# PERCEPTUAL CHARACTERISTICS OF VOICE QUALITY IN DUTCH MALES AND FEMALES FROM 9 TO 85 YEARS

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## ABSTRACT

This study provides a voice quality description of 180 Dutch speaking men and women from 9 to 85. The description was focused on voice characteristics such as pitch, tempo, and whisper. Computed were correlations among age and voice quality, and the mutual correlations among the voice characteristics. Finally, it was investigated how well age can be predicted on the basis of voice quality characteristics.

## INTRODUCTION

Voice quality is the overall auditory colouring of an individual speaker's voice to which both laryngeal and supralaryngeal features contribute [1]. Disciplines such as speech pathology, psychology and psychiatry have studied this topic for a long time. Voice quality in normal speech, however, has been neglected, in foreign and Dutch studies alike. Voice quality studies that have been carried out are limited in sex [2, 3, 4, 5, 6, 7, 8], age [9, 2, 6, 8, 5], and voice quality characteristics described: mostly only pitch [2, 3, 6, 7, 4, 8]. Furthermore, most research has been conducted on the basis of reading texts. The aim of this study is to gain insight in the voice quality parameters in Dutch on the basis of spontaneous speech. The central questions are:

1. What is the correlation between age and voice quality parameters?
2. What is the relation between sex and voice quality parameters?
3. What is the mutual correlation between different voice quality parameters?
4. How well can age be predicted from voice quality parameters?

## METHOD

Non-pathological speech of men and women from 9 to 84 was recorded. Eighteen age categories were distinguished: 9-10, 11-12, 13-14, 15--16, 17-19, 20-24, 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, 55-59, 60-64, 65-69, 70-74, 75-79, and 80-84. Five speakers were selected per sex and per age category. This resulted in 90 speakers for both sexes. Generally, each age category stretched over a period of five years. However, for the younger speakers (9 to 19) the interval was smaller because the breaking of the voice for boys, can be very sudden, whereas the exact moment can vary.

Because it is as yet unknown to what extent voice quality differs for different regional and urban varieties of Dutch, we restricted the description to speakers of Standard Dutch. The material consisted of 45 sec semi spontaneous descriptions of drawings depicting daily events or of spontaneous speech about topics like the speaker's eating habits.

The speech was scored on 21 voice quality parameters. The voice protocol was an extended version of the one described in [10]. The speech aspects covered by the scales were: prosodic aspects, temporal organization, articulation, and phonation. Two types of scales were used: 7-point scales and 4-point scales. The, bipolar, 7-point scales relate to intrinsic parameters of the speech signal that can take different values, e.g. pitch. They go from one extreme (-3) via a neutral reference point to the opposite extreme (+3). The, unipolar, 4-point scales rate features from absent (0) to strongly present (+3); these parameters can only depart from the neutral point of reference into one direction, e.g. harshness. The scales used in this description only cover the non-pathological area of speech. The scales are:

1. pitch (pit): impression of average pitch level, related to speaker's sex (7-point scale)
2. pitch range (prn): distance between the lowest and the highest pitch (7)
3. pitch variance (pva): frequency and/or strength of pitch changes (7)
4. stress (str): frequency and/or strength of accents (7)
5. tremulousness (tre): trembling quality (4)
6. fluency (fln): fluency degree (4)
7. pauses (pau): frequency and/or duration of silent intervals (7)
8. tempo (tem): speech rate (7)
9. tempo variance (tva): frequency and/or amount of rate changes (7)
10. effort (eff): loudness impression (7)
11. effort range (ern): distance between the softest and loudest utterance (7)
12. effort variance (eva): frequency and/or strength of loudness changes (7)
13. precision of articulation (art): extent to which the target positions of the distinct speech sounds are reached
14. whisper (whs): amount of escaping air through the glottis (4)
15. harshness (har): rough and rasping quality - aperiodic vibration (4)
16. creak (cre): discrete pulses can be perceived in phonation (4)
17. sonority (son): extent to which voice sounds superficial/sharp or warm/resonant (7)
18. tension (ten): impression of the muscle tension in the vocal folds (7)
19. audible breath (bre): amount of audible inadequate breathing (4)

The speech parameters were rated by the authors and a speech therapist. A consensus description was made: the scores were compared and, if possible, adjusted if the scores on a scale differed more than one scale position. The percentage adjusted scores for all raters per scale was less than 5%. On average, the percentage adjusted scores was 2.4%.

