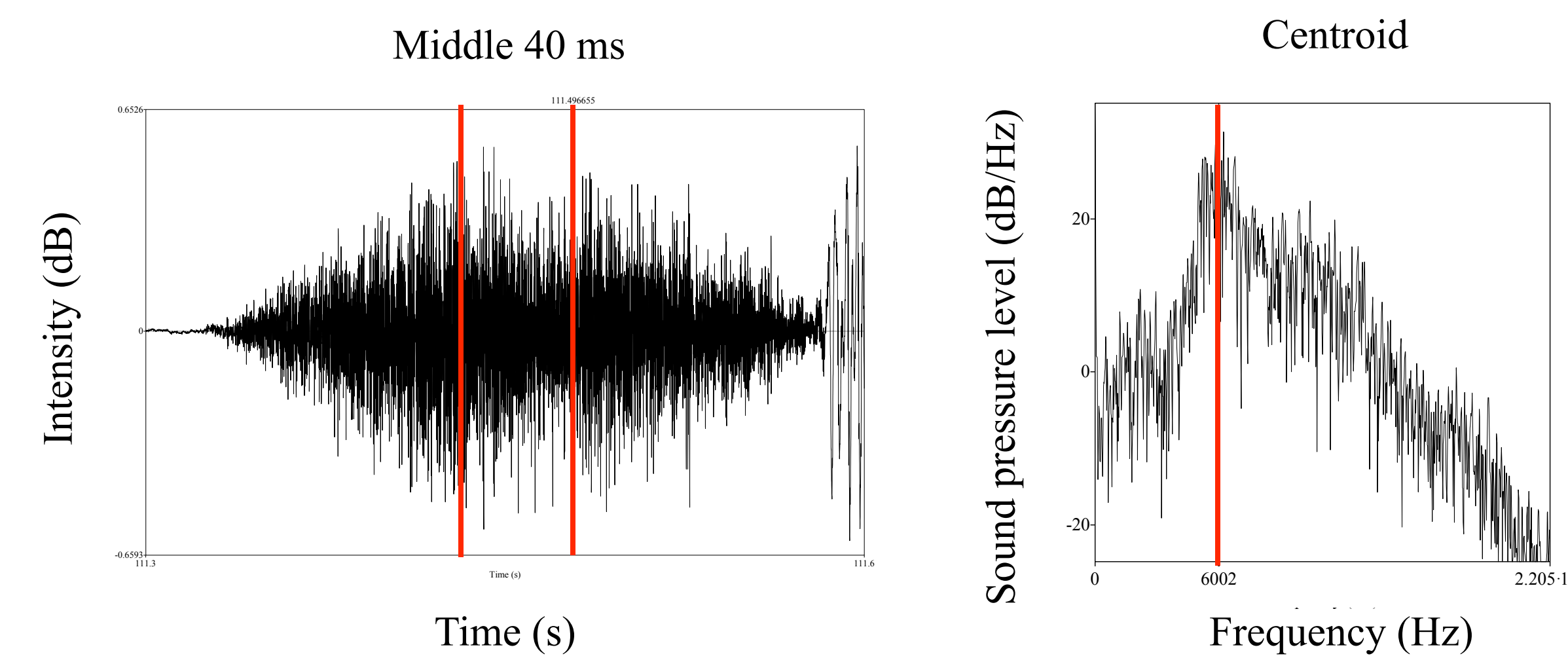
Picture for stimulus word “sister”

## Procedure

- The children participated in an auditory word repetition task.
- The children saw pictures and heard digitized productions of the stimuli.
- Following each stimulus word, the children were supposed to repeat the stimulus word.
- Productions were recorded for later analysis.

