The Relationship between Gender-differentiated Productions of /s/ and Gender Role Behaviour in Young Children

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Abstract

The acoustics of the sound /s/ have been shown to vary as a function of speaker gender in previous research, but the origin of this gender dichotomy remains controversial. The present study aimed to investigate the age at which gender-specific /s/ production begins to appear, and whether this dichotomy was related to gender role formation. Thirty normally developing children aged 4 and 5 participated in a series of experiments which examined their speech production, physical development and gender role behaviour. Word-initial /s/ and /ʃ/ were elicited and recorded for acoustic analysis. The mean spectral frequency of the fricative noise was calculated over the middle 40-ms window. Gender role behaviour was measured through both parental report and a free-play activity in the lab for the children. Our results revealed that even very young children have clearly distinguished gender role behaviour, as well as gender differentiated /s/ productions. No such differentiation was found for the production of /ʃ/. Importantly, correlation between the acoustic variation in /s/ and gender role behaviour began to emerge in these subjects, as evidenced by productions of the word "suitcase". This relationship was discussed in regards to articulatory strategies, gender stereotypes and adult role models.

Index Terms: acoustics, fricatives, gendered speech, development, gender identity

1. Introduction

Human speech not only communicates lexical information, but also carries cues to a variety of social and personal dimensions of an individual, such as age, gender, dialectal background, and social status. However, one of the most salient differences in adult speech is variation which cues a speaker's gender [1]. Ample evidence from sociophonetic literature has demonstrated the varied way in which adult men and women talk. The most noticeable example is vocal pitch, for which females typically have higher fundamental frequency (*f0)* than males [2, 3]. Such variation has been primarily attributed to anatomical differences that separate the two sexes after puberty (e.g., [4], [5]). However, the fact that young boys and girls can produce distinct patterns of *f0* in vowels led to the interpretation that such differentiation could also be the result of social learning, which ultimately reflects one's gender role formation ([6], [7]).

This research focused on a more subtle variation within the consonant sound /s/. It has been frequently demonstrated that females' /s/ productions typically have a higher mean spectral frequency than those of males [4], and that such variation is perceptually salient [8]. The higher mean spectral frequency has been interpreted to reflect a more anterior constriction location, characteristic of female speech [11]. The /s/ sound is particularly interesting because such gender-related variation is more likely to represent learned behaviour than the product of anatomical constraints between the two sexes for the following reasons. First, /s/ is articulated with air being forced through a narrow constriction between the raised tongue tip and the alveolar ridge. Although females and males differ in the length of the oral cavity, especially after puberty, the precise position of the tongue tip can be easily modified [11]. Second, Fuchs and Toda [11] used EPG to demonstrate that adult females tend to utilize a more anterior point of constriction while producing /s/ than do males, even when controlling for morphological differences. Using this articulatory strategy has the effect of raising the spectral frequencies of /s/, and accentuating the relative shortness of the female vocal tract. Third, the acoustics of /s/ could be shown to vary with social class [4]. Specifically, working class females had acoustic features that were closer to the values of males than to females of other classes. It was speculated that these girls were not using the fronted articulation in an effort to project a more masculine identity, and thus the acoustic characteristics of /s/ can be manipulated based on social factors. Last, boys and girls produced differentiated /s/ as young as six years old [9], long before differentiation in vocal tract length occurs (e.g., [5], [12]), suggesting that other factors are responsible for such a variation.

The production of the sound /s/ has also been demonstrated to signal sexual orientation in adulthood [7]. In particular, gay men differed significantly from straight men in terms of the spectral skewness of /s/. Another study [13] noted that the fronted /s/ is typically perceived by listeners as being more feminine. Pierrehumbert et al. [14] stated that the speech used by individuals of differing sexual orientations is not globally masculinised or feminized, but is instead a learned way of highlighting what is unique to that orientation. These studies provide evidence that individuals can learn to alter their speech based on how they want their gender to be perceived, even though this process is likely subconscious. Given what is known about the production of /s/, it seems probable that learned articulation patterns is one of the ways speech acoustics are altered to express sexual orientation and gender identity.

However, so far, all claims about the social origin of differentiated /s/ productions between men and women are based on speculations or inferences of acoustic and articulatory results. The present study was designed to directly investigate the link between sex-related speech variation and gender-typed behaviour in young children. In particular, we tested the hypothesis that the development of gender-differentiated patterns of /s/ is related to children's gender role formation. Specifically, we addressed the two questions below:

1. Are there gender-specific speech patterns in the /s/ production of children younger than 6?
2. If yes, is there a relationship between gendered speech and gender role behaviour?

