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The Perceptual Effect of L1 Prosody Transplantation on L2 Speech: The Case of French Accented German

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Abstract

Research has shown that language learners are not only challenged by segmental differences between their native language (L1) and the second language (L2). They also have problems with the correct production of suprasegmental structures, like phone/syllable duration and the realization of pitch. These difficulties often lead to a perceptible foreign accent. This study investigates the influence of prosody transplantation on foreign accent ratings. Syllable duration and pitch contour were transferred from utterances of a male and female German native speaker to utterances of ten French native speakers speaking German. Acoustic measurements show that French learners spoke with a significantly lower speaking rate. As expected, results of a perception experiment judging the accentedness of 1) German native utterances, 2) unmanipulated and 3) manipulated utterances of French learners of German suggest that the transplantation of the prosodic features syllable duration and pitch leads to a decrease in accentedness rating. These findings confirm results found in similar studies investigating prosody transplantation with different L1 and L2 and provide a beneficial technique for (computer-assisted) pronunciation training.
Index Terms: Second Language Learning, Prosody Transplantation, French, German

1. Introduction

When learning a foreign language a learner is challenged by several phonological and phonetic differences between the native (L1) and foreign language (L2) which usually result in a foreign accent. Not only do learners of an L2 have problems to produce sounds and suprasegmental structures correctly. They also show difficulties perceiving the phonetic and phonological differences produced by a native speaker in comparison to their own non-native productions [1–3]. This paper concentrates on suprasegmental differences, mainly the realization of pitch and (syllable) duration, between native and non-native utterances and how these differences are perceived in terms of accentedness.

In general, evidence suggests that L1 speech is produced faster than L2 speech (e.g., [4, 5] regarding mean utterance duration and [6–9] regarding speaking/articulation rate). In the context of speech rate Baese-Berk and Morrill [8] found that non-native speakers showed a slower speaking rate than native speakers but were also highly variable in their speaking rate from utterance to utterance. However, they point out that inconsistencies found in their study might be a consequence of the two tested native languages Korean and Mandarin Chinese. Munro and Derwing [10] investigated the difference of read and extemporaneous speech between Mandarin learners of English and native English speakers. They demonstrated that native Mandarin speakers showed a slower speaking rate than English native speakers in both conditions. Trouvain and Möbius [9] found that for both French learners of German, and German learners of French, L2 speech was produced with a higher articulation rate than speech by native speakers. However, they report that individual habits in articulation rate in the L1 were only partially transferred to L2 speech.

Regarding pitch, evidence suggests that languages show a characteristic use of range and the alignment of pitch accents (e.g., [11–15], see [16] for a comparison of German and French). Concerning pitch in an L2, a number of studies showed that learners have difficulties concerning (global) long term distributional pitch profiles reflected by differences in pitch range and the correct alignment of pitch accents. It has been shown that producing the correct pitch range is hard for L2 learners (e.g. [17–22]). For example, Finnish learners of Russian have been found to realize smaller pitch ranges in comparison to native speakers [18]. Similar results could be replicated for Dutch learners of modern Greek [17] and French learners of German as well as German learners of French [22].

However, Zimmerer et al. [23] showed in a follow-up investigation of German learners of French and French learners of German that no pitch range differences occurred in comparing native and non-native speech for both speaker groups. In this experiment only short sentences were analyzed whereas in [22] the biggest differences in pitch range were shown for short stories. Also, the number of analyzed speakers was different (14 in [22] and 84 in [23]).

Overall, the role of prosody in what is perceived as a foreign accent has rarely been studied. Boula de Mareüil and Vieru-Dimulescu [24] applied a prosody transplantation paradigm on Spanish and Italian native utterances which transfers phoneme duration and pitch contours of one language to another. A perception experiment was conducted to understand what is perceived by native listeners when combining the segmental specification of a synthesized utterance with suprasegmental features of a different language. They found evidence that listeners were more influenced by prosody than by phonemic features in assessing a foreign accent in the case of synthesized speech. Regarding modified natural speech, listeners are equally influenced by segmental and suprasegmental features. However, prosody transplantation was only applied on recordings of native speech, i.e. applying prosodic cues by a native speaker from one language to segmental information by a native speaker from another language.

