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Effects of task type and task difficulty on oral fluency in native and non-native speech

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Abstract

The aim of this study was to explore differences in oral fluency between native and non-native speech, with a focus on the influence of task type and task difficulty. To reduce the impact of language structure on variability, the study compared High German (HG) and Low German (LG), two closely related languages with similar phonology, grammar, and vocabulary. Native speakers of HG, who had successfully completed a language course in LG, performed eight speaking tasks in both languages. To evaluate the effect of task difficulty on fluency parameters, three of these tasks were presented at different levels of task complexity, which was achieved by varying the availability of relevant information, the pre-task planning time, and the familiarity of the task. Measures of speed and breakdown fluency were obtained from both languages. As expected, LG speech showed lower speed and breakdown fluency compared to HG speech, but this effect varied by task type and task difficulty. We conclude that the assessment of oral fluency through effective variation of task type and task difficulty remains a major challenge for future research.

Index Terms: oral fluency, second language research, task type, task difficulty, High German, Low German

1. Introduction

Speaking a foreign language is a cognitively demanding task that requires additional attention to verbalization processes that are largely automated in the native language. This added cognitive load can lead to a significant decrease in oral fluency in the non-native language, especially for less proficient learners.

Fluency variables are particularly interesting because they provide real-time access to changes in cognitive load, unlike retrospective assessments of task difficulty. In addition, fluency variables have been shown to be sensitive to variations in cognitive load by changing task type and manipulating task difficulty. The present study focuses on how task type and task difficulty affect the fluency gap [1] between native and non-native speech.

Fluency variation has been observed when comparing the speech of native and non-native speakers of the same language [2–9], as well as when comparing native and non-native speech within the same speaker [1, 10, 11]. In addition, variations in fluency have been reported for the speech of non-native speakers at different proficiency levels [12], as well as for the same learners at different stages of the learning process [13–15].

Variations in fluency have been reported across three dimensions: speed fluency, breakdown fluency, and repair fluency [16–18]. Speed fluency refers to the speed with which speech events are produced. Breakdown fluency refers to interruptions in the flow of speech caused by silent and filled pauses. Repair fluency manifests itself in reformulations, replacements, false starts, and repetitions of words and phrases. Among the variables indicating breakdown fluency the phonation/time ratio and the mean length of runs were found to be particularly sensitive to differences between L1 and L2 speech. In addition, fluency has been reported to vary according to the type of speech task and the complexity of the task. Several studies have addressed the issue of task complexity by manipulating inherent features of task design or task implementation features [18]. Significant effects on speed and breakdown fluency have been reported for varying the number and interconnectedness of elements to be processed [5, 19], for varying the amount of pre-task planning time, i. e. the amount of time subjects had to prepare for task performance [17, 19–23], and for varying task familiarity by providing the opportunity to rehearse task performance or to perform the task a second time [24–26].

Our study aimed to investigate the influence of task type and task difficulty on both native and non-native speech within the same speaker. By task difficulty we refer to the level of attention required to perform the task [27], which varies with the complexity of a task, leading to variation in cognitive load.

The current study focused on fluency variables that can be expected to reflect changes in speech behavior aimed at reducing cognitive load during task performance. We used three types of tasks commonly used in fluency research: a direction-giving task, a picture-story task, and a reading task. The level of difficulty was adjusted by varying the complexity of the tasks in three ways: by the availability of visual information and descriptive labels in the direction-giving task; by the amount of pre-task planning time in the picture-story task; and by the familiarity with the text in the reading task.

We expected that our participants would respond to the increased cognitive demands of the more complex tasks by (1) speaking less, (2) breaking the speech down into smaller portions, and (3) speaking more slowly. All three changes in speaking behavior can be expected to decrease the intrinsic cognitive load of the tasks by reducing the number of cognitive operations that must be performed simultaneously at the within-task planning stage [23, 27, 28, 29]. Strategy 1, which involves increasing the proportional pause time, allows more time to plan the utterances in advance. Strategy 2 reduces the processing load during the pre-planning phase because shorter

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portions of speech are likely to require less pre-planning. Strategy 3 provides more time for incremental speech planning and self-monitoring after utterance onset [30, 31]. In general, all three strategies reduce the processing load per unit of time.

