

MALE VS. FEMALE PITCH RANGE IN DUTCH QUESTIONS

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ABSTRACT

This study focusses on possible sex-related differences in pitch range in Dutch questions. In the literature, it has been claimed that female intonation patterns are more varied and more expressive than those of men. This suggests that female pitch ranges are wider than male, but studies on pitch range do not consistently corroborate that. However, these studies concentrate on declarative speech, as well as on global pitch range. We hypothesised that, in *questions*, female ranges are wider as women have been reported to be more directed towards establishing interaction. For this, asking questions is an important tool and it is likely that women mark their questions by at least *locally* widening their pitch range, i.e. in accents and final rises. Examination of read and spontaneous questions showed that, on the whole, female ranges were wider than those of men, not only locally but also globally.

1. INTRODUCTION

In the literature, it has often been put forward that male and female speech differ in several respects. At the same time, it has also been pointed out that, of old, opinions on the subject have been powerfully coloured by stereotyped ideas. As a result, it is sometimes difficult to tell facts from fiction [1]. Nevertheless, with respect to a small number of sex-related speech differences the results of empirical studies seem to converge. Thus, apart from being higher pitched for anatomical/physiological (as well as cultural [2]) reasons, female speech has been shown to be more expressive, more involved, more listener-directed and more standard than male speech [3]. Specifically, female intonation patterns have been claimed to be more varied and more expressive [3,4]. It seems plausible for the two latter properties to be cued by a wider pitch range. In acoustic terms, 'more varied' may be taken to mean greater variation around the average pitch. 'More expressive' may be expected to show up as larger pitch intervals and hence as, again, greater variation around the average pitch. In other words, one would expect female speech to display wider pitch ranges.

Pitch range can be defined as the difference within an individual speaker between the highest and the lowest pitch within a given set of F_0 measurements. In order to rule out possible outliers, the measure of pitch range is frequently based on the central 90% or 95% of the whole distribution, with 5% or 2.5% of both the upper and lower measurements being excluded.

2. PITCH RANGE

2.1 Previous work: crosslinguistic

Judging from the general characteristics of female speech as presented in the literature, one would expect women to produce wider ranges. However, a comparative survey of 17 studies on

pitch range in males and females reported the opposite [1]. In order to ascertain whether the alleged 'swoopiness' of female speech is reality or merely a stereotypical idea, the author transformed the results of these 17 studies from linear hertz values into logarithmic semitones. This enabled her to compare the male and female ranges in terms of perceptually realistic units (ST), and to conclude that 'it is the males who generally have a greater pitch range than females have'. However, some caution is called for here, as the author herself points out. In fact, the 17 studies were fairly heterogeneous in that they comprised semi-spontaneous as well as read speech, and isolated vowels as well as stretches of text. Besides, the subjects were speakers of different languages/varieties, i.e., American English, British English, Polish, and Swedish. Also, in only five out of the 17 studies had the data been collected from both sexes; the other studies were either concerned with male or with female range. In the majority of the studies, there was no guarantee that the subjects had been selected with a view to homogeneity as to age, educational background, etc. Finally, it was not always clear whether the results were based on the entire pitch range or on the middle 90% or 95%. Obviously, these imbalances between the 17 studies detract from the strength of the conclusion that the male pitch range is generally the wider of the two. Therefore, Henton also carried out an experiment herself. She compared the pitch ranges of a homogeneous group of five North American men and five comparable women who read out 90 sec of speech. Taking the central 95.4% of the speakers' F_0 distribution into account, she found a slightly wider range for males in one condition, the reverse in the other condition; the differences were not significant. This led her to relegate the claim, that female speech is 'swoopy' in terms of pitch range, to stereotypical views.

2.2. Previous work: Dutch

As far as Dutch is concerned, four recent studies compare female and male pitch ranges in spontaneous, semi-spontaneous and read stretches of speech. In none of these studies were significant sex-related differences in pitch range found. In [5], read and spontaneous speech utterances of 10 men and 10 women were investigated. In [6], the same was done with respect to read and semi-spontaneous speech of 25 men and 25 women. In part of the material, females displayed a wider pitch range than did males; in another part, however, the reverse was found. Also, there were no significant differences in the size of the excursions of the pitch accents. [7] compared spontaneous conversations across the sexes (57 men, 57 women), and found no significant differences. Similarly, in [8] the differences in range between four men and four women (semi-spontaneous speech) fell short of significance. These results on Dutch seem to suggest that Henton was right in concluding that differences between male and female speech as

posited in the literature do not correspond to differences in pitch range.