If the distinction between female- and male-typed /s/ is a result of anatomic differentiation, we would not expect to see differentiation in young children's speech. The findings of Fox & Nissen [9] refuted such a possibility, as the youngest age group that they examined was children aged 6. The present study is to confirm Fox & Nissen's results, but at the same time push the age range two years earlier in order to identify when such gender-differentiated speech patterns start to

emerge. Furthermore, the present study extended to gender-typed behaviour in other domains, which will enable the examination of the relationship between gendered speech and gender-typed behaviour. The acoustic measure applied was the mean spectral frequency (first moment in moments analysis, or M1) of /s/ because it has been shown to index speaker's gender and sexual orientation [4, 7, 9, 11]. The phoneme /ʃ/ was also included as a control for /s/ because it is produced with a similar articulation, yet does not vary as greatly between genders [9]. The gender behaviour measures included both free play and parental report. We hypothesized that the children with the more feminine-style of play and attitudes would display the higher M1, and vice versa.

2. Methods

Thirty children (16 girls and 14 boys) aged 4 and 5 (M=57.2 months, SD=7.2 months) participated in the study. All participants were residents of southern Alberta for most of their lives, had the same regional dialect, were monolingual English speakers, volunteered with parental consent, and had no known speech, language, hearing or learning disabilities or delays. Demographics were collected through a survey given to the parent that accompanied the child to the lab. Children engaged in a speech production experiment, and were also asked to play in a room filled with toys for 10 minutes (free-play experiment). Following these procedures, each participant's physical height and weight were measured to ensure any differences in the production of /s/ were not due to physical variations. Meanwhile, parents were asked to fill in a questionnaire about children's gender-typed attitudes and home behaviour.

In the speech production experiment, children sat in front of a Dell desktop computer and were presented with a series of pictures of words that began with either /s/ or /ʃ/ and followed by each of the following vowel contexts /i/, /u/, and /æ/, which result in a total of 18 target words per subject. The words are *salad, salmon, sandwich, seahorse, seal, seat, soup, suit, suitcase, shack, shadow, shallow, sheep, sheet, shield, shoe, shoelace,* and *shoot*. In addition to the picture presentations of the words, audio prompts were also presented. Children were then asked to repeat the word into a Shure SM87A microphone which recorded with a Marantz flash card recorder (PMD661). The speech was recorded with a 44.1 kHz sampling rate with 16 bits of digitization. Each child received one of the three random lists of words to reduce any word-order effect in production.

Word-initial fricatives were segmented and extracted by using the speech analysis software, Praat [15]. The extracted fricative segments were then fed into R [16], which calculated the spectral mean frequencies of the middle 40-ms window slice using the multitaper algorithm [17]. Gender role behaviour was assessed by both free play behaviour and parental report. In the free play task, children's behaviour was observed through a one-way mirror and their gender-typicality was measured by the amount of time they played with different toys coded with varying gender-typicality scores ranging continuously from 1 to 5 (1= *extremely masculine*, 3= *gender neutral,* 5= *extremely feminine*). The gender code for each toy was determined by averaging responses from 20 judges. Parents were asked to fill in the Childhood Behaviour and Activities Questionnaire (CBAQ), a 12-question survey evaluating gender-typed behaviour through their play activities at home, choice of friends and entertainment [18]. Parents rated the frequency of these different behaviours, and their child's preferences on the 1-5 scale (1= *extremely masculine*, 3= *gender neutral,* 5= *extremely feminine*).

3. Results

In the following section, results of each aspect of development will be reported separately. That is, speech production, physical development, and gender-role behaviour development will be evaluated to see whether gender dimorphism exists in each of these aspects. If there are any differences related to gender, the differences will be correlated across modalities to explore the relationships between gender-typed behaviour and speech, anatomy, and identity.

3.1. Acoustics of fricatives

A repeated measures analysis of variance (ANOVA) was performed to examine the relationship between gender, the cross-subject independent variable, and M1 of /s/, the dependent variable. The vowel that followed the target fricative was also included as a within-subject factor to facilitate the examination of any effects that the phonetic environment may have on the acoustics of /s/. We found a main effect of gender [$F(1, 30) = 9.85$, $p = 0.0038$], and vowel context [$F(2, 60) = 4.087$, $p = 0.0217$]. Results of a similar ANOVA performed to examine /ʃ/ revealed no significant relationship between M1 and gender. Figure 1 plots the average of M1 values of /s/ and /ʃ/ for boys and girls respectively. It is clear from the graph that young children have already differentiated their /s/ productions between the two genders. No such difference was evident in their /ʃ/ productions.

