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ORIGINAL PAPER

The Influence of Voice Masculinity and Femininity on Adults' Expectations of Children's Academic and Occupational Competence

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Abstract
Gender-related acoustic features of voices may play a role in perceived aptitude for academic subjects and occupations. In the present study, parents and teachers rated the perceived competence of children they did not know with respect to a range of gender-stereotyped academic subjects and future possible occupations. Ratings were based solely on re-synthesized recordings of 8 children (4 girls, 4 boys) saying a single sentence. Voice manipulations involved changing the spacing between vocal resonances (formants), which affects perceived vocal tract length. Resynthesis involved changing format spacing only, either to the mean for each gender in the larger group from which the four speakers had been selected, or to one standard deviation above or below that mean, keeping fundamental frequency (voice pitch) unchanged. In Experiment 1, the speakers were rated for perceived competence in academic subjects by 61 parents and 38 teachers of children of a similar age to the speakers. Results showed that lowered or raised voices led to ratings of different levels of competence in traditionally masculine-stereotyped or feminine-stereotyped academic subjects, although the effects were clearer for boy speakers than for girl speakers. In Experiment 2, the speakers were rated for perceived competence in future occupations by 49 parents and 50 teachers. Results showed that perceptions of both boys' and girls' aptitude for gender-stereotyped occupations were even more clearly affected in stereotypical ways by the raised or lowered voices. The results have implications for possible interventions with adults to prevent unintentional stereotyping of children, and also point to the value of this method as an implicit measure of parents' and teachers' stereotyping of academic subjects and occupations.

Keywords Voice · Gender · Stereotyping · School subjects · Occupations

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Introduction

The role of the voice in shaping impressions about speakers has been widely acknowledged. It serves as a crucial source of information for perceiving stable characteristics like size (Pawelec et al., 2022; Pisanski et al., 2014; Pisanski & Bryant, 2019), age (Ptacek & Sander, 1966) or sexual orientation (Suire et al., 2020). Furthermore, the voice conveys dynamic characteristics, including attributions of speakers' dominance, trustworthiness, and affective states (Gulz et al., 2007).

Key vocal features studied in relation to impression formation are sex-dimorphic traits, with men speaking with lower fundamental frequency and vocal tract resonances than women, resulting in a deeper, lower-pitched and more baritone voice. Numerous studies have explored how gender-related femininity and masculinity cues in the voice influence judgments in a manner that aligns with prevalent gender-based stereotypes. Similar to research findings regarding physical appearance (Little, 2014; Re & Rule, 2017; Rule & Ambady, 2009; Sczesny et al., 2006; Todorov et al., 2005), speakers possessing masculine voices, characterized by lower pitch, are frequently associated with positive personality attributes such as competence and leadership (see, for example, Gulz et al., 2007; Nass & Brave, 2005; Reeves & Nass, 1996). Stereotypical judgments of occupational competence based on vocal characteristics, commonly observed in adults (e.g., Devers & Meeks, 2024), have also been found in pre-pubertal children (Cartei et al., 2021). The significance of impressions of competence is underscored by their potential to influence consequential social outcomes. This impact is evident in decisions such as hiring individuals for specific job roles (e.g., Claeys & Cauberghe, 2014; Fasoli & Hegarty, 2020) or voting for candidates in elections (Tigue et al., 2012).

Existing research has exclusively focused on attributions of competence based on adult voice sex dimorphism. However, children's voices also exhibit sexual dimorphism: before puberty, boys exhibit lower vocal tract resonances than girls, despite having the same pitch (Cartei et al., 2014), and this occurs without corresponding anatomical differences in the vocal apparatus between the two sexes (Fitch & Giedd, 1999). These variations are primarily associated with different spacings between formant frequencies, with wider spacings corresponding to higher, more feminine-sounding voices, and narrower spacings corresponding to lower, more masculine-sounding voices. Such variations in vocal characteristics may play a role in shaping gender-biased perceptions of children, including assessments of competence. Although no study has specifically examined competence, a prior investigation (Cartei et al., 2019a, 2019b) discovered that adult listeners spontaneously associated stereotypical play interests and friendship preferences of a child character with masculinized voices and feminized voices, pointing to adults' susceptibility to vocal cues in children. Our study aims to bridge this gap by directly examining how voice variation in masculinity and femininity has an impact on adults' stereotyping of children in relation to present academic competence and future occupational competence. The adults in question were parents and teachers of children of a similar age to the children whose voices they heard, but they did not know the child speakers of the stimuli used in the experiments.

