

Gender Differences in Visual Speech Variables

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The present study investigated gender differences in the visual speech of talkers that may account for the gender difference in visual intelligibility (favoring female talkers). Eight speech variables were measured from videotapes of 24 talkers (12 female and 12 male) presenting sentences. Measurements for female and male talkers were compared. Underlying factors identified by principal components analysis were used in a multiple regression against mean speech-reading scores for the talkers. Results suggested three reasons for the superior visual intelligibility of female talkers: (a) female talkers used more of the speech variables that have been shown to contribute to visual intelligibility, (b) the visual speech variables used by female talkers correlated more strongly with visual intelligibility than those used by male talkers, and (c) the visual speech of female talkers followed a more standard pattern than that used by male talkers. Possible clinical approaches using these results are considered and recommendations made for future research.

INTRODUCTION

A recent study (Daly, Bench, & Chappell, 1996a) demonstrated gender difference in the visual intelligibility of talkers; female talkers were easier to speechread than male talkers. This finding is consistent with many gender dif-

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ference findings in sociolinguistics which show women to be more successful communicators than men in areas other than speechreading (see, for example, Coates, 1993; Graddol & Swann, 1994; Holmes, 1992). In such studies, a quantifiable linguistic form, such as questions, pragmatic particles, or conversational overlap, is counted and the usage compared between men and women. In Daly et al. (1996a), the 6 male talkers presented the same short sentences as the 6 female talkers. Thus many linguistic forms were controlled. Nevertheless, higher mean speechreading scores were obtained from speechreading 6 female talkers than 6 male talkers. It is possible that the gender difference in visual intelligibility is due to gender differential facial movements used by the talkers in visual speech. In order to establish whether there were gender differences in the visual speech of talkers, the speech variables relevant to visual intelligibility (Daly, Bench, & Chappell, 1996c) were compared for male and female talkers.

Daly et al. (1996c) examined the contribution of eight aspects of visual speech to visual intelligibility: teeth visibility, visible tongue movement, lip rounding, eyebrow movement, mouth area, mouth height, mouth width, and speed of speech. Using a principal components analysis, three factors were identified, accounting for 73% of the variation in the mean speechreading scores for 24 talkers: a Speed Factor, consisting of speech variables which were related to speed of speech (lip rounding and teeth visibility); a Tongue-Plus Factor including visible tongue movement and eyebrow movement; and a Mouth Factor including mouth area, mouth height, and mouth width. The Mouth Factor was strongly correlated with the Speed Factor and, in a multiple hierarchical regression analysis, the Mouth Factor did not account for a significant amount of variation in mean speechreading scores beyond that accounted for by the Speed and Tongue-Plus Factors. The current study considered gender differences in the use of these speech variables and their relationship to visual intelligibility.

A modest volume of literature supports the existence of gender difference in the visual speech variables of talkers. For example, some studies have shown gender differences in articulation among children speaking British English, American English, and Finnish (e.g., Johnson & Somers, 1979; Kenney, Prather, Mooney, & Jeruzal, 1984; Kumin et al., 1984; Pahkala, Laine, & Lammi, 1991; Paynter & Petty, 1974; Qvarnstrom, Laine, & Jaroma, 1991). Most of these studies show girls to have superior articulation ability. However, there is apparently no literature reporting investigations of gender differences in articulation or related skills among adults. Superior articulation skill in female talkers may help to explain the gender difference in visual intelligibility.

Henton (1992) compared vowel spaces¹ for male and female speakers of British English, General American English, French, Swedish, and Dutch. In all

¹A vowel space is a two-dimensional representation of vowels in terms of tongue height and place in mouth (Henton, 1992).

cases, female vowel spaces were larger than male vowel spaces. Henton concluded that female talkers appeared to make their vowels more distinct and therefore potentially more intelligible than did male talkers. The vowel spaces of male and female talkers using Australian English have not been compared in this way. Bench, Daly, Doyle, and Lind (1995) pointed out that work by Bernard (1970) and Mitchell and Delbridge (1965) suggested that females using Australian English will on average use wider mouth apertures than males. If this conjecture is valid, it may also explain differences in speechreadability.

Gender differences in mouth apertures during the production of vowels for speechreading have not been investigated. Studies have either used female talkers (Jackson, Montgomery, & Binnie, 1976; Montgomery & Jackson, 1983; Montgomery, Walden, & Prosek, 1987; Plant, 1980), or did not specify the gender of their talker (Fromkin, 1964).