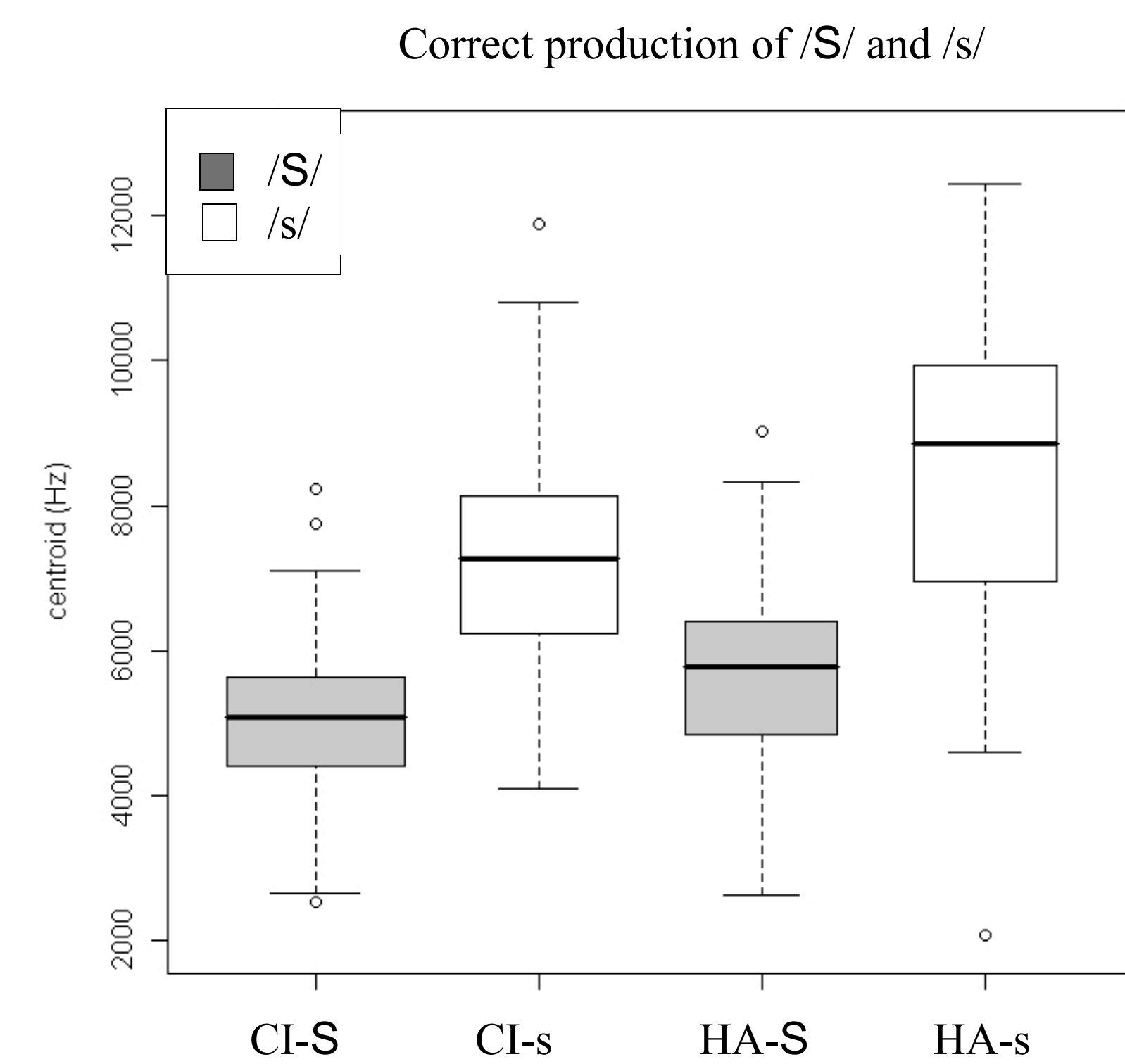
## Analysis

- Initial consonants and vowels were transcribed.
- First spectral moment (centroid) was calculated from the middle 40 ms of correct productions of /s/ and /S/.
- The measure of centroid has been found to distinguish productions of /s/ and /S/ with /s/ having a higher centroid than /S/.