We specifically chose to concentrate on teachers and parents given their paramount roles in the lives of primary school children. Researchers argue that the gender gap is due to gender bias, where certain subjects are linked to traditional gender stereotypes, discouraging children from pursuing non-traditional careers. For instance, a prevailing stereotype

among children's primary influencers—teachers and parents—is the belief that girls are inherently less proficient in mathematics than boys (Gunderson et al., 2012; Hand et al., 2017; Herbert & Stipek, 2005). Another longitudinal study found that parents' early gender-stereotyped expectations for their adolescent children's occupational achievements strongly correlate with the children's actual career decisions as adults (Jacobs et al., 2006). Our current study aims to deepen our understanding of how variations in children's voices affect societal expectations and evaluations of their abilities and future career paths. Specifically, we examine how parents and teachers perceive the competence of unfamiliar children in traditionally feminine and masculine school subjects and their potential careers. Importantly, our focus is on children before the vocal apparatus undergoes dimorphism, unlike the previously mentioned study of adolescents.

In the two experiments reported below, parents and teachers are asked to rate the perceived competence of resynthesized girls' and boys' voices (with formant spacings either at mean level, 1 standard deviation above the mean, or 1 standard deviation below the mean) in relation to competence for a set of traditionally masculine-stereotyped and feminine-stereotyped academic subjects (Experiment 1) and occupations (Experiment 2). Based on the literature mentioned above, it was predicted that the manipulation of vocal cues would affect perceptions of competence in stereotypical ways. In general, raised voices were expected to be associated with greater perceived competence in feminine-stereotyped subjects or occupations and poorer perceived competence in masculine-stereotyped subjects or occupations, whereas the opposite was expected for lowered voices. Given that patterns of gender stereotypes may be shifting in relation to both academic subjects and occupations (e.g., Charlesworth & Banaji, 2021), we also anticipated that there may be more subtle interactions between the sex of speaker (boy vs. girl), the listener role (parent vs. teacher), and the gender-stereotyping of the subject or occupation, but we did not have specific hypotheses about these interactions.

The methods for the two experiments mirrored each other and so are described together below.

Methods

Participants

Parents and teachers with no history of hearing impairments were recruited via school newsletters in two village primary schools in South-East England and via social media. A total of 61 parents (M age = 43.7; SD = 7.5; 30 women) and 38 teachers (M age = 33; SD = 8.4; 26 women) took part in Experiment 1 (school subject competence), and 50 teachers (M age = 38; SD = 10.2; 41 women) and 49 parents (M age = 50.8; SD = 11.8; 29 women) took part in Experiment 2 (occupational competence). Sample sizes were determined pragmatically based on recruitment feasibility and in line with previous studies using similar voice-rating paradigms (e.g., Cartei et al., 2019a, 2019b), which typically report robust effects with comparable participant numbers.

A between-subjects design (different groups of participants completed Experiment 1 versus Experiment 2) was chosen to minimize fatigue and respondent bias effects. All participants gave written consent and were debriefed after each study. Ethical approval was

obtained from the University of Sussex Science and Technology Cross-Schools Research Ethics Committee (reference: ER/VC44/27).

Speaker Selection

Eight child speakers of British English (4 girls, mean age = 9 years, range = 8.4–9.8) were selected from a larger database of 40 8–9 year-old children (23 girls) described in Cartei et al. (2020a) who had completed an additional task (saying "Where were you a year ago?") that was not analyzed in the original publication.

For boys, the selected speakers had fundamental frequencies (F0s) of 229, 230, 232, and 234 Hz. For girls, the selected speakers had F0s of 233, 234, 236, and 237 Hz. The children were not known to the parents and teachers, described above, who made the judgements.

Voice Re-synthesis

We used a standard speech-processing technique (PSOLA algorithm in PRAAT 6.0.28) to create three versions of each child speaker's voice that differed in how "masculine" or "feminine" they sounded. This was done by adjusting the spacing of vocal resonances (formant spacing: Delta F or DF), which listeners interpret as differences in vocal tract length, without altering other aspects of the sound (in particular, F0 was not manipulated).[1] We chose mean DF values of 1406.9 (equivalent vocal tract length 12.43 cm) (raised), 1341.5 (13.04 cm) (mid), 1276.1 (13.7 cm) (lowered) for boys, 1465.1 (11.9 cm) (raised), 1382.4 (12.6 cm) (mid), 1299.6 cm (13.5 cm) (lowered) for girls, based on the mean DF ± 1 SD as measured in our samples (SD for girls: 82.7 Hz, for boys: 65.4 Hz).

