FLUENCY AND SPEAKING FUNDAMENTAL FREQUENCY IN BILINGUAL SPEAKERS OF HIGH AND LOW GERMAN

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ABSTRACT

Studies on second language acquisition have shown that the use of a foreign language is often associated with lower fluency, higher pitch level, and reduced pitch span. This paper examines the question of whether low literacy skills in one's native language have similar effects on read speech. Using a within-speaker design, fluency measures and long-term distributional measures of pitch level and span were obtained for read speech from early High and Low German bilinguals who were less literate in Low German than in High German. Results indicate lower fluency and higher pitch level for Low German speech. Pitch span varied by gender. Males compressed it in Low German speech while females expanded it. These results suggest that low literacy skills in one's native language may have acoustic effects on read speech similar to those found in speaking a foreign language, and that gender should also be taken into account.

Keywords: pitch level, pitch span, fluency, literacy, bilingualism.

1. INTRODUCTION

Speaking a foreign language is a cognitively demanding task that often is accompanied by a reduction of oral fluency. A decrease of fluency in L2 speech was observed both in comparing the L1 and L2 speech of the same speakers [14, 30] and in comparing the speech of natives and non-natives speaking the same language [10, 13, 19]. Differences in fluency were found in various temporal variables including speech rate, articulation rate, phonation/time ratio, mean length of runs, mean length of silent pauses, duration of silent pauses per minute, and number of silent pauses per minute. Fluency measures were reported to correlate with the level of proficiency in the L2 [19, 20, 23]. The reduction of fluency in low-proficient L2 speech can be attributed to increased cognitive effort when speaking an L2, which requires more planning time [10, 12].

Acoustic effects of increased cognitive effort were also found for speaking fundamental frequency (SFF). An increase of pitch level was observed in comparing the L1 and L2 speech of the same speakers [15, 16]. The comparison of the speech of natives and non-natives speaking the same language shows less consistent results, possibly due to the influence of the L1 [32, 33].

L2 speech was also found to have a compressed pitch span and reduced variance when compared to the L1 speech of the same speakers [31, 34] and when compared to native speakers of the same language [5, 13, 24, 31-33]. The findings of [31] further suggest that the difference in pitch span decreases with increasing experience in the L2.

Similar effects on fluency and SFF were found in bilingual speakers. In non-balanced bilinguals, lower fluency was found in the non-native or non-dominant language [9, 22]. Furthermore, un-balanced bilinguals had a higher pitch level and a narrower pitch span in the non-native or non-dominant language [6, 26]. Deviating results were found for speakers with high proficiency in the L2 and speakers of a tone language [1, 7, 22]. The study of balanced simultaneous bilinguals by [11] shows that language-specific factors can be relevant in non-tonal languages as well. Finally, the study of balanced Welsh-English bilinguals by [27], who found an expanded pitch span in Welsh female speech, suggests that sociocultural factors and societal expectations should also be taken into account.

Overall, these results point to less fluency, higher pitch level and narrower pitch span in the L2 of language learners and in the weaker language of bilinguals. Less attention has been paid to the question of how low literacy skills resulting from a lack of reading experience affect fluency and SFF in read speech (cf. [3]). In particular, when examining regional or minority languages, which are predominantly used in oral communication, the possible effects of a lack of reading experience deserve more attention. An interesting case in this respect is Low German, a regional language spoken in northern Germany, which is divided into several dialect groups and has no standard variety. There are almost no monolingual speakers of Low German left today. However, there are still many older speakers who grew up with Low German as their first language and who have acquired High German in their first years of life or at the latest when they entered primary school. Most if not all of these speakers are less familiar with reading in Low German than in High German. In a recent survey in northern Germany, more than half of the respondents said they could read Low German well or moderately well, while only 13% reported that they had read a Low German text within the last week [25]. The positive assessments of their own reading competence could be partly due to the fact that Low German is largely written according to the principles of the High German spelling, which considerably facilitates low-level decoding processes. The reported lack of reading experience suggests that reading in Low German is nevertheless an unfamiliar task for them and requires increased cognitive effort.

This paper examines fluency and SFF in the read speech of early bilinguals of High and Low German who speak both languages equally well, but have less reading experience in Low German than in High German. While these speakers are expected to be less fluent in Low German than in High German, it remains to be clarified whether this difference is due to a lower rate of articulation, which would indicate difficulties in lower-level processing, or to more or longer pauses, which would indicate difficulties in higher-level processing. In addition, effects on SFF reported for L2 speech are expected, that is an increased pitch level and a reduced pitch span. As the self-evaluations reported in [25] suggest that those women who have any knowledge of Low German speak it better than men we include gender as an additional factor.

