Longitudinal trends in speech tempo:
The case of Queen Beatrix

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Abstract: Older talkers speak slower than young ones, but speech tempo has increased in the last decades. Have present-day older talkers slowed down with age or have they sped up with their community? This study investigates longitudinal patterns in articulation rate in formal speeches presented annually by Queen Beatrix between her ages 42 and 74. Her tempo decreased first and then increased in the last decade. Within a speech, acceleration and shortening increased longitudinally. These results suggest that this talker's preferred tempo has not decreased but increased longitudinally, presumably in accommodation to an increasing tempo in the Dutch language community.
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1. Introduction

Older talkers speak at a slower rate or tempo than young or middle-aged talkers.[1–3] This age-related decrease in speech tempo is correlated with age-related reductions of the talkers' articulatory and cognitive capacities.[3,4] In studies of age-related slowing, age groups were compared between talkers (in apparent time). Hence, the observed age effects might also have been due to other differences between younger and older talkers, such as the talkers' education levels,[5] utterance length,[6] and lexical diversity.[7] Thus the question remains whether the present-day older talkers do indeed speak slower than they themselves did at young or middle age.

An important additional factor to consider is the increase in the general pace of Western societies since 1945.[8] In 26 Dutch TV weather reports ranging from 1953 to 2013, for example, speech tempo was found to increase (by about 2% per decade, $p = 0.025, r^2 = 0.159$), while pausing decreased (by about 1% per decade, $p = 0.091, r^2 = 0.098$). Similarly, radio reporters in the 1990s spoke in a less formal style, and at a faster tempo, and with more filled pauses, than similar talkers did a few decades before.[9] This suggests an alternative pattern, viz., that the present-day older talkers are less susceptible to age-related slowing, because they attempt to speak as fast as they did at young or middle age (or even faster) in response to the generally faster tempo in their language community.

There are two approaches to disentangle the age-related decrease and historical increase in tempo. One is to compare similar speech materials collected under similar circumstances at different times from different talkers.[9] However, such materials are nonexistent because of confounding historical changes in speaking style (e.g., news bulletins and weather reports are now presented in a less formal style than before). The second approach is to compare similar speech materials collected from the same talkers at multiple times. A unique longitudinal series for this second approach is provided by the Dutch formal speeches annually read by Queen Beatrix (*Troonrede*). Because these *Troonredes* are always presented by the same talker in the same formal style for a similar audience, the confounding effects of talkers, speech styles, or recording circumstances are minimized. Beatrix's readings are available from her first

Troonrede in 1980 to her last one in 2012, a convenient span long enough to capture relevant age-related and historical trends.

The current study attempts to assess within-talker trends in speech tempo by comparing articulation rate in the *Troonredes* read by Queen Beatrix between 1980 and 2012. The main research question is whether the *Troonredes* are spoken at a decreasing tempo, corresponding to age-related slowing, or at an increasing tempo, as might be corresponding to a generally faster tempo in the Dutch language community.

2. Method

2.1 Materials

The speech materials for this study consist of nine Dutch annual *Troonredes*, from all leap years between 1980 and 2012. The *Troonrede* is a speech written by the ministers (members of government) describing the government's plans; it is read by the Queen (or King, head of government) at the annual opening of the parliamentary sessions in a formal and traditional entourage, always on the third Tuesday in September. Queen Beatrix (born 31 January 1938) was 42 yr old when reading her first *Troonrede* in 1980 and 74 yr when reading her last one in 2012. According to herself and to public sources, she was in good general health throughout this period.

Video recordings were obtained from various websites and from the Netherlands Institute for Sound and Vision in Hilversum, The Netherlands. The audio signal was captured or converted from these recordings and resampled to 16 kHz. Official transcripts of the speeches were obtained from web sources. Global properties of the *Troonrede* speeches are listed in Table 1.

2.2 Tempo measurements

The relevant prosodic information was extracted from each *Troonrede* wavefile by means of PRAAT[10] scripts. The first script[11] detected syllable peaks in the intensity contour (after filtering), requiring adjacent peaks to be separated by a dip of at least −3 dB. The second script was the pause-detection command included in PRAAT, used with an intensity threshold of −22 dB. All resulting fragment boundaries and detected syllables were verified and corrected manually. After combining the outputs, for each speech or pause fragment, the following information was available: Start time, end time, duration, and number of contained syllables (zero for pauses). The position of each speech fragment within a *Troonrede* was expressed as the 3-min period in which the fragment started, i.e., fragments with a start time between 0:00 and 3:00 were considered to be in period 1, etc. An untruncated 3-min period contained 62.0 speech fragments on average with little variation between years or between periods. The numbers

Table 1. Global characteristics of the Troonrede speeches: Year, date (in September of that year), talker's age (in years), number of words in transcript, number of detected syllables, total time (in seconds), pause time (s), articulation time (s), articulation rate (in syllables/s).