School Subjects and Occupations

The feminine school subjects were art, literacy, and music, and the masculine school subjects were science, computing, and mathematics. The feminine occupations were babysitter, nursery teacher, and beautician, and the masculine occupations were builder, mechanic, and lorry driver. The classification of the school subjects was supported by data from, for example, Hand et al. (2017), Master et al. (2021), and Wood et al. (2021). The last of these papers includes UK data on both school subjects and occupations. Other papers from the previous literature, with adults and children, that guided our choice of occupations include Gettys and Cann (1981), Liben et al. (2002), Miller and Budd (1999), Misersky et al. (2014), Vervecken et al. (2013), and Wilbourn and Kee (2010). In addition, we looked at archival data on true gender ratios from the UK Office for National Statistics (ONS). The study was run before that of Canessa-Pollard et al. (2022) was completed, so we could not base our choice of occupations on their results. In that study, we collected children's ratings of the gender-stereotyped occupations we were considering for use in this study. However, the six chosen occupations were those given most extreme ratings in that study, except that nurse

[1] Formants are the resonance frequencies of the vocal tract (the "filter"). The average distance between adjacent formants (ΔF) is inversely related to apparent vocal-tract length: smaller ΔF ≈ longer tract, deeper voice; larger ΔF ≈ shorter tract, higher-pitched voice. In pre-pubertal children, perceived gender differences arise mainly from ΔF rather than fundamental frequency (F0, the "source"). Manipulating ΔF therefore changes the timbre and perceived speaker size/gender expression without altering pitch (F0). The resulting utterances have parameters within the normal range of children of this age and sound natural.

and dancer would have replaced beautician and babysitter as slightly more stereotypically feminine occupations (see Appendix for that study 1-s2.0-S0001879122000148-mmc1.docx).

Playback Procedure

Participants sat individually in a quiet room either at the University of Sussex, or in their own home with the researcher present to ensure standardized conditions.

The voice stimuli were played back one at a time from a laptop through Sennheiser HD 201 professional headphones at a constant, pre-set volume. For each voice stimulus, participants were told they would listen to unknown child speakers, and they would be asked to rate how good or bad they thought that child was at a specific school subject (experiment 1) or occupation (experiment 2).

The question asked of the participants was "Please rate how good or bad this 9 YEAR-OLD BOY/GIRL would be at this school subject/job on a scale from 1 (very bad) to 5 (very good)". All instructions and rating scales (as labelled radio buttons) were presented on the computer screen. Each listener rated all the voice stimuli in two successive blocks, one with all 12 voice stimuli from the 4 boy speakers, and one with all 12 voice stimuli from the 4 girl speakers. So, voice stimuli were blocked by the gender of the speaker. Block order and stimulus presentation within each block were randomized—stimuli from the same speaker were not kept together. Listeners were informed of whether the speakers were girls or boys for each block.

Results

Statistical Analyses

Linear mixed models (LMM) fitted by maximum-likelihood estimation were used to examine the effect of voice resynthesis variant (lowered DF, mid DF, raised DF), listener's role (parent, teacher), speaker's sex, listener's sex, school subject type or occupation type (stereotypically feminine, stereotypically masculine) and their 2-way and 3-way interactions (as fixed factors) on ratings for competence in a school subject (Experiment 1) or a possible future occupation (Experiment 2). Given that listener's sex and its interactions did not significantly affect ratings, this factor was excluded from the final model. Separate analyses were conducted for boy and girl speakers, and competence rating was a scale outcome variable. Each model included listener identity, speaker identity and school subject or occupation within school subject or occupation type as random variables. The intercept was allowed to vary between subjects. All pairwise comparisons were Bonferroni corrected. The form of the models was.

$$\text{Rating} \sim \text{Role}*\text{VoiceVariant}*\text{SchoolSubjectType} + (1|\text{ListenerID}) + (1|\text{SpeakerID}) + (1|\text{SchoolSubject}).$$

With Occupation replacing SchoolSubject for Experiment 2. For overall models including both girl and boy speakers,[2] an additional fixed factor of SpeakerSex was included (SpeakerSex* Role*VoiceVariant*SchoolSubjectType).

Results from LMMs are reported in Table 1 (school subjects) and Table 2 (occupations).