Hall (1984) reviewed 75 studies investigating gender differences in nonverbal communication dating from 1923. She defined nonverbal communications as: "people's communication skills and styles of expression, excluding the actual verbal message they might be using" (Hall, 1984, p. 1). Examples are smiling, gazing, and the ability to judge the meanings of nonverbal cues. It is possible that nonverbal communication skills are relevant to speechreading. In studies of expression in nonverbal communication, researchers generally have videorecorded senders who were presenting an emotion which was either posed (i.e., consciously produced) or spontaneous (senders were shown some stimulus which elicited an unconscious production of an emotion). These videorecordings were then shown to decoders who were asked to judge the emotion being portrayed. Thus in these studies the expression accuracy of the sender was defined by the number of judges who were able to identify the emotion being portrayed correctly. Hall (1984) concluded that females were better encoders (senders) of nonverbal communication than male talkers, particularly for visual as compared to vocal cues. These conclusions provide another perspective on why women are easier to speechread than men.

Thus, there is evidence that female talkers use "superior" articulation, wider mouth apertures, and more interpretable nonverbal communication than male talkers. All these speech variables would enhance the visual intelligibility of female talkers. However, no objective measurements of these speech variables have been investigated for gender differences. Brookman (1993) surmised that "sufficient evidence has accumulated over the past 20 years to support the existence of gender-specific language behaviour" (p. 257). Recent research showing gender differences in visual intelligibility (Daly et al., 1996a) suggests that this may also be true for visual speech. The fact that female talkers were easier to speechread than male talkers suggested that there are gender-specific styles of visual speech. The current study aimed to establish if and how the visual speech of male and female talkers differed.

METHOD

Talkers

Talkers were 12 male and 12 female talkers. The talkers were volunteers from university teaching staff who filled the following criteria: They were tertiary-educated Australian-born Anglo-Australian monolingual speakers of English. Each talker was videorecorded saying one of six sentence lists (each containing 16 short sentences) randomly selected from the 21 BKB/A (Bamford-Kowal-Bench/Australian version) sentence lists (Bench & Doyle, 1979). The sentence lists each contained between 51 and 54 key words (the words carrying the main semantic content) and were, by design, equivalent in syntactic structure with vocabulary drawn from a common pool. They were devised to be within the linguistic abilities of children who were hearing impaired and also of persons with normal hearing aged from 6 years upwards (Bench & Bamford, 1979). The six sentence lists were presented four times each (by the total of 24 talkers), once each by 2 female talkers and once each by 2 male talkers.

All talkers wore blue sweat shirts, with no makeup. Males were clean shaven. Talkers were videorecorded against a black backdrop with a 1,500 W fill light for even lighting across their faces. Talkers were instructed to speak as follows: "Please say these sentences speaking a little slower than you would in normal conversation, as if you were giving a lecture or telling a story. Don't change the way you speak in any other way."

Speechreaders

The speechreaders were 48 volunteer first-year university students (24 females and 24 males) who filled the same criteria as the talkers: Australian-born Anglo-Australians who were monolingual speakers of English. They were aged between 18 and 50 years (females: mean 23.0 years, median 20.5 years; males: mean 26.0 years, median 23.5 years) and had no special experience of speechreading. Their eyesight and hearing fell within normal limits (20/30 on the Snellen Eye Chart at 3 m, and 20 dB HL at 0.5, 1, 2, and 4 kHz respectively).

Speechreading Procedure

Speechreading was conducted in two replications (one of which is reported in Daly et al., 1996a). In Replication 1, 6 male and 6 female talkers were speechread by 12 male and 12 female speechreaders in a balanced cross-over design using latin squares (for further details of the design refer to Daly et al., 1996a). In Replication 2 this procedure was repeated with different talkers and speechreaders. In both replications each talker presented one sentence list. The 6 female talkers presented the same six sentence lists as the 6 male talkers so that their scores could be compared. Similarly, the same six sentence lists were used

for Replications 1 and 2, to ensure that the replications were identical except for the speechreaders and talkers.

Measurements

Two kinds of measurements of visual speech variables were made from the same videorecordings as were used for speechreading: one using an observer who counted incidences of speech variables and measured speed of speech from videotape ("moving picture variables"), and the other obtained by the same observer using a computer program to measure mouth shapes from still pictures from the videotapes ("still picture variables"). Measurements were made using an identical procedure to that used by Daly et al. (1996c). A brief description follows.

