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Pitch Range Variation in High German (L1) and Low German (L2)

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Abstract

L2 speech is often reported to have an increased overall pitch level and a reduced pitch span. The present study examines the question whether similar pitch effects can be found in an L2 that is closely related to the L1 and allows extensive transfer from this language. These effects are investigated for different task types and levels of difficulty. Using a within-speaker design, long-term average measures of pitch level (median) and pitch dispersion (5th percentile, 95th percentile, and pitch span) were obtained from continuous speech of speakers of High German as L1 and Low German as L2. Low German L2 speech had a higher pitch level and a compressed pitch span in most tasks and levels of difficulty. Both effects resulted from raising the pitch floor rather than from variation of peak scaling. There were almost no effects of task difficulty, indicating that either differences in the level of difficulty were too small, or the observed pitch effects reflect a global effect of transition to a foreign language mode. Overall, the results suggest that the use of a foreign language can affect pitch range measures, even if the L2 is closely related to the L1.

Index Terms: pitch level, pitch span, L2 speech, High German, Low German.

1. Introduction

Speaking a foreign language is a demanding task that requires an increased cognitive effort, especially from speakers with low to intermediate language skills. A number of studies have found that the L2 speech of these speakers has acoustic characteristics that indicate increased cognitive stress. The most consistent finding is an increase of the pitch level in the L2 compared to the L1 of the same speakers [1, 2]. Many studies also report a compressed pitch span and a reduced overall variance for L2 speech compared to the L1 speech of the same speakers ([2], [3], and [4]) or of native speakers of the same language ([2], [3], [5], [6], and [7]). Similar effects on pitch level and pitch span were found for the non-dominant language of bilingual speakers ([8], [9], [10], and [11]). Less consistent results were found for the L2 of balanced bilinguals ([12], [13], [14], and [15]) and for native and non-native speakers of the same language, possibly indicating an influence of the L1 ([2], [6], and [16]). [6] found an increase of pitch span in Russian L2 speech with increasing experience in the L2. Additionally, the type of speech task was found to have an effect on pitch level and dispersion measures. Many, but not all, studies report a higher pitch level for read speech than spontaneous speech ([4], [17], [18], [19], and [20]).

Pitch range effects of increased cognitive stress in L2 speech have usually been investigated using standard languages such as English, German, French, Russian, Greek, and Finnish ([1], [3], [4], [6], [7], and [8]). The present study examines whether pitch effects also occur in an L2 that is closely related to the L1 and which allows extensive transfer from the L1. This is the case with Low German, which is closely related to High German. Low German is a non-standardized regional language in Northern Germany, which consists of several dialects. It is primarily a spoken language. Only few speakers of Low German are used to writing or reading in Low German. Although Low German is still spoken by nearly 2 million speakers, it is highly endangered. The use of the language within and outside families is decreasing and the number of speakers is rapidly declining [21, 22].

Since Low German has been in close contact with High German for centuries, it shows numerous influences from High German in both grammar and vocabulary. The resulting similarity between the languages makes it easier for speakers with low language skills to make use of code-mixing strategies. The use of Low German is further facilitated by the fact that most native speakers of High German in Northern Germany have at least some passive knowledge of the Low German spoken in their local communities.

If native speakers of High German speech can master speech tasks in Low German even without advanced language skills, the question arises whether Low German L2 speech is less likely to show acoustic indicators of increased cognitive stress as reported for L2 speech in previous studies. The present study examines Low German L2 speech of native speakers of High German who have attended courses in Low German at beginner level. Task types ranged from free narration to storytelling, giving directions, and reading a fable. To examine whether increased cognitive demands lead to stronger pitch effects, we varied levels of difficulty for all tasks except the narration.

2. Method

2.1. Subjects

We recruited 29 participants for this study, 20 women and 9 men. The age of the female participants ranged from 21 to 47 years (mean = 25.5, SD = 6.2) and the age of the male participants from 21 to 32 (mean = 25.7, SD = 4.0). Participants completed a questionnaire that included demographic questions as well as questions about their language background and attitudes towards High and Low German. All participants grew up in East Frisia or surrounding areas in Northwest Germany and were students at the University of Oldenburg. They were native speakers of the regional standard variety of High German spoken in northwestern Germany and had successfully completed one or two language courses in Low German at their university within the past year. Nearly all participants rated their comprehension of Low German as very good or good and their speaking skills as good or moderate. All speakers were paid for their participation.