In the analyses of the four data sets defined by girl vs boy speaker and school subject (Experiment 1) vs occupation (Experiment 2) the main focus was on the two-way interaction between the stereotype of the school subject or the occupation and the stimulus variant (lowered DF, mid DF, raised DF). If this interaction is significant, the numerical pattern can indicate whether the femininity or masculinity of the voice affects the perceived competence in a way that mirrors stereotypes for the subject or occupation. As described previously, the expected pattern would be increased competence ratings for masculine school subjects or occupations as voices become more masculine (from raised DF to mid DF to lowered DF) and increased competence ratings for feminine school subjects or occupations as voices become more feminine (from lowered DF to mid DF to raised DF).

[2] In the analysis of School Subjects, the effect of VoiceVariant and the interaction of SubjectType with VoiceVariant, which were significant in both the analysis for Girls and the analysis for Boys, were both significant in the combined analysis: VoiceVariant $F(2, 1406.80) = 6.79$, $p = 0.001$; SubjectType*VoiceVariant $F(2, 1446.32) = 13.14$, $p < 0.001$, In addition there were effects of SpeakerSex $F(1, 1405.78) = 20.32$, $p < 0.001$, and of SpeakerSex * VoiceVariant $F(2,1405.84) = 4.99$, $p = 0.007$. Girls received higher ratings overall, perhaps reflecting the perception that girls perform better in school than boys (Wong et al., 2023), and judgements about them were less affected, than for boys, by variations in their voices.

In the analysis of Occupations, the effect of VoiceVariant (significant in the analysis for Boys but not for Girls) and the interaction of OccupationType and VoiceVariant (significant in the analysis for Girls and the analysis for Boys), were both significant in the combined analysis: VoiceVariant $F(2, 1386.39) = 5.34$, $p = 0.005$; OccupationType*VoiceVariant $F(2, 1405.07) = 43.37$, $p < 0.001$. In addition, the interaction of SpeakerSex and Occupation Type was significant $F(1, 1405.28) = 5.32$, $p = 0.021$.

Table 1 Linear mixed models (LMMs) testing the (main and interaction) effects of speaker resynthesized DF (VoiceVariant: lowered DF, mid DF, raised DF) subject type (SbjType: stereotypically masculine, gender-neutral, stereotypically feminine), and listener's role (Role: teacher, parent) and on listeners' ratings of school subject competence in voices presented as belonging to boys and girls (both rated along a 5-point Likert scale)

Speaker Sex	df1	df2	F	p
Boy				
Intercept	1	293.148	9059.113	0.000**
VoiceVariant	2	513.906	7.727	0.000**
SbjType	1	259.278	1.882	0.171
Role	1	293.148	0.509	0.476
VoiceVariant * SbjType	2	612.337	11.881	0.000**
VoiceVariant * Role	2	513.906	0.676	0.509
SbjType * Role	1	259.278	0.361	0.549
VoiceVariant * SbjType * Role	2	612.337	2.870	0.057
Girl				
Intercept	1	89.945	14,300.250	0.000**
VoiceVariant	2	485.766	7.575	0.001*
SbjType	1	668.517	0.015	0.904
Role	1	89.945	0.803	0.372
VoiceVariant * SbjType	2	639.534	4.305	0.014*
VoiceVariant * Role	2	485.766	1.172	0.311
SbjType * Role	1	668.517	0.149	0.699
VoiceVariant * SbjType * Role	2	639.534	1.817	0.163

Table 2 Linear mixed models (LMMs) testing the (main and interaction) effects of speaker resynthesized DF (VoiceVariant: lowered DF, mid DF, raised DF), occupation type (OccType: stereotypically masculine, gender-neutral, stereotypically feminine), and listener's role (Role: teacher, parent) and on listeners' ratings of occupational competence in voices presented as belonging to boys and girls (both rated along a 5-point Likert scale)

Speaker Sex	df1	df2	F	p
Boy				
Intercept	1	95.797	5728.189	0.000**
VoiceVariant	2	499.100	7.829	0.000**
OccType	1	298.375	0.022	0.882
Role	1	95.797	0.013	0.911
VoiceVariant * OccType	2	634.469	25.399	0.000**
VoiceVariant * Role	2	499.100	3.773	0.024*
OccType * Role	1	298.375	0.034	0.854
VoiceVariant * OccType * Role	2	634.469	0.632	0.532
Girl				
Intercept	1	85.966	5080.852	0.000**
VoiceVariant	2	438.461	1.432	0.240
OccType	1	583.370	9.491	0.002*
Role	1	85.966	0.176	0.676
VoiceVariant * OccType	2	576.195	15.558	0.000*
VoiceVariant * Role	2	438.461	1.219	0.297
OccType * Role	1	583.370	0.485	0.486
VoiceVariant * OccType * Role	2	576.195	1.487	0.227

Experiment 1: School Subject Competence Ratings

The competence ratings for school subjects are shown in Fig. 1a for boy speakers and Fig. 1b for girl speakers, and the LMM analyses are summarized in Table 1. Differences not specifically mentioned were not significant.