3. PITCH RANGE AND QUESTIONS

3.1. Sex-related communicative behaviour

However, there are two reasons why such a conclusion may be premature. First, the studies mentioned above predominantly dealt with *declarative* speech and the question arises whether the results will be the same in *interrogative* utterances. There is empirical evidence that the communication patterns of men and women have different characteristics. Men have been reported to be more direct and assertive, and to prefer making statements and carrying out tasks; on the whole, their communicative behaviour aims at 'agency'. Women, by comparison, are more inclined to strive for 'communion'; they are more personally involved and this is reflected in more emotional expression and a greater inclination to listen [9,10]. Also, men and women are reported to adopt different strategies to influence other people. Women are less afraid to ask for help or to reveal lacunae in their knowledge or information [10]. To sum up, female communicative behaviour is generally associated with a greater preparedness to show emotions as well as dependence; primarily, it is directed towards interaction.

Among the communicative functions of speech, interrogativity is pre-eminent in establishing interaction. Given the sex-related differences in communicative behaviour, it seems likely that sex-related differences in intonation patterns will show up more strongly in interrogative speech than in declarative speech. Not only can women be expected to be more prone to asking questions than men, they are also more likely to make maximal use of the intonational devices that go with questions, so as to leave no doubt about the interrogative status of the utterance. Crosslinguistically, interrogativity is cued by high pitch, e.g. by a terminal rise or by other high-pitched elements earlier in the utterance [11]. This predominance of high pitch in questions has been attributed to the existence of a 'frequency code' according to which high tone encodes dependence, low tone dominance [12]. If women are less afraid than men of showing the dependence of questioning, we hypothesize that their questions display a relatively larger proportion of high pitch. That is, we predict that, notably in questions, local pitch movements marking pitch accents and prosodic boundaries (final rises) will have larger ranges in women than in men.

3.2. Global versus local pitch range

This brings us to the second argument against straightaway embracing Henton's rejection of sex-related differences in pitch range. Not only did the studies carried out so far concentrate on *declarative* speech, they also mainly investigated *global* pitch range, that is, range was expressed as the difference of maximal and minimal F_0 across a given stretch of speech. In our approach utterances are broken up into *local* tone configurations (pitch accents, final boundary tone), the individual range of each of which is then compared across the sexes. Obviously, global measures are related to local measures. Nevertheless, by differentiating between the two we hope to pinpoint possible local differences in range that fail to show up in the global measure.

4. METHOD

4.1. Material

The material consisted of a controlled corpus of 800 Dutch utterances, that is, two basic *declarative* utterances (with two potential accent locations) together with their interrogative versions. The latter came in three types: *wh-questions*, formally marked by a question word and subject-finite inversion, *yes-no questions*, marked by inversion only, and *declarative questions*, formally identical to the statement version. Five men and five women, all native speakers of Standard Dutch and sharing an academic-linguistic background, twice read out the eight different sentences, in isolation as well as in pairs (i.e. preceded or followed by an utterance providing a context). They aimed at a maximally natural rendering. This resulted in 200 statements, 200 *wh-questions*, 200 *yes-no questions* and 200 *declarative questions*. F_0 was automatically extracted (see [11]); in each utterance, the rise-fall configurations of the two pitch accents and the question-words (if present) were interactively stylized, as were the final rises. F_0 measurements were made of (i) the beginning of the accentual rise; (ii) its peak, and (iii) the end of the accentual fall. In the question words, the same three measurements were made. No value was entered when a rising or falling part was absent. Of the final rises, the lowest and highest F_0 was measured. All values were expressed in ERB (Equivalent Rectangular Bandwidth), which affords equal or even better perceptually realistic cross-sex pitch comparison than the semitone scale [13,14].

4.2. Results

We calculated the values of the four utterance types on each of the following local and global parameters, broken down by sex:

1. Global: overall range of the entire utterance *excluding* the final rise (OR);
2. Local: range of the final rise (FR, only in questions);
3. Local: range of the accent on the subject (SUB)
4. Local: range of the accent on the object (OBJ);
5. Local: range of the (initial) question word (WH, only in *wh-questions*);
6. Semi-local: difference between accent ranges OBJ and SUB (Δ AR)

Figure 1 (see below) gives the means of the frequency/time coordinates of the F_0 pivot points mentioned in 4.1, broken down by sex and presenting four prototypical intonation contours. Within each utterance type, the overall shapes of the male and female contours appear to be highly similar, at least in terms of rises and falls. Nonetheless, there are considerable quantitative differences, as Table 1 shows.