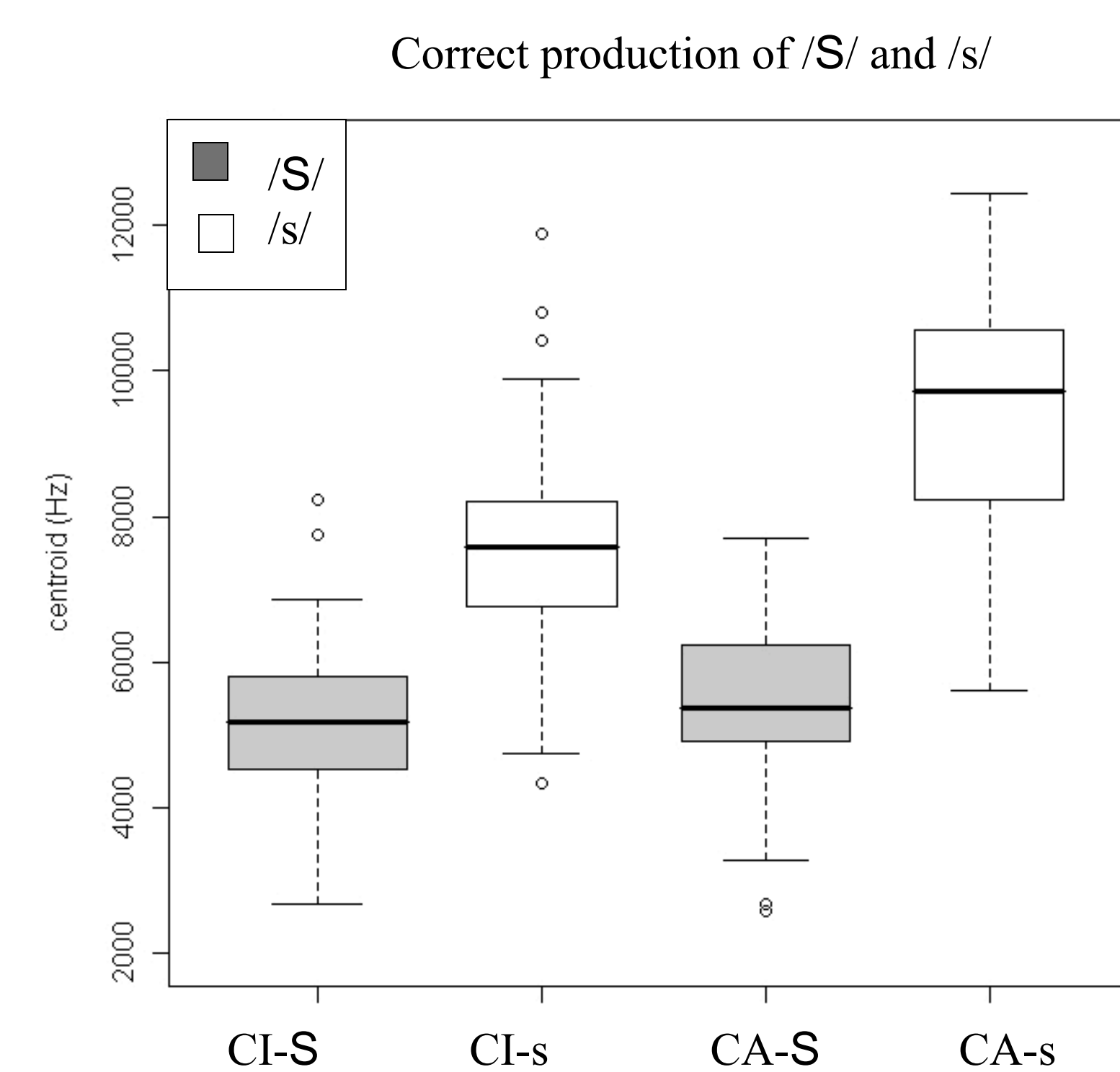
## Results from Spectral Analysis

### CI group compared to HA group



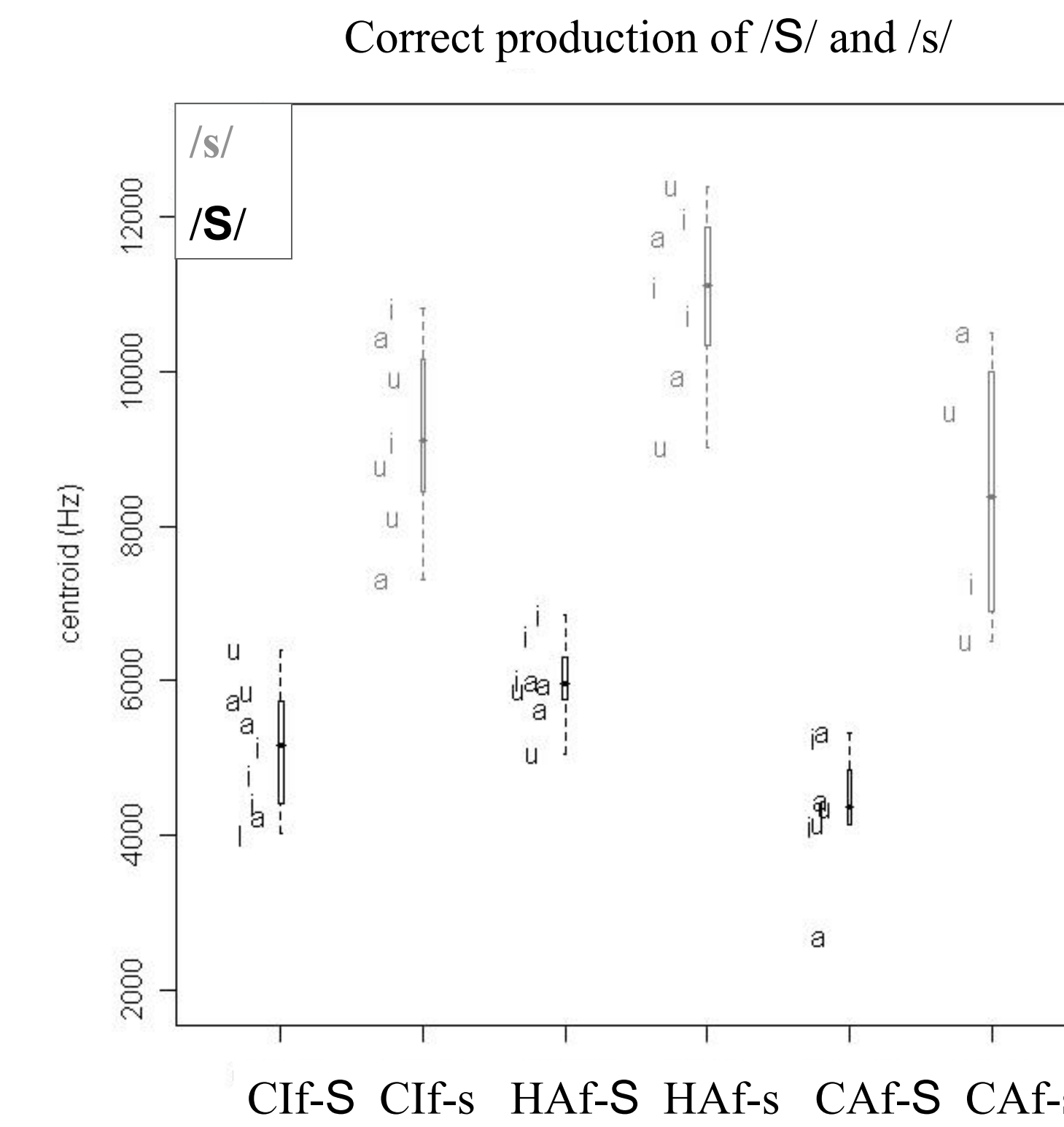
- Significant main effect of group ( $p = .006$ )
- Significant main effect of fricative ( $p < .001$ )
- Significant group by fricative interaction ( $p = .03$ )
- Reduced variability in productions by CI group