Boys. The interaction between school subject type and voice variant was significant (see Table 1, top panel, $F(2, 612.34) = 11.88$, $p < 0.001$). For stereotypically feminine school subjects, participants rated boys with lower DF voices ($M = 3.76$, $SE = 0.07$) as significantly less competent than boys with mid DF voices ($M = 4.12$, $SE = 0.07$), $p < 0.001$. For stereotypically masculine school subjects, boys with raised DF voices ($M = 3.75$, $SE = 0.08$) were rated as significantly less competent compared to boys with mid DF voices ($M = 4.11$, $SE = 0.08$) and masculinized voices ($M = 4.24$, $SE = 0.08$), $ps < 0.001$(Fig. 1a). The fact that the pattern for masculine school subject did not exactly mirror the clear (numerical) pattern for feminine school subjects meant that, overall, boys' mid DF voices received significantly higher competence ratings ($M = 4.11$, $SE = 0.06$) than raised DF voices ($M = 3.86$, $SE = 0.05$), $p < 0.001$. The main effect of voice variant was significant, $F(2,513.91) = 7.73$, $p < 0.001$. Nevertheless, the overall pattern was close to that expected if stereotyping of school subject varied with voice variant in the expected way.

Girls. The interaction between school subject type and voice variant was significant (see Table 1, bottom panel, $F(2, 639.53) = 4.31$, $p < 0.05$). For stereotypically feminine subjects, participants rated girls with lowered DF voices ($M = 3.93$, $SE = 0.07$) as significantly less competent than girls with mid DF voices ($M = 4.36$, $SE = 0.08$), $p < 0.001$ and raised DF voices ($M = 4.24$, $SE = 0.07$), $p = 0.002$. Overall, there was a significant main effect of voice variant on ratings of girl speakers, $F(2, 485.77) = 7.58$, $p = 0.001$): across all school subjects, girls' lowered DF voices received significantly lower competence ratings ($M = 4.04$, $SE = 0.05$) than raised DF voices ($M = 4.21$, $SE = 0.05$), $p < 0.001$, and mid DF voices ($M = 4.27$, $SE = 0.06$).

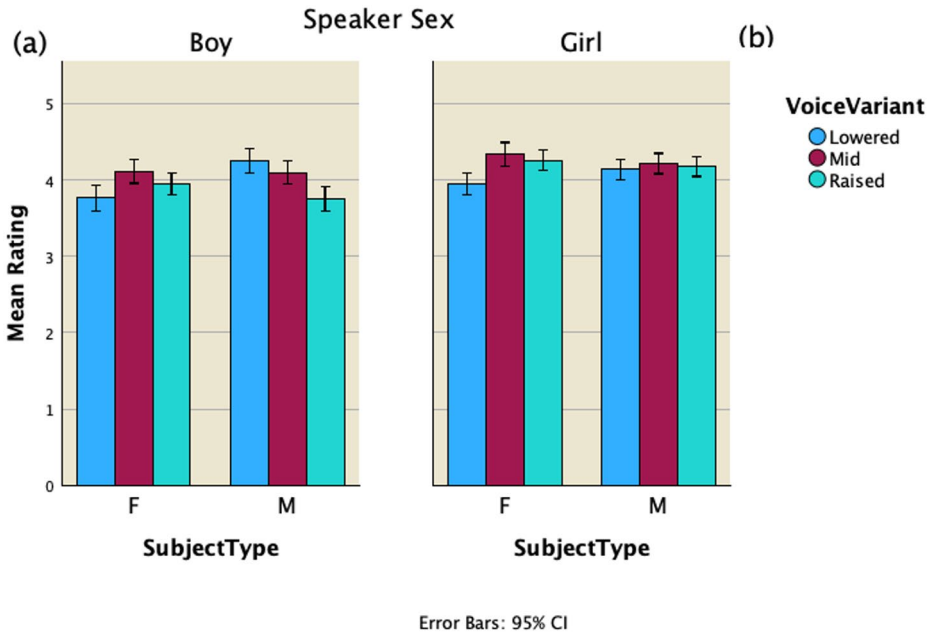

Fig. 1 Mean ratings of boys' (**a**) and girls' (**b**) competence in stereotypically feminine (F) and stereotypically masculine (M) school subjects (Experiment 1) according to voice variants (lowered, mid, and raised DF). Error bars represent 95% confidence intervals

Experiment 2. Occupational Competence Ratings

The competence ratings for occupations are shown in Fig. 2a for boy speakers and Fig. 2b for girl speakers, and the LMM analyses are summarized in Table 2.