The question arises whether manipulation of suprasegmental features is helpful to reduce the perceived accentedness of non-native speech by L2 learners. This question was addressed by recent studies. Ulbrich and Mennen [25] investigated Belfast English native speakers and German learners of English with

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and without previous exposure to the Belfast English (BE) accent. They found that manipulating German utterances with the prosodic features of BE speakers lead to a reduced foreign accent rating for both German groups. They also found that transplanting L2 prosody on BE segmental information led to an increase of perceived accentedness.

Winters and Grantham O'Brien [26] investigated prosodic transplantation on accentedness and intelligibility. They recorded German and English sentences of English native speakers with a high proficiency in German and German natives with a high proficiency in English. Manipulation was carried out for duration only and duration in combination with F0. In general, they found that manipulated sentences received higher foreign accent ratings and lower ratings of intelligibility. However, applying native English prosody (duration and F0) to non-native productions, perceived accentedness ratings decreased. Applying native German prosody to non-native utterances also decreased accent ratings but to a weaker degree.

Similar to the previous study, Rognoni and Busà [27] examined speech by Italian learners of English and English native speakers. They transplanted native prosody on non-native segments and non-native prosody on native segments manipulating duration and pitch individually and together. They showed that manipulating both parameters yielded the strongest reduction in accent rating.

Furthermore, Jilka [28] claims that the most important prosodic factor in the perception of foreign accent is intonation. He showed that listeners were able to successfully distinguish between American English and German low-pass filtered stimuli. However, listeners were significantly worse judging low-pass filtered stimuli with monotonous intonation. Also, foreign accent ratings of resynthesized non-native utterances with native intonation showed that the manipulated versions received lower foreign accent ratings.

Most of these studies focus on English as a target language. This study investigates the perceptual effect of L1 prosody transplantation on L2 speech in the case of French accented German.

2. Experiment

We conducted a perception experiment to test how strongly German native listeners perceive the accentedness of German utterances produced by French learners of German with a basic knowledge (A1-A2 level according to the Common European Framework of Reference for Languages: Learning, Teaching, Assessment (CEFR)). As a control condition we also included utterances produced by German native speakers. There were two versions of the sentences produced by the French learners: 1) the original sentences, 2) the same sentences manipulated for syllable duration and pitch based on one male and one female German native speaker. The research question of the perception experiment was whether the manipulated utterances received lower accentedness ratings than the original French accented utterances.

2.1. General Corpus Description

The material for the perception experiment was taken from the IFCASL bilingual learner corpus. The corpus includes read speech material by French (L1) learners of German (L2) and German (L1) learners of French (L2) and was recorded at the LORIA institute in Nancy, France and the Phonetics Department at Saarland University in Saarbrücken, Germany [29–31]. The recorded material includes 1) read sentences, 2) read sentences after listening to a native recording of the sentence, 3) sentences with different focus conditions, and 4) the recording of the story of "The tree little pigs" in French and German versions.

The speakers were recorded both in their respective L2 and in their native language. This not only allows for a within-subject comparison of their productions but also gives the possibility to compare French accented non-native with native German speech and vice versa.

Recordings were made in quiet office rooms with head-mounted microphones, which were amplified and digitized (16khz, 16 bit) in a M-AUDIO Fast Track USB device. Using a custom-made software developed at LORIA (Corpusrecorder, [32]), recordings were saved on Windows Laptop computers.

2.2. Material

Recorded sentences of the story of "The three little pigs" of both French learners of German and German native speakers were used in this perception experiment. We selected ten French learners of German, five male and five female speakers with a basic knowledge of German as well as ten German native speakers, five male and five female speakers. The story contained 13 sentences in total which differed in lengths (14-38 syllables, $\bar{x}$= 23.5 syllables) and difficulty of words (e.g. the word *Schornstein* (chimney) is considered to be a difficult word for French learners of German).