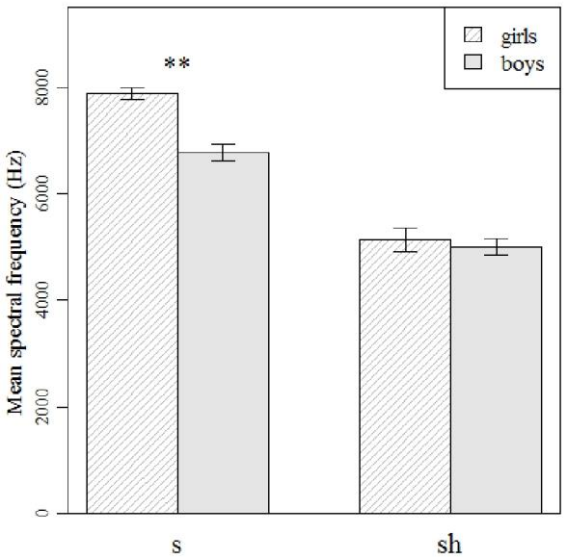

Figure 1: *Barplot of the average mean spectral frequencies in the productions of /s/ and /ʃ/ for both boys and girls. (*:p<0.05; **: p<0.01; ***: p<0.001)*

3.2. Physical development

Two-sample t-tests were performed to compare the physical measures between boys and girls. The dependent variable was height (in cm) or weight (in lbs) and the independent variable was gender. The two genders differed in neither height (t(28)= -1.18, p=0.24) nor weight (t(28)= -0.02, p=0.98).

3.3. Gender role development

Two two-sample t-tests were conducted, one for each of the two behavioral measures of gender role formation, free play and CBAQ. Both measures revealed significant differences between the two genders (free play: $t(28)= 6.01, p<0.001$; CBAQ: $t(28)= 9.86$, $p<0.001$). Furthermore, the two measures of gender typicality were significantly correlated ($r=0.81$, $p<0.001$). Figure 2 illustrates the differences in play behaviour and CBAQ scores between the two genders. It is clear that boys tended to score around 2, while girls were closer to 4. The two different gender role measures yielded similar results.

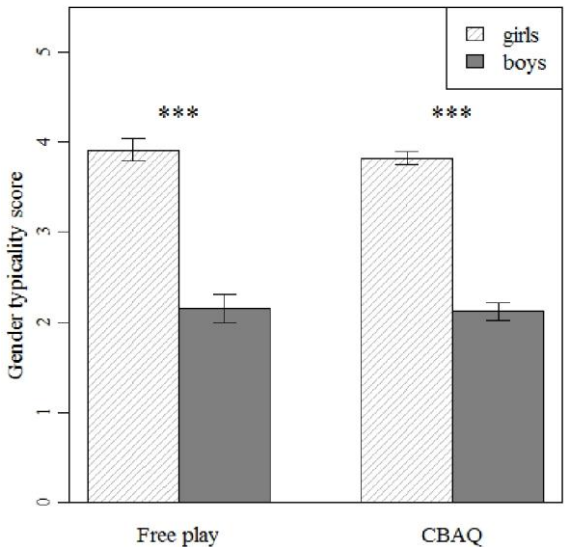

Figure 2: *Average values for both gender role measures separated by gender. Bars indicate 1 standard error. (*:p<0.05; **: p<0.01; ***: p<0.001)*

3.4. Relationship between gendered speech patterns in /s/ and gender-typed behaviour

In order to explore the relationship between gendered /s/ production and gender-typed behaviour while controlling for physical and sex differences, separate multiple linear regression models were constructed for boys and girls respectively. For each model, the dependent variable was M1 of /s/ and the independent variables were CBAQ, height, and weight. No effect of CBAQ was found for either gender group for either model.

A follow-up word analysis was conducted to investigate whether the relationship between CBAQ and /s/ acoustics existed on the basis of individual words. Similar multiple regression models were performed for each word and for each gender. Out of the 9 /s/-initial words, the analysis of the word *suitcase* produced by girls revealed expected relationship. Specifically, CBAQ explained a significant portion of variation in the M1 values of /s/ (β =0.52, $t(13) = 2.6$, $p = 0.02$). The overall model fit was $R^2 = 0.46$. Figure 3 displays the correlation between CBAQ and mean spectral frequency of girls' productions of /s/ in the word *suitcase*. It is clear from the figure that M1 is positively correlated with the CBAQ score, suggesting that the more female-typical a girl's behaviour is, the more effeminate her speech is. It should be noted, however, that the range of CBAQ score is very small (3.0 to 4.5), well within the limit for female-typed behaviour. The small range of variability indicates the sample is not sufficiently broad to include those on either extreme of the cross-gender role continuum.