Boys The interaction between occupation type and voice variant was significant (see Table 2, top panel, $F(2, 634.47)=25.40$, $p<0.001$). For stereotypically feminine occupations, participants rated boys with lowered DF voices ($M=2.92$, $SE=0.06$) as significantly less competent than boys with mid DF voices ($M=3.20$, $SE=0.07$), $p=0.002$, and raised DF ($M=3.21$, $SE=0.07$), $p=0.001$. For stereotypically masculine occupations, boys with raised DF voices ($M=2.77$, $SE=0.07$) were rated as significantly less competent compared to boys with mid DF voices ($M=3.22$, $SE=0.07$), $p<0.001$, and lowered DF voices ($M=3.33$, $SE=0.07$), $p<0.001$.

There was also a significant interaction between voice variant and listener's role: across occupation types, parents rated boys with raised DF voices ($M=2.91$, $SE=0.08$) as least competent compared to mid DF voices ($M=3.21$, $SE=0.07$), $p<0.001$, and lowered DF voices ($M=3.19$, $SE=0.07$), $p<0.001$. There was a significant main effect of voice variant on ratings of boy speakers across all occupations, $F(2, 499.10)=7.83$, $p<0.001$: Boys' mid DF voices received significantly higher competence ratings ($M=3.21$, $SE=0.05$) than raised DF voices ($M=2.99$, $SE=0.05$), $p<0.001$.

Girls The interaction between occupation type and voice variant was significant (see Table 2, bottom panel, $F(2, 639.53)=4.31$, $p<0.05$). For stereotypically feminine occupations, participants rated girls with lowered DF voices ($M=3.04$, $SE=0.07$) as significantly

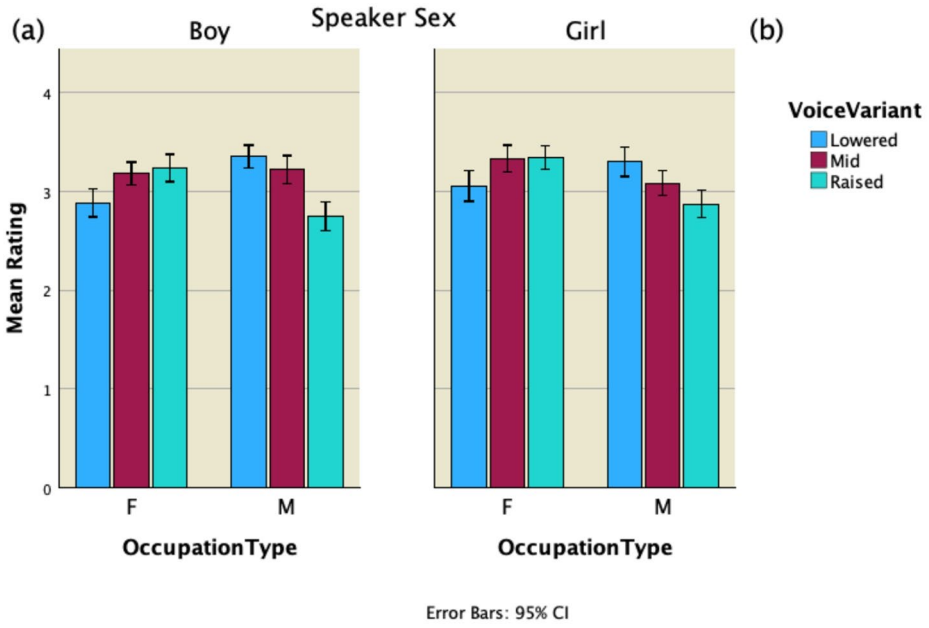

Fig. 2 Mean ratings of boys' (**a**) and girls' (**b**) competence in stereotypically feminine (F) and stereotypically masculine (M) occupations (Experiment 2) according to voice variants (lowered, mid, and raised DF). Error bars represent 95% confidence intervals