2. METHOD

2.3 Participants

We recruited 64 speakers for this study, 29 women and 35 men. The age of the female speakers ranged from 40 to 80 (mean = 68.4, SD = 10.1) and the age of the male speakers from 40 to 82 (mean = 66.4, SD = 11.4). All participants are early bilinguals of High and Low German who acquired Low German as a first language and High German at the latest when they entered primary school. While the participants speak both languages fluently and use them in everyday life, they are much more familiar with reading High German than Low German. Hence, oral reading in Low German should pose a particular challenge to most participants.

The participants were recruited in 16 villages of the Bersenbrücker Land, which is located in the federal state of Lower Saxony in northwestern Germany. These villages pertain to two dialect groups of Low German, the Northern Low Saxon group in the north and the Westphalian group in the south. As no regional differences in fluency and SFF were found and regional variation was not the focus of the present study, the dialectal background of the speakers will be ignored (see [28] for more information).

2.2 Recording procedure and tasks

Speech samples were recorded in the clubhouses of the local heritage societies of the 16 villages. Each participant was asked to read Aesop's fable 'The North Wind and the Sun' in High and Low German. The order of the language versions was changed quasi-randomly between the speakers. The Low German version was a translation of the High German version into the local dialect, which was provided by members of the local heritage societies.

2.4 Recordings and acoustic analysis

All speech samples were recorded on a digital audiotape (DAT) recorder (Tascam DR-100). The recordings were digitized at a sampling rate of 48 kHz and with 16 bits/sample quantization. Acoustic measures include seven fluency variables and two SFF variables. The following fluency variables were examined (dur1 = total duration of speech (sec), dur2 = duration of speech without internal pauses) (adopted from [8] with small adjustments): *speech rate* (number of syllables/dur1), *articulation rate* (number of syllables/dur2), *phonation/time ratio* (dur2/dur1), *mean length of runs* (mean number of syllables between silent pauses), *mean length of silent pauses* (total duration of all silent pauses/number of silent pauses), *duration of silent pauses per minute* (total duration of all silent pauses/(dur1/60)), and *number of silent pauses per minute* (number of silent pauses/(dur1/60)). All these variables were found to strongly correlate with fluency ratings in previous studies [8, 20]. Note that the variables *speaking rate*, *articulation rate* and *mean length of runs* were calculated with reference to syllables and not with reference to phonemes as in [8].

The seven temporal variables were measured automatically in Praat [4] with a script provided by [18]. This script determines syllable nuclei based on intensity and pitch information. As minimum pause length, we chose 0.25 seconds, which falls in the range of values that correlate most strongly with fluency judgments [17]. To determine optimal values for the remaining settings of this script, we labeled manually eight sound files, in which the two languages, genders, and dialect regions were equally represented. We ran the script with varying settings for the silence threshold and the minimum dip between peaks and determined the values that yielded the smallest absolute deviation from manually determined syllable numbers in the automatic identification of the syllable nuclei. These values were -20 dB for the silence threshold and 4 dB for the minimum dip between peaks.

The SFF measures included two long-term distributional measures, the mean pitch level and the pitch span encompassing the middle 90% of all pitch values.

2.5 Statistical analysis

We performed linear mixed effects analyses using the *lme4* package in R [2, 29]. We built separate regression models for the dependent temporal and SFF variables introduced in sec. 2.4. As fixed effects, we entered LANGUAGE and GENDER into the initial models. As random effects, we had intercepts for subjects. *P*-values were obtained by eliminating non-significant effects of the initial model with the step function of the *lmerTest* package and calculated using the Satterthwaite approximation [21]. Visual inspection of histograms and residual plots did not reveal any obvious deviations from normality and homoscedasticity, except for the variable *mean length of runs*, which showed a right-skewed distribution. To compensate for this deviation from the normal distribution we used log-transformed data for statistical analysis.

3. RESULTS

Table 1 shows a significant main effect of LANGUAGE for all fluency measures, except for articulation rate. As can be seen in Figure 1, Low German speech has a lower speech rate, a lower phonation/time ratio, a shorter mean length of runs, a greater mean pause length, a greater pause length per minute, and a higher number of pauses per minute. For speech rate, phonation/time ratio, and pause length per minute, LANGUAGE was found to interact with GENDER. Male speakers show a stronger reduction of speech rate and a lower phonation/time ratio in Low German than female speakers, and a stronger increase of pause length per minute. As speech rate is a compound measure depending both on articulation rate and pause length, the present findings suggest that the difference in speech rate can be reduced to a difference in pausing rather than in the speed of articulatory movements.