As a first step, all recordings were labeled for disfluencies (e.g. hesitations, repetitions) as well as pauses that appeared after disfluencies. With the help of a Praat [33] script we then removed the hesitation parts of these disfluencies and pauses to allow for a correct prosody transplantation process and in case they might interfere with the accentedness rating.

To apply the prosody transplantation, i.e. manipulation of syllable duration and pitch, we used a Praat script originally used in a variety of studies by Boula de Mareüil and colleagues (see for example [24, 34]). This technique extracts and transplants phoneme by phoneme duration and pitch with the help of the PSOLA algorithm. We decided to manipulate syllables instead of phonemes because the French learners of German often deleted or inserted phonemes. Due to the incremental procedure of the script it could not be ensured that duration and pitch of the same phonemes are matched. However, a correct syllable matching was much easier to obtain by checking for the same number of syllables before applying the technique. However, a few manipulated sentences sounded obviously odd. Unfortunately, this could not be resolved even after checking for correct syllable boundaries and syllable matching.

The manipulation of duration and pitch (see [24]) was narrowed down to the following four-step procedure:

1. Calculating duration coefficients for each syllable or pause of a speaker with respect to the male or female *golden speaker*.
2. Replacing the original syllable durations for each syllable and pause.
3. Calculating F0 coefficients for each syllable of a speaker with respect to the male or female *golden speaker*.
4. Replacing the F0 values for each syllable.

We chose one male and one female German native speaker from the set of ten speakers to manipulate the French accented utterances. Male French speakers were manipulated on the basis of the male German speaker and female French speakers

on the basis of the female German speaker. To decide which German speakers to use for the manipulation, we calculated the mean speaking rate for each speaker and chose the speakers with the median value.

To decrease the length of the experiment, only the first six sentences of the story were used. Overall, the experiment consisted of 180 trials: 60 French accented utterances without disfluencies, 60 German native utterances, and 60 manipulated utterances.

2.3. Acoustic Analysis of the Material

Before conducting the perception experiment, speaking rate and pitch range were extracted automatically using different Praat scripts [33] from the utterances by the German native speakers and French learners of German to examine the difference between native and non-native utterances. To calculate pitch range, minimum and maximum values were extracted using the recommended Praat pitch range settings of a floor of 75 Hz and ceiling of 300 Hz for male voices and 100 Hz and 500 Hz for female voices. To allow for cross-gender comparisons, Hz values were normalized by converting them to semi tones (st). The conversion was performed with the following formula (cf. [35]):

(1) Range = $12 \times \log2(\max f0/\min f0)$

Data analysis was performed using JMP 12 [36] for all tests. For each of the parameters speaking rate and pitch range as a dependent variable, ANOVAs were carried out for the effects of conditions L1 (of the speaker), GENDER, SENTENCE and all their interactions.

2.3.1. Speaking Rate

The statistical analysis for speaking rate (including all sentence-internal pauses) showed that all conditions and interactions had a significant effect except for the three-way interaction. Therefore, the model was performed again without the this interaction. French native speakers have a lower speaking rate (3 syllables/s) than German native speakers (5 syllables/s) when speaking German ($F(1,292.6)=1638.6$, $p<0.0001$) which was expected from the literature. Furthermore, male speakers seem to be faster than female speakers ($F(1,292.6)=6.6$, $p<0.05$). However, this is only true for German male speakers (5.15 syllables/s) in comparison to German female speakers (4.89 syllables/s). No significant difference was found for French male and female speakers who are both significantly slower than German speakers (3.03 and 3.05 syllables/s, respectively) ($F(1,292.6)=8.5$, $p<0.01$). Figure 1 illustrates these differences.

2.3.2. Pitch Range

Similar to speaking rate, all conditions and interactions with pitch range as a dependent factor showed a significant effect. French speakers (19 st) seem to have a higher pitch range than native German speakers (17.5 st) when speaking German ($F(1,440.5)=32.83$, $p<0.0001$). Also, female speakers show a larger range (22 st) than male speakers (14.3 st) ($F(1,17194.4)=1281.55$, $p<0.0001$). The interaction GENDER×L1 ($F(1,2348.8)=175.07$, $p<0.0001$) shows that French female speakers have a significantly higher pitch range than German female speakers (24.1 st and 20 st, respectively). However, French male speakers show a lower range than German male speakers (13.4 st and 15.1, respectively) which is illustrated in Figure 2.