less competent than girls with raised DF voices ($M=3.36$ $SE=0.07$), $p=0.002$, and mid DF voices ($M=3.35$, $SE=0.07$), $p=0.001$. For stereotypically masculine occupations, participants rated girls with lowered DF voices ($M=3.28$, $SE=0.07$) as significantly more competent than girls with mid DF voices ($M=3.09$, $SE=0.07$), $p=0.039$, and raised DF voices ($M=2.88$, $SE=0.07$), $p<0.001$. There was a significant main effect of occupation type on ratings of girl speakers: $F(1, 583.37)=9.49$, $p<0.01$: girls received slightly, but significantly, higher competence ratings for the stereotypically feminine occupations ($M=3.25$, $SE=0.05$) compared to the stereotypically masculine occupations ($M=3.09$, $SE=0.05$), $p=0.002$.

Discussion

This is the first study to show that parents and teachers make gender-stereotypical judgments of child speakers based on variation in vocal masculinity and femininity. These results extend previous research which exclusively focused on adolescents' and adults' competence based on voice variation. Overall, the results show a relation between masculine vs. feminine aspects of voice and judged competency in both school subjects and occupations, where these are gender stereotyped. The results take this form more clearly for occupational judgements (see Figs. 1 and 2) and we touch on possible reasons for the difference between occupations and school subjects below. Importantly, these results cannot be explained by assuming that deeper sounding voices indicated greater age and hence greater competence.

Specifically, we found that boys with masculinized voices were rated by adults as least competent for stereotypically feminine school subjects and boys with feminized voices were rated as least competent for stereotypically masculine subjects. This pattern was replicated in occupational ratings, Thus, boys whose voices went against a stereotype for either a school subject or an occupation received the lowest ratings.

Girls with masculinized voices were rated as the least competent in stereotypically feminine school subjects, whereas voice variations did not influence ratings for masculine school subjects. For occupations the results for girls' voices mirrored those for boys' voices. Girls with masculinized voices were perceived as the least competent for traditionally feminine occupations, yet most competent among girls for traditionally masculine occupations. For school subjects, the results are potentially influenced by decades-old efforts to encourage girls' participation in STEM (Science, Technology, Engineering, and Mathematics) fields (Archer et al., 2013; Clark et al., 2024), which are typically stereotypically masculine, assuming that previous reluctance of girls to participate in these school subjects does not relate to lack of competence. Both parents and teachers are likely to be influenced by these considerations in their judgements of how well girls can perform in traditionally masculine school subjects. The lack of a similar moderating effect for male voices may reflect the fact that these educational campaigns specifically emphasize STEM subjects in schools and encourage girl pupils to consider them. They tend to overlook the fact that feminine subjects are potentially accessible to boys as well as girls. So, the idea that all boys, and particularly those with more masculine voices, might succeed and even excel in traditionally feminine school subjects may not be at the front of parents' and teachers' minds.

This pattern does not generalize to occupations, where stereotype effects persist for both girls' and boys' voices. Occupational ratings reveal a clear interaction between speaker gender and gender roles of the type predicted: girls with masculinized voices were perceived as more competent in traditionally masculine jobs, whereas for boys, those with feminized voices received lower competence ratings. This finding aligns with findings for adult voices, where women's judged competence in traditionally masculine occupations is boosted if they have masculine voices (Devers & Meeks, 2024), indicating a need for women who want to succeed in these occupations to adopt masculine traits despite an increased preference for more feminine leadership qualities (Feenstra et al., 2023; Powell et al., 2021).

Numerically, our results showed higher competence ratings for girls than boys in future occupations, though the difference was not significant. This pattern does not directly reflect the experiences of women and men when they actually enter the workforce. Men often find themselves favored over women for reasons not always associated with actual competence. It is possible that our results were influenced by the particular set of occupations we chose. In addition, the judgements we elicited, about future competence of 9-year-old children in occupations they might adopt many years in the future are not directly related to expectations of what might happen in career paths after entering those professions.

One other aspect of the results worth noting is that ratings for occupations were lower than for school subjects (as shown by the descriptive statistics). An obvious reason for this difference, though not one that our results provide direct evidence for, is that parents and teachers are likely to be less confident in assessing children's future occupational competence compared to their current competence in school subjects, even, as in the present case, children they do not know.