Year	Date	Age	No. words	No. syllable	Total time	Pause time	Artic time	Artic rate
1980	16	42	1875	3230	1017	306	711	4.52
1984	18	46	2233	4283	1418	472	946	4.54
1988	20	50	2669	4849	1520	429	1091	4.41
1992	15	54	3020	5759	1830	536	1294	4.35
1996	17	58	2676	5242	1717	501	1215	4.23
2000	19	62	2355	4753	1494	442	1052	4.50
2004	21	66	1895	3903	1237	383	854	4.61
2008	16	70	2000	3425	1111	326	786	4.28
2012	18	74	1556	3010	923	267	656	4.46

of syllables and total durations of speech fragments and of pause fragments are summarized in Table 1.

2.3 Data analysis

Speech tempo was assessed by means of articulation rate (AR) in realized syllables/s, for each speech fragment ("phrase" as determined automatically), excluding pauses. Outlier fragments with extremely slow (<0.95 syllables/s; $n = 9$) or fast AR (>7.92; $n = 4$) were excluded from further analysis. The phrase length or number of syllables[6] in a phrase was included as a covariate. Phrases were excluded if they were extremely long (>27 syllables; $n = 36$), and $n = 2$ fragments were left out because of measurement errors. In total, 51 (1.2%) phrases were excluded, with $N = 4109$ phrases remaining. The average AR of these remaining phrases is listed in Table 1.

ARs were analyzed by linear mixed-effects modeling[6,12,13] (LMM), with years as random units of sampling and using maximum likelihood estimation. In the first, simpler model (1), both the linear and quadratic effects of the 3-min period (centered to 3, median period of shortest *Troonrede*) were included as predictors. The number of syllables (log-transformed and centered to the log of 8, median number of syllables per phrase) was also included as a predictor. These three predictors were also included in the random part at the years level, yielding a "random slopes" model.[14] This LMM acknowledges that observations within a year may well be correlated, so that observations within a year may not be independent and that slopes may vary randomly between years (e.g., due to content and historical circumstances). The second, more complex model (2) contained the same fixed and random effects. Additional predictors were the linear and quadratic effects of year of speech (centered to the median year 1996). Interactions between phrase position and year, and between phrase length and year, were also included if they contributed significantly to the model; interactions that did not increase the model's performance were included only if they were involved in higher-order interactions. Raw data and scripts for analyses (with detailed specifications of the models) are available online at http://www.let.uu.nl/~Hugo.Quene/personal/troonredes. Fixed effects were evaluated by means of conservative *t*-tests, taking into account the numbers of observations and predictors.[15] The validity of the final model (2) was also assessed by means of diagnostic statistics and diagnostic plots of fitted values and residuals, which did not indicate any problems.

3. Results

The expanded model (2), which includes the linear, quadratic and interaction effects involving year, performs significantly better than the simpler model (1) without these terms. Model (2) yields a proportional reduction[14] of unexplained phrase-level variance of $R_1^2 = 0.026$ relative to the simpler model (1), and a proportional reduction of unexplained year-level variance of $R_2^2 = 0.282$. (Detailed LMM results are available online.)

First, the LMM shows a positive linear effect of within-year 3-min period ($\gamma_1 = +0.0638, t = 2.88, p < 0.0001$), as well as a negative quadratic effect ($\gamma_2 = -0.0066, t = -3.14, p < 0.0001$). Within each annual *Troonrede*, Queen Beatrix tended to first accelerate toward the third 3-min period and to decelerate afterward. Second, the LMM shows a positive quadratic effect of year ($\gamma_5 = +0.00088, t = 2.27, p = 0.0343$). Third, the linear effect of period also interacted with year ($\gamma_{14} = 0.0032, t = 2.66, p = 0.0319$). Figure 1 illustrates the combined linear, quadratic, and interaction effects of period and year on AR. In the first decades (darker lines), Queen Beatrix maintained a relatively constant AR within a *Troonrede*; between years the AR (centered to third period) tended to decrease. In the later decades (lighter lines), however, Queen Beatrix tended to accelerate within a *Troonrede* with an increasing amount of acceleration (increasing slope) over the years, so that between years the AR tended to increase again.