Table 1: Effects of LANGUAGE and GENDER on temporal variables.

		β	*SE*	*df*	*t*	*p*
Speech rate	LANG	-0.28	0.04	64	-6.15	<.001
	LANG X GENDER	0.16	0.07	64	2.37	<.05
Articulation rate	-	-	-	-	-	-
Phonation/time ratio	LANG	-0.06	0.01	64	-7.40	<.001
	LANG X GENDER	0.03	0.01	64	2.72	<.01
Run length	LANG	-0.21	0.04	64	-5.25	<.001
Mean pause length	LANG	0.05	0.02	64	3.42	<.01
Pause length/min	LANG	3.71	0.50	64	7.40	<.001
	LANG X GENDER	-2.02	0.74	64	-2.72	<0.01
Pauses/min	LANG	2.75	0.56	64	4.89	<.001

Table 2 shows a significant main effect of LANGUAGE and GENDER on pitch level, which was higher in Low German than in High German (see Figure 2, left panel). As expected, the pitch level was higher in females than in males, but the difference was only about half an octave. For pitch span, LANGUAGE was found to interact with GENDER. The right panel in Figure 2 shows that while the male speakers compressed the pitch span when speaking in Low German, the female speakers expanded it.

Table 2: Effects of LANGUAGE and GENDER on pitch variables.

		β	*SE*	*df*	*t*	*p*
Pitch level	LANG	0.53	0.12	64	4.43	<.001
	GENDER	6.21	0.70	64	8.91	<.001
Pitch span	LANG X GENDER	1.00	0.33	64	3.08	<.01

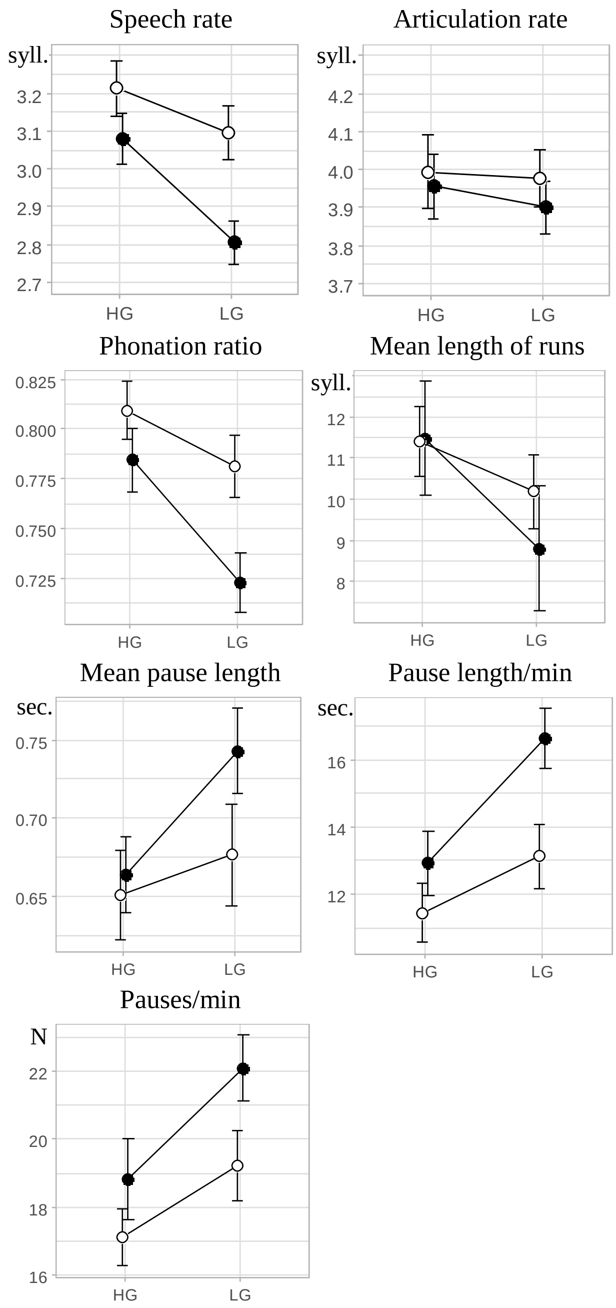

Figure 1: Temporal variables of male (filled circles) and female speakers (open circles) in High (HG) and Low German (LG). Error bars indicate ±1 SE.

