A Case Study of Extreme L1 Attrition in the Domain of Phonetics

Esther de Leeuw
Aurela Tusha
Hui Zhao
Kyle Helke
Alice Greenfield

Queen Mary, University of London

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ABSTRACT

Research on L1 attrition of speech generally investigates group data, often making generalisations based on the group's norm (see de Leeuw, Schmid & Mennen 2010; de Leeuw, Mennen & Scobbie, 2011; 2012; although Mayr, Price & Mennen, 2012 is a recent exception). In contrast, the focus of the present research was to investigate a case study of L1 attrition in the domain of phonetics. The analysis of this late bilingual's speech was specifically chosen because he displayed L1 attrition in all of his previously investigated phonetic variables, whilst other comparable late bilinguals, with similar ages of L2 acquisition, did not do this to the same extent (see de Leeuw et al., 2010; 2011; 2012 for comparisons of this participant in group analyses). Therefore, as an outlier within a larger group, he is considered to be an exemplary case of extreme L1 attrition in the domain of phonetics, indicating instability of L1 speech which may go unnoticed in group analyses. More specifically, results from the analysis of his speech revealed that, like the previously investigated phonetic variables, his L1 German rhotic deviated from the expected German monolingual norm. Indeed, the F_2 and F_3 frequencies of his German rhotic (identified to be English-like in a preliminary impressionistic analysis) were within the English rhotic norm, i.e. for these tokens his F_2 and F_3 frequencies were English-like in both his German and English. The results of both the impressionistic and acoustic analysis are discussed in relation to the amount and type of his German and English language use; and it is suggested that his extreme L1 attrition in the domain of phonetics may have resulted from his prolonged reduced use of German coupled with extended complete immersion in a monolingual English environment.

INTRODUCTION

According to a maturational constraints perspective, the loss of plasticity for language processing in the brain makes the L1 resistant to loss when an L2 is acquired in adulthood. Furthermore, it has been claimed that the L1 stabilises around the age of 12, at which point it can essentially cope with the L1 not being the dominant language without significant loss (Bylund, 2009). Indeed, there is a growing body of research which suggests that the L1 system can be dramatically eroded if the onset of L2 acquisition occurs before puberty (Köpke & Schmid, 2004). In line with this, since Oyama (1976), studies have suggested that L2 acquisition is moderated by a sensitive period, e.g. Long (1990; 2005) suggests there exists a sensitive period, typically between 6 and 12 years old, for the phonological

system, thereby avoiding a "cut-off point" (see also Lee & Schachter, 1997). What unifies all of these explanatory models is that they premise some kind of biological constraint which differentiates language development in adulthood from language development in childhood. Indeed, although to date no L1 attrition research incorporates both child and adult L2 learners, research which has focused on speakers for whom L2 acquisition began after the age of 12 has not been able to find anything close to such a dramatic loss for prepubescent attriters (Schmid, 2011). In contrast to a maturational constraints perspective, Flege's (1995; 2003) Speech Learning Model (SLM) proposes that the phonetic system(s) of both the L1 and L2 can adapt throughout one's life. According to this model, when the sounds of an L2 are encountered, the phonetic system will either form new categories or modify existing ones to accommodate these speech sounds. Similar to the maturational constraints perspective, the SLM proposes that although young learners are able to accommodate L2 speech sounds through new categories, those who learn the L2 in late adolescence or adulthood will only form a new category for L2 sounds which are perceptually different. Moreover, according to SLM, interlingual identification prompts the L2 learner to "merge" (Flege, 1987: 62) the phonetic properties of L1 and L2 similar phones into a category that is intermediate to the two respective language categories. Accordingly, the interaction between the two languages results in inaccuracies and deviations from monolingual norms in both the L1 and L2. Therefore, within SLM, there is an acknowledgement of accommodation of the L1 speech system upon L2 acquisition *throughout* life, which is not stipulated to the same extent within frameworks based on maturational constraints.

In line with SLM, numerous studies have indicated that both the L1 and L2 phonetic systems adapt across the lifespan. For example, in their study of VOT productions of native-French speakers living in the US, Flege and Hillenbrand (1984) found that interlingual classification leads the French speakers of English to merge the phonetic properties of French and English /t/ because they judge these acoustically different phones to be realisations of the same phoneme. Evidently, the late L2 learners do not establish new categories for "similar" phones, but rather identify them as belonging to the same category. This not only prevents late learners from producing L2 phones natively, but also causes existing L1 structures to be modified.