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2.2. Tasks

The participants completed four tasks including an elicited narration (Task 1), retelling a story (Task 2), a route description (Task 3), and a reading task (Task 4). Each task was completed both in High German and in Low German in different versions. In Task 1, the participants talked about their home region or their family. The participants were given six to seven keywords that suggested possible topics. In Task 2, the participants were presented with a pantomime comic from the series "Father and Son" by E. O. Plauen, which in 6 pictures tells a story that they were asked to retell in their own words. In Task 3, the participants were asked to describe a path across the campus of their home university. In Task 4, the participants read two fables from Aesop, "The North Wind and the Sun" and "The Raven and the Fox", one in a High German and one in a Low German version. For the latter, the teacher of the language course had translated the High German version into the East Frisian dialect of Low German, which was taught in the language course.

To determine whether increased cognitive demands affect the pitch variables, we varied the difficulty level of Tasks 2, 3, and 4. Task 2 was performed twice in each language version with two different comic strips. In each language, the subjects had to retell the story of one comic strip without preparation time and after that another comic strip with a preparation time of one minute. Task 3 consisted of three route descriptions in each language version, first without a map of the campus, second with a campus map lacking names of paths and landmarks, and finally with a campus map containing all names of paths and landmarks. In Task 4, we were interested in whether the repeated reading of the same text reduces the cognitive demands such that it affects the pitch range variables. Accordingly, the participants read each fable of Aesop twice in a row. Language mode, task type, and materials used in Task 2–4 (comic strips, routes, and fables) were randomly varied for each participant. Table 1 gives an overview of task types and task levels per language.

Table 1: *Task types and levels for High German (HG) and Low German (LG).*

Task	Language	Task type	Task level
T1	HG	Narrative	–
T1	LG	Narrative	–
T2	HG	Storytelling	No preparation time
T2	HG	Storytelling	Preparation time
T2	LG	Storytelling	No preparation time
T2	LG	Storytelling	Preparation time
T3	HG	Route description	No map
T3	HG	Route description	Unlabeled map
T3	HG	Route description	Labeled map
T3	LG	Route description	No map
T3	LG	Route description	Unlabeled map
T3	LG	Route description	Labeled map
T4	HG	Reading task	First reading
T4	HG	Reading task	Second reading
T4	LG	Reading task	First reading
T4	LG	Reading task	Second reading

2.3. Recording procedure and acoustic analysis

Speech samples were recorded in a soundproof booth at the University of Oldenburg. All speech samples were recorded on a portable digital recorder (Tascam HD P2) with a head-mounted microphone (DPA 4065 FR). The recordings were digitized at a sampling rate of 48 kHz and with 24 bits/sample quantization and downsampled to 16 kHz for further analysis. The pitch range measures included the mean, the median, the 5th and 95th percentile, and the f0 span encompassing the middle 90% of all pitch values. All measures were extracted with the acoustical analysis software Praat [23].

2.4. Statistical analysis

We performed separate linear mixed-effects analyses in R with the lme4 package ([24, 25]). We built separate regression models for each task type and each dependent pitch variable. As fixed effects, we entered the within-subject effects LANGUAGE (High German vs. Low German) and TASK LEVEL (2 or 3 levels of difficulty) as test variables and the between-subject effect GENDER (female vs. male) as a control variable into the initial models for each task type. As crossed random effects, we included intercepts for subjects and items. The *p*-values were obtained by eliminating non-significant factors ($\geq .05$) of the initial model with the step function of the lmerTest package and calculated using the Satterthwaite approximation [26]. For all pitch variables we entered log-transformed data into the statistical analysis. Visual inspection of histograms and residual plots of the transformed data revealed no obvious deviations from normality or homoscedasticity.

3. Results

Figure 1 shows mean values of *Median*, *5th percentile*, *95th percentile*, and *Span* for each task type, broken down by LANGUAGE and GENDER. For the arithmetic mean we obtained results which are very similar to those for the median and which we do not report here for lack of space.

The upper panel of Figure 1 shows that the median of f0 is higher in Low German than in High German in all task types but the differences are rather small. The lower panel indicates that the span is more compressed in Low German than in High German in all task types, and it is generally more compressed in male than in female speakers. The middle panels showing mean values of the 5th and 95th percentile suggest that the raised pitch level in Low German speech originates from raising the pitch floor rather than from raising the pitch peaks. Similarly, the compressed pitch range observed for Low German speech results from raising the pitch floor rather than from lowering the pitch peaks.

Table 2 lists mean values for the dependent variables separately for task levels, which were varied in Task 2–4 by level of difficulty (see Table 1). Overall, there is little variation between the task levels per task and language. Table 3 shows significant main effects of LANGUAGE for all dependent variables and all tasks except the *5th percentile* and *Span* in T1. The beta coefficients indicate a higher *Median*, *5th percentile*, and *95th percentile* in Low German, with values ranging from 0.21 to 1.79 semitones, except for the *95th percentile* in T2 (-0.37). For the *95th percentile* in T4, LANGUAGE was found to interact with GENDER. The *95th percentile* is lower in Low German but this difference mainly derives from lower values in the male participants. *Span* was found to be more compressed in Low German in all tasks except the narration task (T1), with values ranging from -1.28 to -1.68 semitones.