Fourth, there is indeed a main effect of phrase length ($\gamma_3 = +0.6874, t = 12.50, p < 0.0001$). Queen Beatrix' AR clearly shows anticipatory shortening, i.e.,
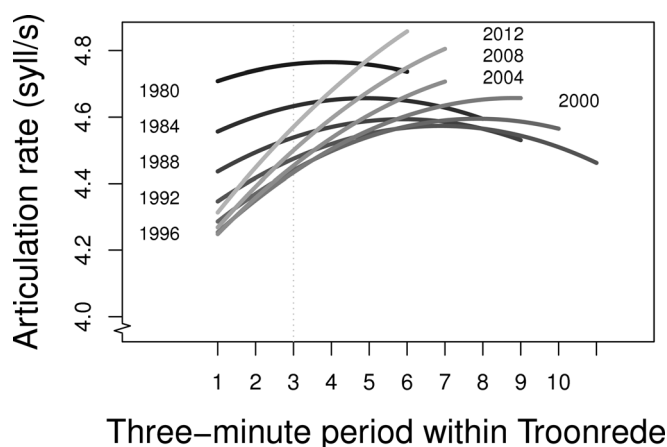
Fig. 1. Estimated articulation rates in syllables per second, broken down by year and by 3-min period within each *Troonrede* (centered to third period, marked with dashed line).

she reads longer phrases with faster AR. Fifth, this linear effect of length also interacted with year ($\gamma_{345} = +0.00013, t = 2.84, p = 0.0045$). The amount (slope) of anticipatory shortening started relatively low in the first *Troonrede* of 1980, then increased in the first decade and increased further again in the last decade.

4. Discussion

As usual in most speaking tasks, AR in the *Troonredes* varies greatly, depending mostly on the linguistic content of the phrases. The LMMs used here can only capture a small part of the overall variation in AR because of the absence of detailed predictors such as the phonemic content of each phrase, emphasis, etc. Nevertheless, the combination of within-year predictors (period, phrase length) and between-year trends allows us to assess and evaluate the longitudinal trends in AR of the *Troonredes*.

Most noticeably, there is only scarce evidence for age-related slowing in these unique materials. Although the longitudinal trends in AR suggest a small decrease in tempo in the first decades, this decreasing trend was halted and reversed in the last decade, a reversal that is not compatible with age-related slowing. Two other longitudinal trends in the *Troonrede* materials are also not compatible with age-related decline in speech tempo, viz., the longitudinal increase of acceleration during a year's *Troonrede*, as well as the longitudinal increase of anticipatory shortening or compression. The three trends together suggest that Queen Beatrix' speech tempo increased in later years even though she tended to start the later *Troonredes* at a somewhat slower AR than she did in earlier years.

The longitudinal increase in speech tempo may have been due to multiple factors. One factor may be the increasing speech tempo in the Dutch language community as illustrated in the preceding text by spoken weather reports. This first explanation assumes that Queen Beatrix has accommodated her speech tempo in reading the *Troonrede* to the overall speech tempo in the Dutch language community. This seems quite plausible because reading the *Troonrede* is intended to persuade both the members of Parliament and the general population to agree with its contents (i.e., with the government's plans) and because this persuasive goal may be helped by accommodating to the habitual tempo of the audience.[16]

Second, it could be argued that these longitudinal trends are not related to historical changes in speech tempo but that they are due to effects of learning and practice. With decades of experience in reading the annual *Troonrede*, Queen Beatrix may have learned over the years to accelerate more and to compress more. This second explanation may in fact overlap with the first one. With experience and practice,

Queen Beatrix may have learned better to achieve her goals, but presumably that goal is to persuade her audience rather than to speak as fast as possible. Thus learning and practice may have resulted in better accommodation.

Finally, one could also argue that these longitudinal trends may have been due to the particular circumstances of the particular *Troonrede* speeches in the sample (such as its authors or its length). The length could be important if the protocol would require a longer *Troonrede* to be read with a faster AR. However, the day's protocol explicitly allows the Queen as much time as she desires to read the *Troonrede* (Netherlands Government Information Service, personal communication), and reading a longer *Troonrede* does indeed take more time (see Table 1, $r = 0.96$). Moreover, years were included as higher-level random units in the LMM, allowing random variability among years in their intercepts and slopes (due to differences in authors, length, etc.). In other words, longitudinal trends must have been quite robust to achieve significance in the final model reported in the preceding text.

Is it remarkable that Queen Beatrix has adapted her speaking habits to speakers who are generally younger and less prestigious? Materials for comparison are necessarily scarce, but Queen Elisabeth II of the United Kingdom gradually changed her vowel formants toward Standard Southern British norms[17] between the 1950s and the 1980s, and Emperor Hirohito of Japan did reportedly[18] adapt his speech style to that of his lower-ranking listeners during countryside visits. These scarce findings suggest that Queens and Emperors are not immune to phonetic or stylistic accommodation toward the speaking habits in their environment.

5. Conclusion

In this unique case study, Queen Beatrix has shown only minor effects of age-related slowing in her readings of the *Troonrede* between 1980 and 2012 (ages 42–74). Instead, over the decades, the amount of acceleration within a year's speech has increased as has the amount of anticipatory shortening. These longitudinal trends are contrary to the natural and frequently reported tendency for older talkers to speak slower than they did before. The longitudinal trends may be explained by assuming that this unique talker is adapting to a generally increasing speech tempo in the Dutch language community in combination with Queen Beatrix' accumulated experience in successfully reading the *Troonrede* and other persuasive speeches.

Acknowledgments

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