Moving Picture Measurement

Measurements were made on a 30 cm Samsung monitor at a distance of 1 m between screen and observer. Speed of speech was measured with sound as syllables per minute (spm). Other behaviors were measured without sound, with one point available for each sentence spoken by each talker. Thus a total of 16 points was available for each speech variable other than speed of speech. Measurement details are described below.

Visible tongue movement. A point was given if a tongue movement was observed at any time during a sentence, regardless of whether the movement was large or small. It should be emphasized that this was a measurement of tongue movement rather than visibility of the tongue.

Teeth visibility. For each sentence spoken by each talker, a point was given if top or bottom teeth or both were visible. The point was given regardless of whether the teeth were seen momentarily, or could be seen at various times during sentence production.

Lip rounding. Lip rounding was defined as an inward movement along the horizontal plane of both top and bottom lips. This definition excluded "rounded lips" that occurred due to an opening of the mouth, rather than a movement of the lips and incidents of talkers rounding their bottom lips only. A point was given if lip rounding was used at any time during the production of a sentence. The degree of horizontal movement (i.e., slight or strong) was not considered.

Eyebrow movements. A point was given when the eyebrows of a talker were seen to move in any direction during the production of a sentence.

Speed. Speed was measured by stopwatch, started when the talker began to speak, and stopped when the talker completed the sentence. The measurements for each sentence in the sentence list were added together and a syllables per minute (spm) measure was computed using the number of syllables in the appropriate sentence list. Although this method of measuring speed is relatively crude, it was shown to be reliable (see below).

For all five measurements, a random sample of 25% of the talkers (i.e., 6 talkers from 24) was remeasured by the original observer after a period of a month. Intra-rater reliability was calculated as an "event by event percentage agreement" by tallying the number of agreements for each recording opportunity, and dividing by the total number of agreements and disagreements (Cordes, 1994). The intra-rater reliability for the measurement of speed of speech could not be calculated in this way, as it did not comprise "events." Instead, a correlation coefficient was calculated between the speed estimated at the two measuring times. Results were 80.3% agreement for lip rounding; 89.9% for visible tongue movement visibility; 97.4% for teeth visibility; 99.7% for eyebrow movement; and $r = .99$ for speed of speech.

Inter-rater reliability was examined using random samples of 25% of the talkers for each of the five speech variables. Three female qualified speech-language pathologists or audiologists counted incidences of the five speech variables in the random samples. Inter-rater reliability was 78% agreement for lip rounding; 91% for visible tongue movement visibility; 94% for eyebrow movement; 98% for teeth visibility, and $r = .95$ for speed of speech.

Still Picture Measurements

Still frames of maximum mouth openings in each sentence were measured using a computer based measurement program (McIntosh program, NIH Image 1.52 [Rasband, 1995]) to provide a representative measure of how widely talkers opened their mouths. This method was exactly the same as that used by Daly et al. (1996c): A measurement of the maximum mouth opening was made for one predesignated word in each sentence (chosen as the word requiring the largest mouth opening by a panel of six monolingual English speaking Anglo-Australians with speech-language pathology training). This measurement was used to represent the extent of mouth opening used by each talker. Measurements made of mouth area, height, and width were made as a ratio of face area, height, and width respectively in order to overcome problems of differing zoom levels used for recording individual talkers. Inter-rater reliability was achieved by the measurement of a random selection of 10% of the total measurements by two observers, yielding a correlation coefficient of $r = .82$ ($p < .001$) between the two sets of measurements.

Data Transformations

The raw data were transformed ($[\log_{10} X]^2$) for all subsequent analyses to achieve homogeneity of variance. This transformation had the effect of reversing the magnitude of the three moving picture measurements which consisted of decimal proportions in their original form. Therefore negative correlations with these factors represent positive correlations in the original findings, and have been shown as such in the tables.

RESULTS

Analysis of variance on measurements across the eight speech variables (see Table 1) for the 24 talkers by talker gender revealed no significant difference for talker gender ($F_{1,22} = 1.11$, NS). Unpaired t -tests with a Bonferroni adjustment ($\alpha = .0064$) were conducted on each of the eight speech variables, comparing the difference between male and female talkers. The only variable to show a significant gender difference was lip rounding. Female talkers used significantly more lip rounding than male talkers (female mean = 13.42; male mean = 9.17, $p < .0064$). Female talkers also used more teeth visibility than male talkers (female mean = 15.21; male mean = 11.67), and male talkers spoke more quickly than female talkers (female mean = 189.78 spm; male mean = 217.75 spm). However the teeth and speed comparisons just failed to attain significance. There was also no significant difference in the amount of visible tongue movement or eyebrow movement used by male and female talkers. For still picture variables, female talkers' mouth height and mouth area were greater than male talkers', but not significantly so. However there was very little gender difference between mouth width measurements.