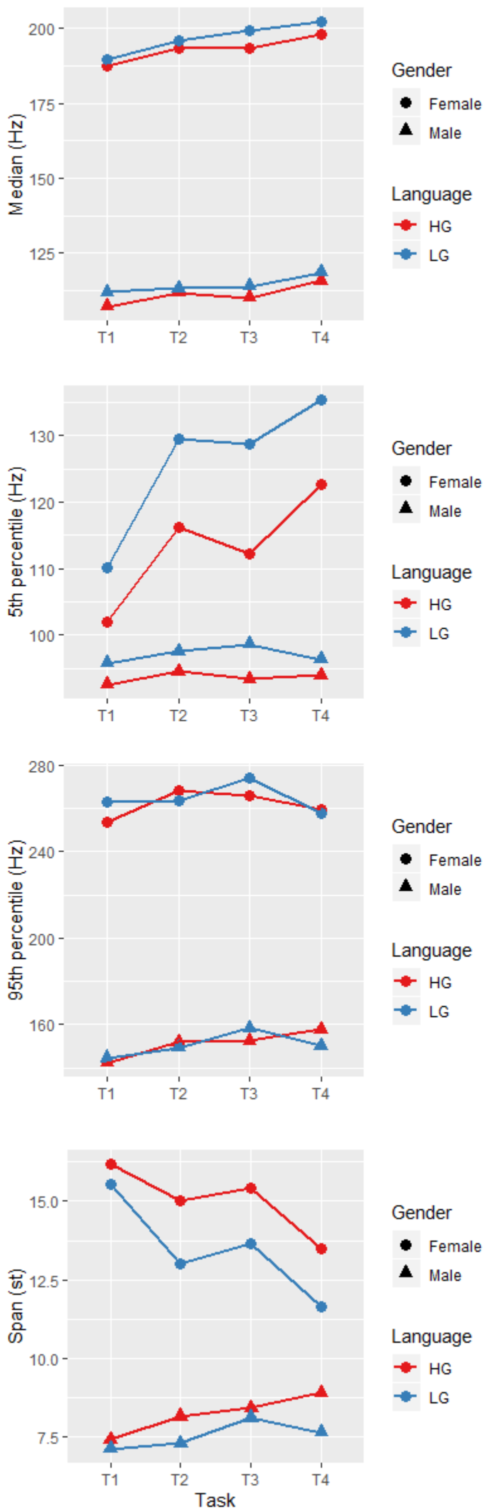

Figure 1: *Mean values of Median, 5th percentile, 95th percentile (all in Hz), and Span (st) per task type, broken down by* GENDER *and* LANGUAGE *(with HG for High German and LG for Low German).*

As expected, the *Median*, *5th percentile*, and *95th percentile* were lower in male than in female voices. However, *span* was also more compressed in males than in females, with values ranging between -4.33 and -8.59 semitones. No effects of TASK LEVEL were found, except for the 95th percentile, which was lower on the less difficult task level (comic strip with preparation time).

Table 2: *Mean values of Median, 5th percentile, 95th percentile, and Span per task (T2–T4) and task level (descending degree of difficulty), broken down by* GENDER *and* LANGUAGE.

	Task	Task level	Female		Male	
			HG	**LG**	**HG**	**LG**
Median (Hz)	T2	1	194	196	112	113
		2	193	196	112	114
	T3	1	192	198	108	113
		2	194	200	111	114
		3	194	200	111	115
	T4	1	198	202	116	120
		2	198	202	116	117
5th perc (Hz)	T2	1	114	129	94	98
		2	119	130	95	98
	T3	1	111	128	92	98
		2	121	129	94	99
		3	105	130	94	99
	T4	1	122	133	94	96
		2	123	137	94	96
95th perc (Hz)	T2	1	275	267	154	153
		2	262	260	150	146
	T3	1	267	275	152	161
		2	266	274	153	158
		3	265	273	152	155
	T4	1	260	257	159	153
		2	259	259	157	147
Span (st)	T2	1	15.8	13.2	8.4	7.7
		2	14.3	12.8	7.9	6.9
	T3	1	15.7	13.9	8.6	8.5
		2	14.3	13.7	8.4	7.9
		3	16.3	13.5	8.3	7.8
	T4	1	13.6	11.9	9.1	7.9
		2	13.4	11.5	8.7	7.3

4. Discussion

The aim of this study was to determine whether pitch range effects reported for L2 speech in previous studies can also be observed in an L2 closely related to the L1. Native speakers of High German as L1 and Low German as L2 completed four tasks in both languages: narration, storytelling based on a pantomime comic, route description, and reading a fable. In addition, we varied the level of difficulty of these tasks, except for the narrative.