This finding was also replicated in Flege (1987), in which he examined VOT of both native American-English speakers living in Paris, and native French speakers living in Chicago. Exposure to the L2 began in late adolescence or adulthood, thus what is generally considered to be past the potential plastic phase for language processing in the brain. Results revealed that for both groups, the VOT of their native language became more like the VOT of the L2. This meant that the native English speakers immersed in a French environment produced shorter English VOT than English monolinguals. Likewise, the native French speakers living in the US produced longer VOT in French than the monolingual group. Again, Flege (1987: 62) found that the phonetic properties of English and

French /t/ were "merged" as the participants tended to have intermediate VOT values in both languages.

Similar to Flege's studies, Major (1992) examined the VOT of five native American-English speakers who had been living in Brazil for between 12 to 35 years. All subjects had moved in adulthood – the youngest age of arrival was 22. This again meant that if maturational constraints determined language learning, the L1 system should not be affected as a result of migration to a country where the L2 is acquired as the dominant language. For the participants in Major's study, using English was an essential part of their daily roles; however, despite "strong personal and professional reasons to maintain their L1", all of the participants in the study displayed some loss of their native English (Major, 1992: 200).

The question of whether a speaker's native speech is affected by the knowledge of an L2 acquired in adulthood was also addressed by Dmitrieva, Jongman and Sereno (2010). In their study, Dmitrieva et al. examined word-final devoicing in Russian, a language with minimal pairs that have an underlying voicing distinction for final stops and fricatives. The study examined three participant groups. Among these were native speakers of Russian living in the US who had extensive knowledge of English, a language that maintains a voicing contrast for final obstruents. As was the case in the previous studies, it is important to note that in their study, the participants acquired English in late adolescence or adulthood. The Russian speakers that were immersed in an English environment were found to devoice word-final obstruents in their native language less than their monolingual Russian counterparts, indicating that an English phonemic contrast in coda position affected the allophonic variation of Russian native speech. In line with the previously discussed studies, this investigation similarly revealed that the acquisition of an L2 can result in significant changes in L1 speech production.

The studies discussed thus far did not take into account the impact of language use on phonetic L1 attrition. Although some non-phonetic studies (e.g. Schmid, 2007 and Gürel 2004; 2007) have examined L1 attrition and language use, there is presently little research examining the relationship between L1 attrition of speech and language use. However, in a recent study on German native speakers who migrated to Canada or the Netherlands, de Leeuw, Schmid & Mennen (2010) investigated whether a foreign accent rating in the L1 correlated with age at which the L2 was acquired (AOA), length of residence (LOR) in the host country, and quantity and quality of contact, i.e. amount and type of L1 language use. Of these variables, AOA and LOR were not significant predictors of the L1 foreign accent ratings of the late bilinguals. Instead, the results indicated that German native speakers with a high amount of C-M (language use in which code-mixing in the L1 was not expected to occur, i.e. in a monolingual environment) were less likely to be rated as non-native speakers of their L1 than those with a high amount of C+M (language use in which code-

mixing between the L1 and L2 was expected to occur, i.e. in a bilingual environment). Such findings give rise to further investigations examining the relationship between phonetic L1 attrition and language use, such as the study at hand aims to do.

PRESENT INVESTIGATION

The present case study examines L1 attrition in a specific late consecutive bilingual, FS, who moved to Anglophone Canada at the age of 20, from Diestedde, Nordrhein-Westfalen, in North-West Germany. At the time of the recording, FS was 73 years old and had been living in Canada for over 50 years (see Table 1). The reason for his immigration was primarily economic as he was expecting to find a better job in Canada. Regarding education both in Germany and Canada, FS finished the *Realschule* in Germany, taking English, Latin and some French, and, after moving to Canada, he completed a 4-year BA in English, French, Business and Economics. In Canada, he met his Scottish-born wife, with whom he only spoke English, and with whom he had been married for 49 years. He had two adult daughters with his wife and three grandchildren, with whom he also spoke English. FS was retired at the time of recording, but previously, he had worked in a relatively high position in the information technology sector of a large company. During the interview, the general impression of FS was that he was outgoing and enjoyed conversing with the interviewers (e.g. after data collection, he invited the interviewers to dinner). Finally, FS reported to have no regional accent when speaking German, although he claimed to have learned *Plattdeutsch* before entering school. Similarly, although his wife was Scottish, the interviewers perceived him to have a standard American accent in his English. More information regarding the exact quantification of his language use is discussed in section 4.6.