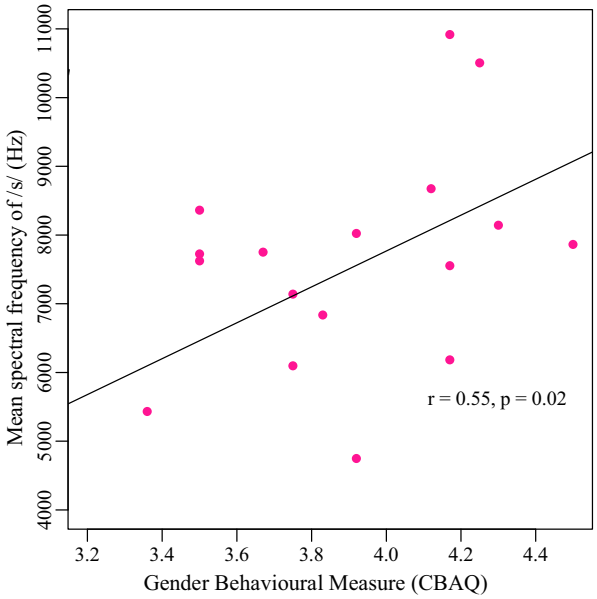

Figure 3: *Correlation between CBAQ score and mean spectral frequencies of /s/ for girls' productions of the word "suitcase".*

4. Discussion

The objective of this research was to examine gendered speech in young children, as well as its relationship to gender role behaviour and attitudes. We theorized that gender-differentiated speech could occur as early as age 4, despite the absence of difference in physical morphology between boys and girls. We further hypothesized that portions of this speech variation could be related to gender role behaviour. Our first hypothesis was confirmed: girls produced the /s/ sound with higher spectral mean frequencies than boys. Our second hypothesis was partially confirmed: spectral mean frequency variation was positively correlated with gender-typed behaviour scores, but only for the word 'suitcase'. The lack of such a relationship for other /s/-initial words may be due to the lack of variation in the gender behaviour measure; all boys tested had CBAQ scores between 1 and 3, while all girls had scores ranging between 3 and 5. There were no children in our sample who exhibited cross-gender behaviour. It is also possible that children in this age range have not completely formed their individualized gender identity, and therefore appear to conform to somewhat generic gender-typed behaviours. Furthermore, children at this age are still in the process of mastering the correct articulation of the /s/. It is not until their school years that they are able to produce an adult-like /s/ sound [19]. These immature /s/ articulations may not be able to convey the subtle fine-tuning that is needed for children to express their gender identity.

It is worth noting that such gender-typed speech patterns do not affect all sounds equally or develop at the same rate for all sounds. This was illustrated by the fact that /ʃ/ did not show clear differentiation in this group of children. Further, the lesser effect of play score as compared to CBAQ score suggests that perhaps this play measure was only partially representative of the children's normal behaviour or gender construct. It may not have captured the children's gender attitudes, which could contribute to the process of mediating gendered speech development. In the future, it might be interesting to include analysis of other factors that affect this

gender role formation, such as peer group or sibling compositions.

Our results concerning the emerging relationship between the CBAQ score and M1 are in line with what Stuart-Smith et al. [4] proposed regarding the use of articulatory strategies to convey gender identity. In the case of children, it is possible that their gender role subconsciously influences their productions of /s/. Furthermore, our findings are consistent with the literature regarding speech acoustics and sexual orientation. As noted earlier, spectral skewness is highly related to perception of sexual orientation, and frontal /s/ (which has the effect of raising M1) has been found to be perceived as more feminine ([7], [13]). We speculated that children may use adults as gender ideal and alter their realizations of /s/ to exaggerate the gender differences that are based on morphology. This has been hypothesized before, in that there are non-biological factors leading to males sounding larger and more masculine (i.e. lower frequency spectra), and to females sounding smaller and more feminine, than would be predicted based on anatomy alone [8]. So, a child with a feminine gender role may produce /s/ with the tongue farther forward in the mouth in an unconscious attempt to align their gender with their role model. Further investigation is necessary to verify the relationship between speech acoustics and gender identity formation in a larger sample of children. It is also important to include children in older age groups to determine whether the trend found in the current study in individual words becomes clearer and can be generalized over more words.

5. Conclusion

In summary, the results of this study demonstrate that children as young as four years of age show gender differentiated acoustics of /s/. Furthermore, the mean spectral frequency of /s/ was significantly related to gender role behaviour in the word "suitcase". This relationship was independent of any height and weight differences between children, suggesting a behaviorally based nature of such an endeavor. Our results are therefore consistent with the hypothesis that children may use articulatory strategies to emulate the acoustic characteristics of their adult gender role models, and thus provide supporting evidence for the social-origin of gendered speech in /s/.

6. Acknowledgements

The authors would like to acknowledge the Community Research Excellence Development Opportunity Fund (CREDO) at the University of Lethbridge awarded to Fangfang Li. We thank all of the children who participated in the study, and their parents for facilitating this research. Further thanks go to all of the Li Lab members, particularly Nicole Netelenbos and Giancarlo Diano for their assistance with data collection.

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