For all pitch measures and all task types, the language mode was found to affect pitch level and pitch span. The median was consistently higher in Low German L2 speech, as previously observed for the L2 speech of other languages ([1], [2], and [3]). The effects for the 5th and 95th percentile in Task 2–4 suggest that the raised pitch level derives from raising the pitch floor rather than from lowering the pitch peaks, which remain fairly constant across the two language modes. Raising the pitch floor without raising the pitch peaks leads to an overall compression of the pitch span, which was attested for all tasks except the narrative. These findings are in line with previous studies on pitch span in L2 speech ([2], [3], and [4]).

Table 3: *Effects of* LANGUAGE *and* GENDER *on Median, 5th percentile, 95th percentile, and Span. Main coefficients for* LANGUAGE *indicate the change from High to Low German, for* TASK LEVEL *from more to less difficult, and for* GENDER *from female to male (all differences are expressed in semitones).*

			β	SE	t	p
Median	T1	LANGUAGE	0.42	0.12	3.42	.0018
		GENDER	-9.51	0.78	-12.19	<.0001
	T2	LANGUAGE	0.21	0.10	2.14	.0354
		GENDER	-9.50	0.82	-11.59	<.0001
	T3	LANGUAGE	0.49	0.07	6.72	<.0001
		GENDER	-9.63	0.80	-12.03	<.0001
	T4	LANGUAGE	0.41	0.09	4.33	<.0001
		GENDER	-9.29	0.89	-10.44	<.0001
5th perc.	T2	LANGUAGE	1.31	0.55	2.37	.0202
		GENDER	-3.66	1.42	-2.59	.0150
	T3	LANGUAGE	1.79	0.41	4.38	<.0001
		GENDER	-3.37	1.33	-2.54	.0169
	T4	LANGUAGE	1.34	0.44	3.09	.0027
		GENDER	-4.77	1.48	-3.22	.0031
95th perc.	T1	LANGUAGE	0.51	0.19	2.61	.0139
		GENDER	-10.38	0.83	-12.56	<.0001
	T2	LANGUAGE	-0.37	0.18	-2.12	.0368
		TASK LEVEL	-0.55	0.18	-3.10	.0026
		GENDER	-9.94	0.87	-11.47	<.0001
	T3	LANGUAGE	0.59	0.12	5.02	<.0001
		GENDER	-9.65	0.88	-10.99	<.0001
	T4	LANG X GENDER	-0.77	0.33	-2.37	.0203
Span	T1	GENDER	-8.59	1.09	-7.87	< .0001
	T2	LANGUAGE	-1.68	0.60	-2.82	.0060
		GENDER	-6.29	1.22	-5.15	< .0001
	T3	LANGUAGE	-1.28	0.41	-3.15	.0020
		GENDER	-6.29	1.26	-5.01	< .0001
	T4	LANGUAGE	-1.67	0.45	-3.69	.0004
		GENDER	-4.33	1.50	-2.89	.0072

Hardly any effect was found for the change in the level of difficulty of the tasks. Only for Task 2 (storytelling) the 95th percentile was found to be lowered by about half a semitone when switching to the less difficult task (storytelling with preparation time). These findings suggest that either the task levels did not differ sufficiently or the pitch range variables did not change in proportion to the cognitive load imposed on the speakers. In the latter case, the pitch effects found in Low German speech could be a non-specific stress response to the task of speaking a foreign language triggered by an unfamiliar task ([27]).

GENDER interacts with LANGUAGE only in the reading task. In this task, the 95th percentile was lowered when switching to Low German by male speakers but not by female speakers (see Figure 1). In general, however, the pitch effects in our data were not gender-specific, apart from general differences in pitch level.

While earlier studies on prosody of L2 speech examined the acquisition of national standard languages, such as English, Russian, Finnish, or Greek, this study examined the use of a regional language as L2, which is closely related to the L1 of the same speakers, and which shows effects of language contact with this language in grammar and vocabulary. This means that in the case of Low German the native language can be used more for coping with the tasks than when speaking a foreign standard language. In addition, our participants were acquainted with Low German in their local communities. Nevertheless, in most tasks the same pitch effects were found as in other research on L2 speech, even if the differences in pitch level found for Low German were rather small. We conclude that speaking Low German as L2 by native speakers of High German increases cognitive stress as in speaking other foreign languages. The finding that varying the level of difficulty of individual tasks had no effect on pitch variables suggests that in our speakers, the use of Low German as L2 may have led to a global stress response that affects pitch range variables in a similar way as increased cognitive load. To examine more closely whether the observed pitch range variation arises from a global or specific stress response, it is useful to include fluency measures which may more directly reflect differences in the cognitive load imposed by different tasks (cf. [27]).

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