We expected that an increase in task complexity would have a more pronounced negative effect on fluency in L2 speech compared to L1 speech. However, in accordance with Skehan's Limited Attention Capacity model, it is also possible that speakers narrow this fluency gap by sacrificing accuracy and reducing syntactic and lexical complexity in their L2 [27, 28]. In this scenario, L1 and L2 speech would differ more in accuracy and complexity than in fluency.

To reduce language-specific influences on speech flow, particularly those arising from variations in syntactic structure and rhythm, we analyzed fluency variables in High and Low German, two closely related West Germanic languages with similarities in phonology, grammar, and vocabulary. Low German consists of several dialects spoken in northern Germany, along with standard High German. It differs from High German mainly in that it has not undergone the Second Germanic Consonant Shift and has a less complex case system. As the number of native speakers of Low German is rapidly declining [32], there is a growing interest in promoting the learning of Low German as a second language.

2. Method

2.1. Participants

We recruited 29 participants, including 20 women and 9 men. The age range of the female participants was 21 to 47 years (mean = 25.5, SD = 6.2) and for male participants 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 toward High and Low German. All participants were students at the University of Oldenburg and grew up in East Frisia or the surrounding areas in Northwest Germany. 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 either very good or good and their speaking skills as either good or moderate. All participants were compensated for their participation.

2.2. Speech tasks and procedure

Participants were instructed to complete three tasks, each varying in difficulty: giving directions (direction-giving task), retelling a picture story (picture-story task), and reading a text aloud (reading task). In the direction-giving task, participants were requested to provide a description of one of two routes through their university campus. The task had three levels of difficulty, which varied according to the availability of relevant information: giving directions with a map showing paths, landmarks, and labels (level 1), giving directions with a map showing paths and landmarks but no labels (level 2), and giving directions from memory without a map (level 3). In the picture-story task, participants were asked to construct a storyline from a set of six pictures of a comic strip arranged in a logical order. The task had two levels of difficulty, which varied according to the available pre-task planning time: telling the storyline of one comic strip with one minute of pre-task planning time (level 1) and telling the storyline of another comic strip without pre-task planning time (level 2). The first condition was expected to reduce cognitive demands by offering more time for strategic planning [23]. In the reading task, participants read one of two fables of Aesop. The task had two levels of difficulty: reading the unfamiliar fable aloud for the first time (level 2), and reading the same, now familiar, fable for the second time (level 1). It was expected that the second reading would reduce the cognitive demands by allowing the first reading to be used as training [23]. To minimize training effects that counteract effects of increasing task difficulty, all tasks started with the most difficult condition (level 2 or 3) and ended with the least difficult one (level 1). Each participant was randomly assigned one of the two versions of the materials for each task.

2.3. Recording procedure and acoustic analysis

Speech samples were recorded in a soundproof booth using a head-mounted omnidirectional microphone (DPA 4066) and a portable digital recorder (Tascam DR-100 MKIII). 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. We used a Praat script by de Jong et al. [33, 34] to calculate three fluency measures: (1) the phonation/time ratio, which was calculated by dividing the phonation time by the total time taken to produce the speech sample; this variable refers to the proportional phonation time and is negatively correlated with the proportional pause time; (2) the mean length of runs, which was calculated by dividing the number of syllables by the number of runs; this variable corresponds to the mean number of syllables between two silent pauses; and (3) the articulation rate, which was calculated by dividing the number of syllables by the phonation time and is the inverse of the average syllable duration. For all measurements, we used default values of the script including 0.3 seconds for the minimal duration of silent pauses.

2.4. Statistical analysis

We fitted generalized linear mixed models using the *glmmTMB* package [35] in R [36] for the dependent variables Phonation/Time Ratio, Mean Length of Runs, and Articulation Rate. As fixed effects, we included the within-subject factors LANGUAGE (LG vs. HG) and DIFFICULTY LEVEL (levels 1–3 for the direction-giving task and levels 1–2 for the picture-story and reading task) and the between-subjects factor GENDER (female vs. male), which was included as a control variable. As random effects, intercepts were included for SUBJECT, VERSION (two versions of materials for each difficulty level of each task), and by-subject random slopes for the effect of LANGUAGE. We fitted generalized linear mixed models and selected either the Gaussian or the Gamma distribution based on the AIC criterion. Likelihood ratio tests were used to obtain *p*-values for full models. As we had no specific hypotheses about the role of GENDER, we will focus on reporting main effects of LANGUAGE and DIFFICULTY LEVEL as well as interactions including LANGUAGE and DIFFICULTY LEVEL. To compare contrasts between LG and HG for different values of DIFFICULTY LEVEL, we used the R package *emmeans* [37].