Table 1. Differences in pitch range (ERB) between women and men on six local, semi-local and global measures (see text), broken down by utterance type. A positive difference indicates a larger range in women. **: $p \leq 0.01$; ***: $p \leq 0.001$ (two tailed t-tests)

UTT. TYPE	OR	SUB	OBJ	FR	Δ AR	WH
stat.	0.86**	0.31**	0.52**		0.21	
wh-q.	0.15	0.13*	-0.19	0.59**	-0.29	-.010
y/n-q.	0.65**	0.04	0.51**	0.63**	0.45**	
decl-q.	0.80**	0.11	0.78**	0.50**	0.67**	

In the *statements* realized by the women, the local ranges of both pitch accents (SUB, OBJ) are larger than those of the men; the global range is also significantly wider. In the *wh-questions*, there are significant differences in the ranges of SUB and the final rise. In *yes-no questions*, women have significantly larger local ranges of final rise and OBJ; the same holds for the overall range. The *declarative questions* show significantly larger female ranges in four of the five relevant measures: final rise, range of OBJ, semi-local range of Δ AR and overall range.

5. DISCUSSION

The results show that, on 13 of the 20 measures, the female range is significantly wider than its male counterpart. The differences show up strongest in the yes-no and declarative questions, notably on the parameters FR (final rise), OBJ (range of accent on object) and OR (overall range). The only parameter on which no significant difference was found is WH (local range of the question word). Starting with the range of final rises, the finding that in all three question types the sexes display significant differences is interesting, since wh-questions have been claimed to lack a final rise (e.g. [15]). Here, a final rise would seem redundant as the interrogative status is already signalled by the question word, as well as by inversion. Nevertheless, as Figure 2 shows, both men and women frequently produce a final rise in wh-questions. Note also that, in all three question types, women make more rises than men. Final rises have often been called the intonational hallmark of questions. Our finding that the female final rises are more frequent as well as higher than the male supports our hypothesis that women exploit the intonational devices of questioning more extensively than men do.

Second, in three of the four utterance types did the women produce larger ranges on the second accent, the object (OBJ). In the yes-no and declarative questions, this did not come as a surprise. Earlier we found that, in these question types, ranges of this accent were considerably larger than in the statement versions, whereas in the first accents (SUB) they were often smaller [16]. This produces a sort of 'upstep' in pitch between the first and second accent, lending more prominence to the constituent that is being questioned (i.e. the *comment*). In females, this upstep is significantly larger (Table 1, Δ AR). However, the finding that female SUB and OBJ are also significantly larger in statements is somewhat surprising, given earlier reports in the literature. Yet it might, in part, explain why their speech creates an overall impression of being more lively, which is in line with empirical findings. It should be noted that, in statements, the female upstep is *not* significantly larger; this phenomenon only occurs in the two question types. Finally, compared with the overall intonation patterns of yes/no-questions and declarative questions, wh-questions are clearly different (Figure 1). Characteristic properties are a strikingly narrow global range as well as an overall downward trend of F_0 . These features follow from the accentuation pattern typical of this question type, which is governed by focus on the initial wh-word. As a consequence, the accentual weight is shifted onto the first half of the utterance, whereas in the other two question types it rests on the second half, which accounts for their globally upward trend (grey areas in Figure 1).

As regards the third main parameter, overall range, women and men also differed significantly, again not just in two of the

three question types but also in statements. Clearly, sex-related differences in range need not be restricted to interrogative speech.

On the whole, the sex-related differences are largest in the declarative questions. This question type depends entirely on intonation for it to be interpreted as a question. Earlier, we found that in this question type realizational means are maximally employed, as compared with the pragmatically similar yes-no questions [11]. Breaking up these results by sex, it now appears that women are in fact largely responsible for this phenomenon.

Summing up the results, we found local as well as global sex-related differences in pitch range in *interrogative* speech, which conformed to our hypothesis. To a lesser extent, such differences were also found in *declarative* speech; this did not quite conform to earlier studies comparing pitch range. Now the latter finding might be explained by the fact that the speakers were instructed to render the utterances as naturally as possible. This may have caused them to behave like actors in a radio play and the five female speakers may simply have made better actors. In order to check this possibility we also investigated pitch ranges in spontaneous questions which are, by definition, unpremeditated and do not invoke the speakers' histrionic talents.