### CI group compared to CA group

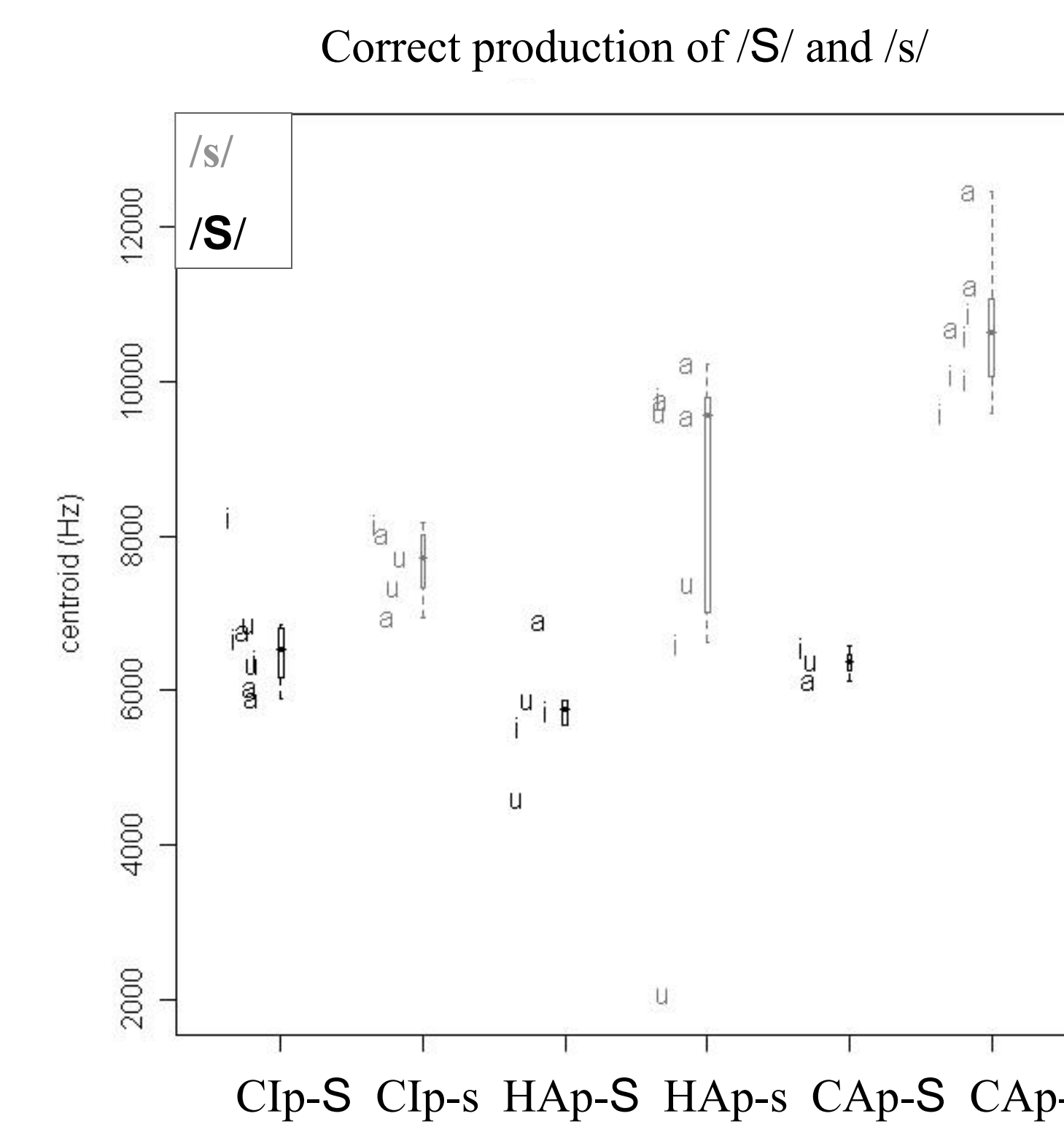


- Main effect of group marginally significant ( $p = .056$ )
- Significant main effect of fricative ( $p < .001$ )
- Significant group by fricative interaction ( $p = .028$ )
- Reduced variability in productions by CI group

## Individual subjects



This child with CI's shows a similar amount of distinction between /s/ and /S/ and a similar amount of variability as the NH children.



This child with CI's shows less distinction between /s/ and /S/ and less variability in productions of /s/ than the NH children.

## Results from Transcription

### Accuracy

Group	Correct /s/	Correct /ʃ/
CI (n=18)	66 %	84 %
HA	68 %	78 %

The children with CI's and the HA group showed similar percents of correct /s/ and /S/.

Group	Correct /s/	Correct /ʃ/
CI (n=11)	57 %	77 %
CA	71 %	90 %

The children with CI's showed a lower percent correct /s/ and /S/ than the CA group.

## Percent of total errors for /s/

Group	[ʃ]	[k]	[f]	[ts]
CI	3.7 %	9.2 %	44.4 %	12.9 %
HA	24.4 %	13.3 %	2.2 %	15.5 %

Group	[ʃ]	[k]	[f]	[ts]
CI	4.7 %	11.9 %	30.9 %	16.6 %
CA	15.3 %	50 %	0 %	11.5 %

- The sound substitutions for /s/ produced by children with CI's were different from those produced by the NH children.
- These differences were probably due to the perceptual difficulty of the children with CI's during the word repetition task.

## Percent of total errors for /S/

	[tʃ]	[ts]	[kʃ]	[ks]	[s]
CI	57.6 %	3.8 %	7.6 %	11.5 %	11.5 %
HA	45.4 %	6 %	0 %	0 %	21.2 %

	[tʃ]	[ts]	[kʃ]	[ks]	[s]
CI	54.5 %	4.5 %	9 %	13.6 %	9 %
CA	44.4 %	0 %	0 %	0 %	55.5 %

- The sound substitutions for /S/ produced by children with CI's were similar to those of the NH children.

## Conclusion

- The acoustic analysis revealed group differences that did not show up in the transcription analysis.

• The centroids of /s/ produced by children with CI's were lower in frequency than those of NH children, which may be due to CI's providing poor frequency resolution above 4000 Hz.

• Reduced variability was apparent in the centroids of /s/ and /S/ produced by children with CI's. Further research is needed to examine whether the reduced variability is related to reduced coarticulation.

• The children with CI's exhibited a wide range of performances. Further research is needed to determine what characteristics distinguish children who perform similarly to NH children from those who do not.

## Acknowledgments

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