The data for the speech variables were then analyzed separately by talker gender using correlations, principal components analysis, and regression analysis. For both male and female talkers, moving picture speech variables were analyzed separately from still picture speech variables, because of the different ways in which each type of data was measured. Factor scores were regressed against mean speechreading scores (see Table 2) obtained for the 24 talkers in a previous study (Daly, Bench, & Chappell, 1996b). Briefly, speechreading scores were obtained by the 24 talkers being speechread by 48 speechreaders.

Table 1
Means and Standard Deviations of Speech Variable Measurements for Male and Female Talkers

Variable	Male		Female	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
<i>Moving picture</i>				
Visible tongue movement	8.83	4.53	8.92	4.38
Teeth visibility	11.67	4.58	15.21	2.14
Lip rounding*	9.17	4.04	13.42	1.93
Eyebrow movement	3.17	4.84	4.33	5.45
Speed of speech	217.75	26.09	189.78	4.89
<i>Still picture</i>				
Mouth area	.02	.01	.03	<.01
Mouth height	.07	.02	.09	.01
Mouth width	.32	.12	.35	.04

* $p < .0064$.

Table 2
Means and Ranges of Speechreading Scores for 24 Individual Talkers

Talker	M	Range
<i>Female</i>		
Talker 1	7.84	0-20
Talker 2	11.57	1-26
Talker 3	4.44	0-19
Talker 4	8.41	0-22
Talker 5	4.44	0-15
Talker 6	12.11	1-36
Talker 7	8.33	1-27
Talker 8	15.01	2-35
Talker 9	6.21	0-31
Talker 10	4.78	0-14
Talker 11	10.02	1-30
Talker 12	12.03	3-34
<i>Male</i>		
Talker 13	2.98	0-9
Talker 14	5.90	0-19
Talker 15	4.12	0-12
Talker 16	9.68	0-22
Talker 17	4.25	0-15
Talker 18	7.19	0-16
Talker 19	6.83	0-23
Talker 20	4.32	0-15
Talker 21	7.23	0-24
Talker 22	8.72	1-17
Talker 23	8.96	1-30
Talker 24	11.87	0-28

Note. Scores from a total of 50 key words.

Female Talkers

Simple correlations between the mean speechreading scores obtained for female talkers and measurements of each of the eight speech variables demonstrated that, of the moving picture variables, only visible tongue movement and speed of speech correlated significantly with the mean speechreading score (see Table 3). Mean speechreading score increased with increased visible tongue movement and decreased with increased speed of speech. Thus the moving picture variables that may be regarded as strongly predictive of mean speechreading scores for female talkers, based on the results of simple correlations, were visible tongue movement and speed of speech.

Although the sample size in the current study was small, it was decided to conduct principal components analysis on the speech variables in order to make pre-

Table 3
Correlations Between Mean Speechreading Score and All Speech Variables
Measured for Female Talkers and Male Talkers

Speech variables	Correlation with mean speechreading score	
	Female talkers	Male talkers
<i>Moving picture variables</i>		
Visible tongue movement	.754**	.654*
Teeth visibility	.477	.702*
Lip rounding	.469	.487
Eyebrow movement	.503	.181
Speed of speech	-.704*	-.365
<i>Still picture variables</i>		
Mouth area	.583*	.217
Mouth height	.607*	.522
Mouth width	.384	.533

$p < .05$. ** $p < .01$.

liminary comparisons with the findings of a previous study of the contribution of speech variables to visual intelligibility (Daly et al., 1996c). A principal components analysis with varimax rotation was conducted on the five moving picture variables (visible tongue movement, teeth visibility, lip rounding, speed of speech, and eyebrow movement). Results showed two factors (Factor 1, eigenvalue = 2.311; Factor 2, eigenvalue = 1.322). The composition of the two factors was very similar to the analysis for talkers irrespective of gender reported by Daly et al. (1996c): lip rounding, teeth visibility, and speed of speech loaded on Factor 1 (previously labelled the Speed Factor), and visible tongue movement and eyebrow movement loaded on Factor 2 (previously labelled the Tongue-Plus Factor). Thus Factor 1 was labelled the "Female Speed Factor," and Factor 2 the "Female Tongue-Plus Factor."