## RESULTS AND DISCUSSION

### Correlations between age and voice quality parameters

To gain insight into the coherence between the speakers' age and the 19 voice quality parameters Pearson product-moment correlations were calculated.

The older men and women get (table 1), the lower their perceived pitch becomes and the more creaky and sonorous their voices sound. Age related pitch has been studied rather extensively. It appears that fundamental frequency (F0) of babbling babies, is

*Table 1. Correlations between the speaker's age and the 19 voice quality parameters. Significant r-values at .01 (two-tailed) are printed in bold.*

| | ♂ | ♀ | ♂ + ♀ |
|---|---|---|---|
| pit | **-.46** | **-.31** | **-.38** |
| prn | -.10 | .21 | .05 |
| pva | -.21 | .10 | -.06 |
| str | -.20 | .20 | -.01 |
| tre | .23 | .14 | .19 |
| fln | -.18 | **-.28** | **-.23** |
| pau | .25 | .14 | .19 |
| tem | **-.28** | -.19 | **-.23** |
| tva | .25 | **.30** | **.27** |
| eff | .01 | .09 | .05 |
| ern | .11 | .22 | .16 |
| eva | .07 | .23 | -.15 |
| art | -.02 | **.32** | .14 |
| whs | .11 | -.15 | -.03 |
| har | .01 | .02 | .02 |
| cre | **.41** | **.41** | **.40** |
| son | **.45** | **.28** | **.35** |
| ten | .06 | -.19 | -.08 |
| bre | **.40** | .23 | **.31** |

about 400 Hz [9]. Till puberty there is no difference between both sexes, F0 being about 200 to 250 Hz [8]. Then pitch lowers till adulthood is attained: F0 for adult males becomes approximately 100 Hz but shifts upward from about 65 years [3, 5] and F0 for adult females decreases to approximately 190 Hz with no further systematic change [11, 12]. This U-shaped curve is also observed in our data: till the age of about 20 perceived pitch decreases, till about 50 to 60 it stays more or less stable to shift upwards from about 60, especially for men. This U-curve masks the linear correlation till about 60 years and probably causes the low r-values. Calculating correlations omitting all speakers over 60, indeed causes higher r-values, viz -.69 for men (for whom the U-curve was observed), -.54 for women and -.61 for all speakers.

At the same time both creak and sonority correlate positively with age. This is not surprising, since for both sexes these parameters show a (fairly high) significant correlation with pitch (table 2). As for creak, the increase with age could be explained in physiological terms, related to a change in the vibration of the vocal folds. It might also be possible that older speakers adapt to socially based, stereotypical ideas about how the voice of an older person is expected to sound.

*Table 2. Correlation matrix for men (upper right half) and women (bottom left half). Significant r-values at .01 are printed in bold. The decimal dot is omitted.*