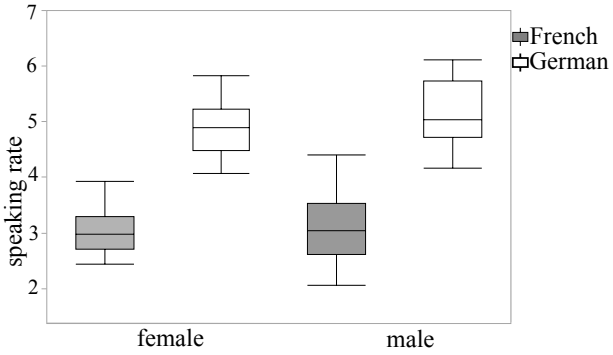

Figure 1: *Box plots for speaking rate (in syllables per second) for male and female German native speakers and French learners of German.*

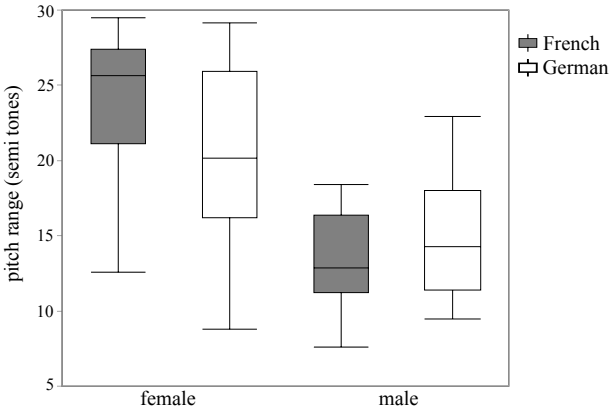

Figure 2: *Box plots for pitch range (in semitones) for male and female German native speakers and French learners of German.*

2.4. Procedure

The perception experiment was carried out as a PraatMFC experiment by ten German native listeners (four male, six female listeners from which six had a phonetic background). Participants were instructed to listen to each utterance with headphones and decide how accented each recording was (1 = not accented, 7 heavily accented) and whether the recording sounded natural or artificial. Before starting the experiment, they received the information that some sentences were manipulated and might sound artificial. They were asked to ignore artificiality when rating accentedness. Furthermore, they did not receive any information about the language background of the speakers.

3. Results Perception Experiment

The ratings of the listeners showed that the productions of native German speakers were rated with a least square mean (LSM) of 1.24, whereas the original productions of learners were rated with an LSM of 5.68 (see Figure 3). Manipulated stimuli received an LSM rating of 4.98. The productions of female speakers were overall rated with an LSM of 3.87, male productions received an LSM rating of 4.07. For all speaker groups, female speakers received a lower LSM rating compared to male speakers (native: female 1.08, male 1.41; learners: female 5.57, male 5,78; manipulation: female 4.95, male 5.01).

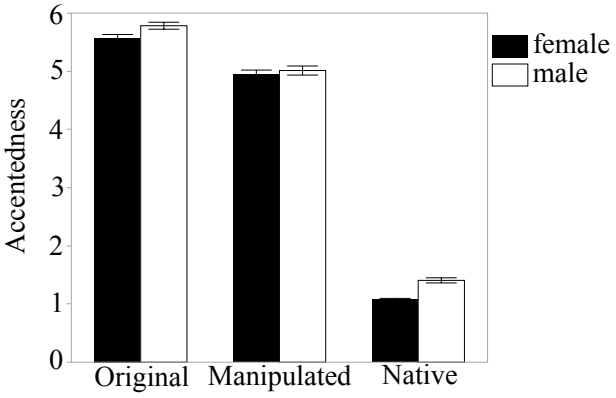

Figure 3: *Mean accentedness ratings for native, non-native (original) and manipulated utterances by male and female speakers.*