Simple correlations between individual still picture measurements and mean speechreading score showed significant positive correlations with the mouth area and mouth height of female talkers (see Table 3). One factor (eigenvalue = 2.197) was found when principal components analysis was conducted on the three still picture variables for female talkers. This factor was similar to that previously labelled a Mouth Factor by Daly et al. (1996c), and was thus labelled the "Female Mouth Factor." Simultaneous multiple regression using the three factors (Female Speed Factor, Female Tongue-Plus Factor, and Female Mouth Factor) accounted for 77% of the variation in mean speechreading scores (see Table 4). This regression analysis also showed that the two moving picture factors each accounted for a significant level of unique variance in the mean speechreading scores.

Table 4
Multiple Regressions of Mean Speechreading Scores
Against Still Picture Factors and Moving Picture Factor for Female and Male Talkers

Variables	Beta	R ²	Adjusted R ²	F	df
<i>Female talkers</i>					
Female Speed Factor	.82**				
Female Tongue-Plus Factor	.82**				
Female Mouth Factor	.32				
All three factors		.84	.77	13.54**	3, 8
<i>Male talkers</i>					
Male Visual Intelligibility Factor	.65*				
Male Unrelated Factor	.05				
Male Mouth Factor	.43				
All three factors		.71	.61	6.68*	3, 8

* $p < .05$. ** $p < .01$.

Male Talkers

Simple correlations between the mean speechreading scores and measurements of each of the eight speech variables demonstrated that, of the moving picture variables, only visible tongue movement and teeth visibility correlated significantly with the mean speechreading score (see Table 3). Mean speechreading score increased with increased visible tongue movement and teeth visibility. Thus the moving picture variables that may be regarded as strongly predictive of mean speechreading scores for male talkers were visible tongue movement and teeth visibility.

Two factors were identified by principal components analysis conducted on the five moving picture measurements for male talkers (Factor 1, eigenvalue = 2.253; Factor 2, eigenvalue = 1.307). Lip rounding, speed of speech, and eyebrow movement loaded on Factor 1, and visible tongue movement and teeth visibility loaded on Factor 2. Factor 1 consisted of the moving picture variables that did not correlate significantly with the mean speechreading score of male talkers, and Factor 2 consisted of the two moving picture variables (teeth visibility and visible tongue movement) that did correlate significantly with the mean speechreading score of male talkers. Thus Factor 1 was labelled the "Male Unrelated Factor" and Factor 2 was labelled the "Male Visual Intelligibility Factor."

Simple correlations between the mean speechreading score and measurements of each of the three individual still picture variables demonstrated that neither mouth area, mouth height, nor mouth width, correlated significantly with the mean speechreading score for male talkers (see Table 3). A principal components analysis was conducted on the three still picture variables (mouth area, mouth

height, mouth width). Results showed one factor (eigenvalue = 1.808) which was labelled the "Male Mouth Factor." In multiple regression the three factors (the Male Unrelated Factor, the Male Visual Intelligibility Factor, and the Male Mouth Factor) accounted for 61% of the variance in mean speechreading scores for male talkers (see Table 4). This regression analysis also showed that only the Male Visual Intelligibility Factor accounted for a significant level of unique variance in the mean speechreading scores ($p < .05$).

In summary, the three factors identified as contributing to the visual intelligibility of female talkers were: a Female Speed Factor and a Female Tongue-Plus Factor from moving picture variables, and a Female Mouth Factor from still picture variables. These three Factors explained 77% of the variance in the mean speechreading scores for female talkers.

Three factors were also identified in the speech variable measurements for male talkers: the Male Visual Intelligibility Factor and the Male Unrelated Factor from moving picture variables, and the Male Mouth factor from still picture variables. Together, these three factors accounted for 61% of the variation in mean speechreading scores for male talkers.