3. Results

Figure 1 shows lower values for Phonation/Time Ratio, Mean Length of Runs, and Articulation Rate in LG speech compared to HG speech. In line with this, Table 1 indicates a significant main effect of LANGUAGE for all fluency measures and tasks. In addition, it reveals a significant effect of DIFFICULTY LEVEL for all fluency measures and tasks, except for Articulation Rate in the picture-story task.

Closer inspection of the graphs in Figure 1 reveals that the fluency gap between LG and HG was generally larger in the more difficult versions of the direction-giving task and the reading task, except for Articulation Rate. Table 1 indicates interactions between LANGUAGE and DIFFICULTY LEVEL for Phonation/Time Ratio and Mean Length of Runs in the direction-giving task and for all three variables in the reading task. No interactions were found for the picture-story task. Contrast analyses in Table 2 indicate for the direction-giving task an increase in the difference between LG and HG from level 2 to level 3, but not from level 1 to level 2. In other words, the interaction effect emerged when giving directions *with* a map (level 2) as opposed to giving directions *without* a map (level 3). Table 2 also demonstrates a greater difference between LG and HG speech for all three variables for the more challenging condition of the reading task (level 2).

A comparison of the panels for female and male speech in Figure 1 reveals further variation, which we had not anticipated. In the graphs showing the Phonation/Time Ratio in the picture-story task, for example, increasing the difficulty level apparently had a different effect on the Phonation/Time Ratio in female and male HG speech. Across all task types, however, there is no evidence that DIFFICULTY LEVEL affected fluency variables differently in LG and HG speech among women and men in any systematic way.

Table 1: Assessing model fit (χ^2).

	LANGUAGE	DIFFICULTY	LANG:DIFF
Task 1: Route			
Phonation/Time Ratio	86.3414***	9.8121***	6.5054**
Mean Length of Runs	56.6130***	12.1824**	10.6115**
Articulation Rate	68.3133***	7.8645*	1.6689
Task 2: Story			
Phonation/Time Ratio	54.5679***	18.5958***	1.9170
Mean Length of Runs	121.0905***	6.8119**	2.8388
Articulation Rate	96.0547***	0.0741	1.1412
Task 3: Reading			
Phonation/Time Ratio	72.9003***	7.8728**	23.3763***
Mean Length of Runs	129.8619***	5.9521*	19.1653***
Articulation Rate	196.8516***	16.7413***	8.9016**

p-levels: *** <0.001, ** <0.01, * <0.05

Table 2: *Contrasts between LG and HG for interactions involving Language (Lang) and Difficulty Level (Diff). DV = Dependent variable, PTR = Phonation/Time Ratio, MLR = Mean Length of Runs, and AR = Articulation Rate.*

Task	DV	Diff	Estimate	SE	*t/z*-ratio	*p*
Route	PTR	1-2	-0.786	0.172	-0.457[2]	.8911
Route	PTR	1-3	0.368	0.186	1.978[2]	.1176
Route	PTR	2-3	0.446	0.174	2.567[2]	**.0227**
Route	MLR	1-2	-0.426	0.395	-1.079[2]	.5273
Route	MLR	1-3	0.557	0.414	1.347[2]	.3693
Route	MLR	2-3	0.983	0.393	2.504[2]	**.0329**
Reading	PTR	1-2	0.871	0.239	3.648[2]	**.0003**
Reading	MLR	1-2	1.797	0.512	3.508[2]	**.0005**
Reading	AR	1-2	0.134	0.055	2.451[1]	**.0159**

[1]*t*-ratio (Gaussian). [2]*z*-ratio (Gamma).