| ♂ / ♀ | pit | prn | pva | str | tre | fln | pau | ten | tva | eff | ern | eva | art | whs | har | cre | son | ten | bre |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pit | 1.0 | 33 | 41 | 19 | 03 | -16 | -02 | 08 | -28 | 03 | -30 | -12 | 00 | 08 | 38 | -60 | -68 | -45 | 04 |
| prn | 25 | 1.0 | 74 | 46 | 02 | 02 | 05 | 07 | 25 | 13 | 29 | 25 | -04 | 14 | 22 | -17 | -26 | -27 | -01 |
| pva | 32 | 76 | 1.0 | 48 | -01 | -01 | -15 | 22 | 14 | 16 | 22 | 23 | -10 | 09 | 25 | -19 | -31 | -19 | -11 |
| str | 05 | 37 | 44 | 1.0 | 01 | -04 | -10 | 17 | 09 | 40 | 34 | 39 | 14 | 02 | 25 | -20 | -36 | -15 | -23 |
| tre | 17 | 17 | 17 | 10 | 1.0 | 11 | 09 | -11 | -13 | 08 | -09 | -02 | -11 | -00 | 05 | 20 | 12 | -08 | 20 |
| fln | 25 | 12 | 23 | 14 | 00 | 1.0 | 07 | -08 | -11 | -05 | 11 | -10 | -25 | 01 | -11 | 09 | 02 | 14 | -18 |
| pau | -02 | 06 | -05 | 22 | 03 | 03 | 1.0 | -38 | 07 | -14 | 06 | -10 | -02 | 11 | 07 | 04 | -06 | -08 | 09 |
| ten | 10 | 10 | 16 | -19 | 04 | 07 | -50 | 1.0 | 12 | 15 | 12 | 23 | -16 | 05 | -10 | -19 | -12 | 12 | -11 |
| tva | -05 | 37 | 42 | 36 | 04 | 17 | 03 | -01 | 1.0 | 14 | 47 | 46 | -00 | 21 | -05 | 08 | 13 | -02 | -17 |
| eff | 24 | 12 | 28 | 41 | 22 | -05 | 01 | 04 | 19 | 1.0 | 28 | 29 | 07 | -11 | 23 | 03 | -13 | -09 | -02 |
| ern | 03 | 41 | 45 | 39 | 22 | 14 | 12 | -01 | 56 | 32 | 1.0 | 73 | 11 | 04 | -07 | 09 | 07 | 10 | -06 |
| eva | 05 | 46 | 51 | 49 | 16 | 02 | 08 | -00 | 59 | 47 | 78 | 1.0 | 16 | 07 | 03 | -05 | -07 | -11 | -08 |
| art | -10 | 25 | 15 | 27 | -07 | -10 | 28 | -26 | 19 | 33 | 14 | 22 | 1.0 | -18 | 08 | -11 | 01 | 11 | -10 |
| whs | -00 | -09 | -15 | -04 | -08 | 02 | 10 | -03 | -16 | -32 | -10 | -13 | -08 | 1.0 | 30 | 03 | -34 | -61 | 32 |
| har | 32 | 07 | 05 | -07 | 29 | 21 | 11 | 04 | -04 | 05 | 05 | 02 | -39 | 05 | 1.0 | -09 | -31 | -49 | 18 |
| cre | -28 | 03 | 06 | 06 | 11 | 02 | 04 | -07 | 31 | 16 | 26 | 25 | 13 | -14 | -05 | 1.0 | 42 | 10 | 13 |
| son | -69 | -24 | -26 | 01 | -13 | -32 | -04 | -28 | -04 | -05 | -07 | -05 | 22 | -16 | -47 | 25 | 1.0 | 66 | 05 |
| ten | -37 | -07 | -03 | -08 | -28 | -12 | -24 | -03 | -02 | -03 | -05 | -07 | 15 | -50 | -59 | 05 | 55 | 1.0 | -24 |
| bre | -12 | -02 | -11 | -04 | 10 | 02 | 03 | -00 | 00 | -09 | -00 | -06 | 08 | 31 | -31 | 10 | -03 | -19 | 1.0 |

## Interrelationship among the voice quality parameters

To get a clearer picture of the interrelationship among the different voice quality parameters, factor analyses were conducted. Factor analysis was succesful for the male speakers, but failed for the female speakers because communality of a variable exceeded 1.0. Therefore we present the correlation matrix (table 2).

Seven factors could be extracted for the male speakers, four of which exceeded an eigenvalue of 1.0. These four factors, explaining 45% of the variance, are a) laryngeal voice quality with high loadings of tension, whisper, harshness, and audible breath; b) prosodic variation with loadings of effort range, effort variance, and tempo variance; c) pitch variation with loadings of pitch range and pitch variation, and d) pitch with loadings of sonority, creak and pitch. These factors explained 18.4%, 13.1%, 8.2%, and 5.3% of the variation respectively. Inspection of the correlations for the women in table 2, reveals similar sets of correlating parameters.

## Multiple regression

In order to know how well age can be predicted on the basis of voice quality parameter, we performed a stepwise multiple regression analysis. The powerfull predictors for the male speakers were: pitch, audible breath, pauzes, fluency, tension and sonority, which explained 60% of the age variance. In predicting women's age only 48% of the age variance could be explained by the predictors creak, fluency, articulation, harshness, audible breath, tempo variance and sonority.

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