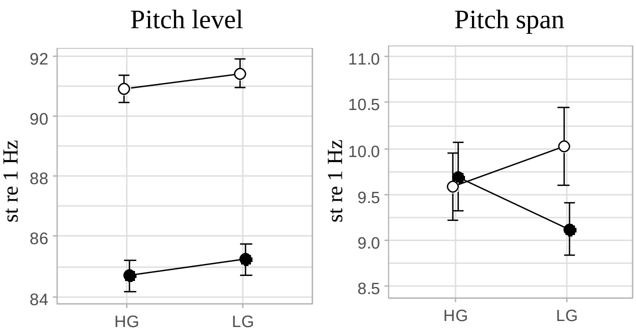

Figure 2: Pitch level and span of male (filled circles) and female speakers (open circles) in High (HG) and Low German (LG). Error bars indicate ±1 SE.

4. DISCUSSION

The aim of this study was to examine fluency and SFF in read speech of early bilinguals of High and Low German with different reading experience in their two languages.

The study revealed differences in both fluency and SFF variables. The Low German text was read with a lower speech rate, a lower phonation/time ratio, shorter runs, a greater mean pause length, a greater pause length per minute, and a higher number of pauses per minute, whereas there was no effect on articulation rate. These findings are in line with reports on reduced fluency in L2 speech and in the non-dominant language of bilinguals [9, 22]. The fact that differences in the frequency and length of pauses were found, but not in the speed of articulatory movements, suggests that the lower speech rate in Low German is caused by increased cognitive effort in speech planning rather than by a general slowing down of articulatory activity. Lack of experience in reading Low German appears to be more challenging at higher levels of processing than at lower levels, such as phonemic decoding.

The interaction effects found for speech rate, phonation/time ratio, and pause length per minute indicate that the language effect was modulated by gender. Male speakers reduced their speech rate more than female speakers and spent more time on speech planning. Apparently, reading in Low German was a harder task for males than for females.

The study of SFF revealed that both male and female speakers increased the pitch level in Low German, as was also observed for low-proficient L2 speech and the non-dominant language in bilinguals [6, 15, 16, 26]. However, there is no evidence that male speakers have increased their pitch level more than female speakers, suggesting that pitch did not increase in proportion to the cognitive load imposed on the speakers. It is more likely that the pitch increase in Low German is a non-specific stress response triggered by an unfamiliar task.

Finally, a language effect on pitch span was found, which is modulated by gender. Whereas male speakers compressed the pitch span in Low German, as expected for non-proficient L2 speakers, female speakers expanded it. Using a within-speaker design we can exclude anatomical and physiological factors as possible causes. Furthermore, there is no indication that this difference derives from systematic differences in the intonation systems of the two languages. A more likely reason for the compression of pitch span in male speakers is an increased cognitive effort in the Low German reading task. Lower literacy skills in Low German could have had the effect that the male speakers had fewer resources available for the informational highlighting of parts of the sentences by more or higher pitch peaks. However, the compressed pitch span could also result from lower confidence, as suggested for L2 speech by [24, 33, 34].

It remains unclear why female speakers have a wider pitch span in Low German rather than a narrower or equal span. Ordin and Mennen [27] bring sociocultural factors into play as a possible explanation. In a study of early Welsh-English bilinguals, they observed that the female speakers had a wider pitch span in Welsh than in English, while no language effect was found in male speakers. According to [27], this finding may be explained by a greater willingness of female speakers to conform to societal expectations linked to the use of the two languages.

In the case of High and Low German bilinguals, we do not know what these expectations might look like, especially since there are no monolingual speakers of Low German who could serve as role models. However, there is a strong emotional bond with Low German, as this language is mainly used in family and in communication with friends [25]. Therefore, the wider pitch span observed in the Low German speech of female speakers could be the result of greater emotional involvement. In the male speakers, such an effect could have been obscured by the effects of increased cognitive effort.

Overall, the results of our study suggest that lower literacy skills in a native language can affect fluency and SFF in a similar way as it was observed in low-proficient L2 speech and in the weaker language of bilinguals. Further research is needed to get more information about the type of cognitive effort responsible for the observed variation in fluency and SFF. For this purpose, we plan to extend the present research by comparing read speech with spontaneous speech and using tasks of different complexity.

5. REFERENCES

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