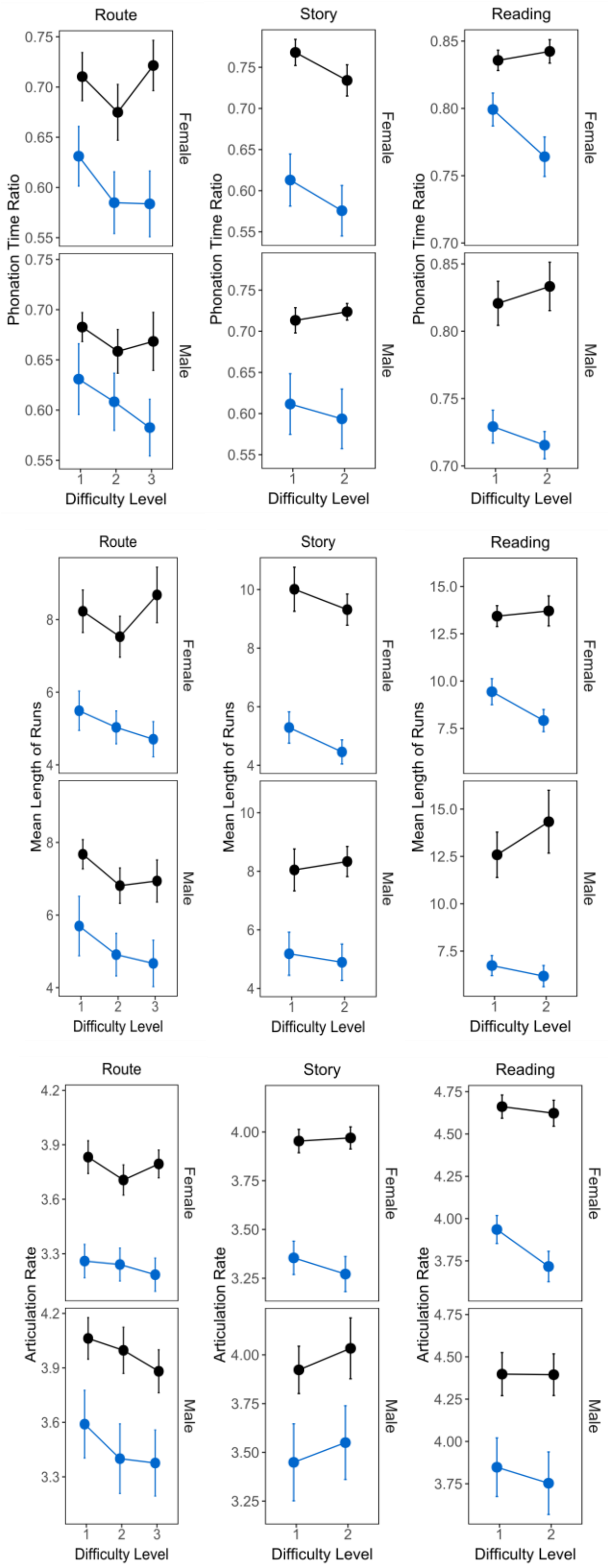

Figure 1: *Phonation/Time Ratio, Mean Length of Runs, and Articulation Rate for Low German (blue lines) and High German (black lines) with standard errors.*

4. Discussion

Native speakers of High German who have learned Low German as a foreign language tended to speak less, use smaller portions of speech, and speak more slowly in their L2, which aligns with similar findings for non-balanced bilingual speakers of High and Low German in read speech, except for articulation rate [38]. However, the extent of this effect varied by task type and task difficulty. Increasing task difficulty decreased Phonation/Time Ratio, Mean Length of Runs, and Articulation Rate in all tasks, except for Articulation Rate in the picture-story task. In addition, for Phonation/Time Ratio and Mean Length of Runs, the fluency gap between L2 speech and L1 speech increased with task difficulty in both the direction-giving task and the reading task, whereas no such interaction was found for the picture-story task. Articulation Rate was more affected by increased task difficulty in L2 speech than in L1 speech, but only in the reading task.