DISCUSSION

The results suggested three areas of measurable difference in visual speech which may account for the superior visual intelligibility of female talkers. Firstly, female talkers spoke in ways which have been shown to improve visual intelligibility. Daly et al. (1996c) showed that teeth visibility, visible tongue movement, lip rounding, mouth area, mouth height, and mouth width correlated positively with visual intelligibility. Speed of speech was shown to correlate negatively with visual intelligibility. In the present study the only speech variable that showed a significant gender difference was lip rounding. Thus the superior visual intelligibility of female talkers may be explained by their use of significantly more lip rounding. As discussed earlier, a number of studies have shown that, among children, girls used superior articulation (e.g., Johnson & Somers, 1979; Kenney et al., 1984). The present study has indicated that adult female talkers also use superior visual articulation.

As previously mentioned, gender differences in teeth visibility, speed of speech, mouth area and mouth height just failed to achieve statistical significance. However in all cases the gender difference favored female talkers' visual intelligibility. Future studies with larger sample sizes may show these differences to be significant, and thus add to the explanation for superior female visual intelligibility. For example, female talkers were found to talk more slowly than male talkers. In their study of speech rates of monolingual Anglo-Australian adults aged between 21 and 30 years, Block and Killen (1996) found no evidence of gender differences. The suggestion of a gender difference shown in the present study may have been due to the older age of the talkers (mean age 37.9 years) in

the present study as compared with the talkers in Block and Killen's study. That is, although there do not appear to be gender differences in the speed of speech of young Australian adults, it is possible that there is a gender difference for middle-aged talkers. Alternatively, female talkers may have been more willing or more able to adapt their speed of speech for a task which they knew would be used for speechreading. This explanation is supported by a number of sociolinguistic studies showing that women are more cooperative than men in conversation (see Coates, 1993 for a review of this area).

A second aspect of the results that may explain the gender difference in visual intelligibility is that more speech variables correlated significantly with the visual intelligibility of female talkers than male talkers. Visible tongue movement, speed of speech, mouth area, and mouth height were significantly correlated with mean speechreading score for female talkers. However, for male talkers, only teeth visibility and visible tongue movement were significantly correlated with mean speechreading scores. When the three factors (two moving picture factors and one still picture factor) identified for female and male talkers were used in a simultaneous multiple regression analysis, they accounted for more of the variation in the mean speechreading scores of female talkers than they did for male talkers (77% and 61% respectively). This implied that the visual cues used by female talkers were more relevant to visual intelligibility than those used by male talkers. However, it may also be because women used more of all the countable moving picture variables, thus making their speech easier to speechread. Because of the small number of talkers in this study, further studies are required using larger sample sizes in order to validate the proposed explanation.

The third aspect of the results which may explain gender difference in talker visual intelligibility is the similarity of the three factors identified for female talkers in the present study with the three factors identified for talkers regardless of gender in a previous study (Daly et al., 1996c). This similarity suggested that female talker visual intelligibility is a reflection of the norm or the standard for visual speech. In sociolinguistic studies it has been repeatedly shown that, when there are phonological variants in a language, women more often choose the form closer to the prestige or "correct" way of talking than do men of the same social class, age, and level of education (Holmes, 1992). There is evidence that Australian women also follow this trend in their language use (see Pauwels, 1987 for a review of this literature). Possibly females' more standard use of visual speech variables made their utterances comparatively easier to predict, and hence easier to speechread.

A study by Gagné, Masterton, Munhall, Bilida, and Querengesser (1994) showed that some talkers are unable to improve the clarity of their speech spontaneously. In planning an approach to work with the frequent communication partners of individuals with hearing impairment, the clinician may wish to start with a focus on speech variables particularly relevant to the gender of the talker.

It may be that clinicians will be more effective in their work with the frequent communication partners if they are able to concentrate on specific speech variables that have been shown to be poorly used by talkers of a particular gender. For example, they may wish to work with speed of speech with male talkers, and teeth visibility with female talkers. However, if these speech variables need no improvement, other speech variables shown to contribute to visual intelligibility can be addressed. It is unknown whether therapy focusing on specific speech variables will be successful in improving the visual intelligibility of talkers. It is possible that it may be quite inappropriate, or that the success of such an approach will vary between individual talkers. These questions remain to be investigated.

In conclusion three explanations for the gender difference in talker visual intelligibility are suggested: (a) female talkers speak in ways that improve visual intelligibility, (b) more of the visual speech variables of female talkers are correlated with visual intelligibility, and (c) female talkers' visual speech follows a standard pattern which may make their visual speech easier to follow. Future studies using a larger sample of talkers should be conducted to examine the validity of these proposed explanations. Nonetheless these findings are evidence that not only do women differ from men in the auditory language they use, but they also have visually different ways of producing speech.

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