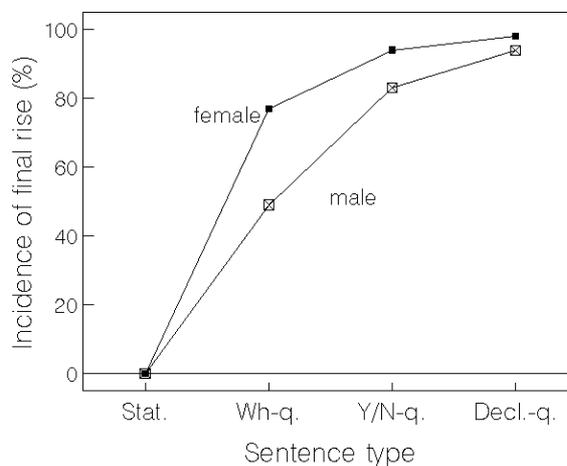


Figure 2. Occurrence (%) of final rises in statements, wh-questions, yes/no-questions and declarative questions, broken down by sex.

6. SPONTANEOUS QUESTIONS

6.1. Material and method

The material consisted of 153 utterances taken from ten doctor-patient consultations (five male, five female GP's, five male, five female patients), a type of conversation naturally conducive to the asking of questions. As the interactions, totalling two hours of spontaneous speech, were genuine it was not possible to influence the speakers with a view to obtaining similar numbers of each of the four desired utterance types. We ended up with 13 statements and 140 questions: 48 wh-questions, 74 yes-no questions and 18 declarative questions. Apart from this quantitative imbalance, there was also unevenness of the material with respect to utterance length, number of pitch accents, technical quality, etc. Of each utterance, the same measurements were made as in the read material. (for details, see [17])

6.2. Results and discussion

Taking together the three question types it becomes obvious that, again, the range of the female final rises (FR) is significantly larger than that of the men: $t(86)=2.91$ ($p<0.005$). As for the individual question types, here the difference reaches significance only in the yes-no questions, probably because of the relatively low occurrence of the other two question types. Also, the spontaneous questions turn out to have fewer final rises than the read ones, presumably because in conversation context as well as non-verbal cues play roles of their own. As the spontaneous questions differed with respect to the number of accents, we concentrated on the range of the only or the main pitch accent. As in the read speech, the effect of sex was significant: female ranges were considerably larger than male; $t(138)=4.34$ ($p<0.001$). Among the three question types, the difference was only found to be significant in the yes-no questions, probably again due to an underrepresentation of the other types; $t(72)=5.17$ ($p<0.001$). Though the spontaneous corpus was smaller and, inevitably, not as well-balanced as the read corpus, the local ranges of women were found to be almost large as wide as those of men. Obviously, these results cannot be put down to play-acting.

7. CONCLUSION

Given earlier findings that the communicative behaviour of women is conducive to asking questions, we expected women to rely more strongly on intonation for conveying interrogativity than men. One way of achieving this is by widening the pitch range at local points in the utterance. Due to their focus structure, questions are more prone to such local variation than statements. Our results bore out this expectation; what is more, even in declarative speech were women found to have larger ranges, locally as well as globally. It was also shown that sex-related differences in pitch range are not restricted to read speech. The differences might well account for the greater liveliness and variety of intonation patterns attributed to women by the literature.

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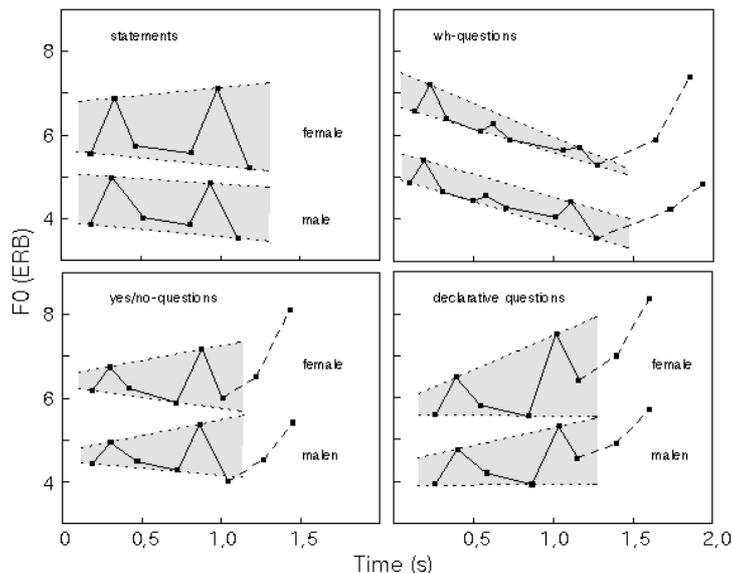


Figure 1. F_0 pivot points (ERB) in pitch accents, final rises and question words in four utterance types, broken down by sex. Each dot represents the mean of nominally 100 F_0 measurements

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