We can assume that it is not so much the task type per se that is responsible for the different results, but rather the qualitatively different manipulations of the difficulty level per task type. In the direction-giving task, it was primarily the difference between the condition with a map and without a map that showed a different effect on L1 and L2 speech, not the difference between the labeled and unlabeled map. As can be seen in the top and middle left panels in Figure 1, Phonation/Time Ratio and Mean Length of Runs decrease or remain at approximately the same level during the transition from level 2 (unlabeled map) to level 3 (no map) in the L2, while both measures increase in the L1. Similar findings have been reported by [25] for the immediate repetition of a picture-story task. Apparently, during the more challenging task, speakers tended to allocate more time in their L2 to pre-planning and planned smaller speech units, leading to reduced processing load. Conversely, in their L1, speakers could have increased the complexity of their utterances, resulting in more and longer speech units [27].

In the picture-story task, providing one minute time for pre-task planning reduced the Phonation/Time Ratio and the Mean Length of Runs in both L1 and L2 female speech. Possibly, female participants compensated for the higher cognitive demands in both their languages by extending the planning time between speech units, and for increased processing load by reducing the size of the planned speech units. This is in line with the results for the overall duration and number of pauses reported by Foster [2] who provided 10 minutes of pre-task planning-time. Note that the overall duration of pauses varies in proportion to the Phonation/Time ratio when repairs are included in phonation time, as was done in our analysis. Additionally, the number of pauses varies in proportion to the mean length of runs when the overall number of syllables is kept constant. In contrast, the top and middle central panels in Figure 1 indicate a slight increase in both fluency variables in the L1 with increasing difficulty, along with a decrease in the L2, for male participants. For Phonation/Time Ratio, but not for Mean Length of Runs, this interaction between DIFFICULTY LEVEL and GENDER reaches significance.

In the reading task, results for all three fluency variables indicate that participants benefited more in their L2 than in their L1 from familiarity with the fable. The top and middle right panels in Figure 1 show that in the more demanding task condition, participants tended to reduce proportional phonation time in their L2 and to use smaller speech units, whereas in their L1 they tended to increase proportional phonation time and to use longer speech units. Again, the effects on L2 speech can be interpreted as reducing cognitive load. In contrast, speaking more and using longer speech units in the L1 in the more difficult condition could reflect a closer orientation toward syntactic clause structure of the written text, leading to longer prosodic phrases. Finally, the lower right panels in Figure 1 show that in the reading task increased task difficulty led to a decrease in Articulation Rate, while it remained at about the same level in L1 speech.

In summary, all three task types exhibit the expected fluency gap between L1 and L2 speech, and in almost all conditions they also show an effect of manipulating task difficulty. However, only the direction-giving task and the reading task showed that a reduction of difficulty level reduced the fluency gap between L1 and L2 speech. For the picture-story task, it was expected that the additional time for pre-task planning would help speakers to engage more in strategic planning and thus reduce the fluency gap. That this expectation was not met could indicate that strategic planning did little to enhance fluency in the variables considered. Possibly, the time gained for strategic planning was used in both languages to enhance the accuracy of speech complexity rather than to improve fluency, which would be consistent with Skehan’s Limited Attentional Capacity model [27, 28]. Additional information about the accuracy and complexity of the speech events produced in the picture-story task is needed to shed light on this issue.

5. Conclusions

The results of our study indicate a decrease in speed and breakdown fluency with increasing complexity of the task. Increasing the availability of information to be verbalized in the direction-giving task as well as task repetition in the reading task emerged as effective strategies for improving fluency, especially of L2 speech. Providing additional pre-task planning time in the picture-story task was effective in both languages, but with no additional benefit for fluency in L2 speech.

The current study aimed to explore the effectiveness of a small number of speed and breakdown fluency variables in a pair of closely related languages that have thus far received little attention in second language research on fluency. Due to its exploratory nature, this study is not without limitations. To further validate the interpretation of the observed variation in fluency as strategies for reducing cognitive load, additional information on accuracy and grammatical complexity is needed. In addition, a stronger separation between task type and task difficulty would be desirable, which can be achieved by applying different manipulations of task complexity within the same task. For the direction-giving task, one approach could be to vary both the amount of information that needs to be verbalized and the pre-task planning time or the familiarity of the task. We conclude that the assessment of oral fluency through effective variation of task type and task difficulty remains a major challenge for future research.

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7. References

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