Two other factors that could influence our results are social desirability and experimental compliance. The former would likely make participants minimize stereotypical responding, while the latter would likely encourage them to maximize such responding, assuming they took the experiment to be about social stereotypes. Given that we saw stereotypical responding, the effects of social desirability clearly did not cancel this effect out. Participants may have been reluctant to rate girls as less competent in masculine domains, which could attenuate the influence of vocal cues for girls in masculine subjects and reduce variability in ratings. However, ratings for girls were only slightly less variable than those for boys (overall SDs 0.77 vs. 0.81). The hypothesis about social desirability might therefore be best addressed in future research using measures specifically designed to capture social desirability bias. The effect of experimental compliance cannot completely be ruled out, but the literature on stereotyping (e.g. Oakhill et al., 2005) suggests that it is difficult to bring completely under control.

Our results are based on adults' ratings of children's competence in current school subjects and future occupations, not ratings made by the children themselves. Nevertheless, more generally judgements by significant adults in children's lives may have an indirect influence on children themselves, for example via implicit or explicit expectations about their performance. To the extent that adults are not aware that their judgements are being influenced by aspects of the voice, a mere recognition of this fact, or some kind of implicit bias training, may put them in a position to avoid stereotyping based solely on voice characteristics, assuming that they wish to do so. Avoidance of stereotyping on the part of adults could have a benefit on children's thoughts about themselves and, for example, on the possible future careers they might consider. This in turn might influence their actual futures. As far as the interventions themselves are concerned, it is relatively unlikely that simply telling adults that their judgements are being affected by characteristics of children's voices would be sufficient. Their attention would need to be drawn specifically to characteristics of children's voices, how to recognize them, and how those characteristics can make children sound more feminine or masculine and hence to be gender stereotyped. Adults would then have to be made aware that those characteristics have no necessary connection to competence in school subjects or occupations. Hence, they must be aware that judgements of competence could potentially be influenced by a combination of feminine or masculine characteristics of a child's voice and gender-stereotyping of occupations, and that those judgements do not necessarily reflect actual competence.

A great deal is known about the general characteristics of interventions that can reduce stereotyping and their effectiveness both immediately and across relatively short time periods (e.g., Devine et al., 2012; Lai et al., 2014, 2016; Lenton et al., 2009; Paluck & Green, 2009). While these findings suggest that adults' judgments can be influenced by vocal characteristics, our study does not provide direct evidence that such biases would persist when other cues are available, such as information about actual competence, nor that interventions based on voice stereotyping would be effective in real-world contexts.

This observation might temper the potential use of our task as an indicator of (unconscious) gender stereotyping of academic subjects and occupations among parents and teachers, or indeed by adults more generally. We know that adults do make gender-stereotypical judgements about children based on their vocal characteristics (Cartei et al., 2020a). Our task might therefore provide a simple way of making this stereotyping explicit and hence forming the basis for programs to correct such biases. However, although such tasks might

serve as a starting point for developing bias-awareness strategies, further studies are needed to test their feasibility and impact outside controlled conditions.

In relation to possible interventions with children, it is hard to draw any definite conclusions from our results. The children's voices were artificially manipulated, and although we know pre-pubertal children can modify their voices (e.g., Cartei et al., 2019a, 2019b, 2020b), it is not clear that they would or could easily modify them to avoid being stereotyped for performance in school subjects or occupations. Furthermore, it is also not clear whether such modification would bear any relation to their actual or potential competence in those subjects or occupations. And it is hard to say how any such modification might affect those around them, particularly parents and teachers, who were the focus of our study. Indeed, it is likely that any such effect would be complex and would occur over the longer term, in which either the children or their significant adults might respond to such modifications.

In conclusion, parents and teachers are influenced by characteristics of children's voices in rating the perceived competence of those children in a range of gender-stereotyped academic subjects and future possible occupations. Because our results are based on adult judgments, they have direct, though somewhat complex, implications for possible interventions with adults to prevent unintentional stereotyping of children. Their implications for interventions with children are less direct. Our findings might also form the basis of an implicit measure of parents' and teachers' stereotyping of academic subjects and occupations.

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Author Contributions The study was conceived and developed by AG, VC-P, JO, RB and DR. VC-P implemented the study and managed its execution. VC-P, LR and SA finalised the methodology, collected, analysed and provided the initial interpretation of the data. VC-P drafted the manuscript. AG refined and finalized the manuscriptAll authors reviewed the manuscript.

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Data Availability The data will be made available on the University of Sussex Research Data Repository https://sussex.figshare.com/.

Declarations

Competing Interests The authors declare no competing interests.

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