A first analysis was carried out to test the extent to which the transplantation had an effect on perceived foreign accent. The responses were entered into the model as continuous variable into a linear mixed model with RATING as dependent variable, PARTICIPANT and ITEM as random variables, and SENTENCE (1-6), GROUP (native, learner, manipulated), SPEAKER GENDER, and all two-way interactions were entered as fixed factors. The analysis showed that GROUP ($F(2,154)=2534.86$, $p<0.0001$) and SPEAKER GENDER ($F(1,154)=13.67$, $p<0.001$) were significant factors. No other factor or interaction was significant.

With respect to the naturalness ratings, native productions were rated as natural 578 (out of 600) times, learner productions were rated as natural 550 (out of 600), and manipulated items as natural 121 (out of 600) times. Thus, manipulated productions were rated significantly more often as unnatural compared to native and the unmanipulated items.

4. Discussion

The material that was used for the research reported here replicated earlier findings showing that language learners produced L2 speech slower than native speakers, and that there is a difference with respect to the use of pitch in the L2. Although the investigated male French learners of German seem to have a lower pitch range than male German native speakers, the opposite holds true for the investigated female speakers. Unfortunately, no comparison can be drawn to pitch range values of the learners speaking their native language. Because pitch was extracted automatically, errors in the extraction of minimum and maximum pitch values can also not be ruled out.

These differences in native and non-native speech rate and pitch range let us analyze the degree of benefit the learners' productions can receive when native speakers' prosodic features are transplanted onto the learners' productions. By using the technique of prosody transplantation which was already successfully applied by [24] on synthesized and natural speech, we transferred syllable duration and pitch contours of a German male and female golden speaker onto the non-native utterances of French learners of German. Results of a perception experiment suggest that the manipulation of pitch and syllable duration reduces the perceived foreign accent. However, listeners in the experiment rated the manipulated stimuli more often as unnatural than unmanipulated stimuli. Nevertheless, this shows that listeners - despite perceiving manipulated stimuli as less natural - still judged the items consistently as having less accent compared to original learner productions.

Other studies investigating the effect of prosody transplantation argue that although manipulation of (phoneme or syllable) duration and pitch contour has a beneficial effect on the perceived accentedness of non-native utterances, segmental information still has a strong influence [25–27]. Our perception experiment can be interpreted in a similar way. Although foreign accent rating decreased significantly from an LSM of 5.68 for original productions of learners to an LSM of 4.98 for manipulated utterances, the rating for manipulated utterances is still considerably high. This might be an impact of non-native segmental cues which were not manipulated.

Another explanation might be the influence of the manipulation procedure itself. Winters and Grantham O'Brien [26] noted the decline in quality of the produced stimuli after applying the PSOLA synthesis algorithm which is also noticeable for this experiment. Manipulated productions were rated significantly more often as unnatural compared to native and unmanipulated items. Only 121 items (out of 600) were rated as natural. As a matter of fact, for some utterances the prosody transplantation created a strong artificial outcome, including odd pitch behavior as well as syllables with either too long or too short durations. But even if the prosodic cues were transplanted *correctly*, most of the manipulated utterances remained somewhat artificial.

5. Conclusion

Despite perceiving manipulated stimuli as less natural, utterances were consistently rated as having less accent compared to original learner productions. This means that transplanting syllable duration and pitch from a native utterance to a learner's non-native production does have a positive influence on the perception of non-nativeness.

Regarding feedback in second language learning, prosody transplantation might be considered to be a promising technique. Bissiri and Pfitzinger [37] showed that resynthesizing the voice of Italian learners of German had a beneficial and motivating effect on learning lexical stress in German. Also, Henry et al. [38] propose a tool for analyzing, processing and visualizing of a learner's speech to help acquiring the correct prosody of a foreign language.

It would be interesting to see whether language learners find it helpful to 1) hear their own voice manipulated for syllable duration and pitch contour, and 2) whether they would be able to extract and implement useful information from the manipulation to their productions.

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