As already mentioned, what was particularly interesting about FS was that in previous investigations of his speech, he consistently displayed “merging” (Flege, 1987: 62) in the phonetic variables investigated; and he did this to a much greater extent than the other participants. For example, in a previous study involving FS, de Leeuw et al. (2012) conducted an analysis of the lateral phoneme /l/, and found that FS displayed merging of the /l/ phoneme in his German and English. In another phonetic task, he displayed prosodic L1 attrition in his native German (de Leeuw et al., 2011). Finally, in a study examining the perception of foreign accented native speech, FS was rated to be a non-native speaker of his native German consistently by German functional monolinguals (de Leeuw et al., 2010). Taken together, the previous studies indicate that FS underwent extreme phonetic L1 attrition in his native German speech. The current study adds to the formerly mentioned by examining potential phonetic L1 attrition his FS’ /r/ phoneme. As such, the primary objective of this case study was to initially investigate whether FS exhibited any L1 attrition of the German rhotic at all. Confirmation of L1 attrition of the German rhotic was interpreted as support for the SLM, rather than for the maturational constraints perspective, as, according to a strict interpretation of maturational

constraints, one would expect little L1 attrition in his German rhotic. Furthermore, a secondary objective was to determine whether FS produced two discrete categories for the rhotic, or whether they were "merged" into one category. Given that the SLM predicts intermediate merging, i.e. a new phone emerges which is intermediate to the two respective language norms, the secondary objective was more specifically to examine whether the predicted new category was indeed merged *between* the German and English norms, or whether it more clearly aligned with *either* the German norm *or* the English norm. Finally, taking the findings from previous investigations which involved FS into consideration, the third objective of this case study was to examine how language use may have impacted the extent of attrition FS' native speech underwent. In doing this, the amount and type of FS' language use was compared with the other participants.

GERMAN AND ENGLISH RHOTIC PRODUCTION

In most dialects of Standard American English (AE), /r/ is realised as a voiced retroflex approximant (Ladefoged & Maddieson, 1996; Wells, 1982)[1] whilst the German rhotic can be articulated either as a voiced alveolar or uvular trill, or as a voiced uvular fricative, the latter of which is most common in Standard German (Ladefoged & Maddieson, 1996; Wells, 1982). The alveolar trill is produced by the tip of the tongue vibrating against the alveolar ridge, whereas the uvular trill involves the uvula vibrating against the tongue dorsum (Thomas, 2010; Davenport & Hannahs, 2010). Kohler describes the German rhotic, when it is not vocalised in post-vocalic position, as a uvular fricative. More specifically, he (1977: p. 169) writes: "*Im alemannischen und bayrisch-österreichischen Sprachraum, aber auch in Schleswig-Holstein, gilt weithin ein apikaler Vibrant [r] bzw. die Reduktion zum Anschlag; auch uvularer Vibrant [R] kommt vor. Sonst sind uvularer Frikativ und friktionsloser Laut vorherrschend, die immer mehr an Vertreitung zunahmen.* [...]."[2] Crucial to the current investigation, the German rhotic is not acoustically characterised by a low F_3 frequency. For example, Ladefoged and Maddieson suggest an average F_3 frequency of between 2500 and 3000 Hz for Standard German (1996 : 226).

Alternatively, one can investigate the AE rhotic through analysis of the F_2 and F_3 frequencies which both have the salient acoustic cue of a low value (Zhou, Espy-Wilson, Boyce, & Tiede, 2007; Zhou et al., 2008; Ladefoged & Maddieson, 1996; Thomas, 2010; Lawson, Stuart-Smith, Scobbie, Yaeger-Dror & Maclagan, 2011). The characteristically low F_2 and F_3 frequencies for the retroflex

[1]It should be noted that the American English retroflex approximant here also includes Canadian English. This is based on studies which show that the consonantal system of American and Canadian English is very similar (Wells, 1982).

[2] The translation of this is: In both Schleswig-Holstein and the Alemannic and Bavarian-Austrian German language areas, the apical trill [r], or reduced contact , are widely evident, along with the presence of the uvular trill [R]. Otherwise, the uvular fricative and fricationless sound, which have experienced increased use over time, prevail.

approximant may be associated with a constriction in the lower pharynx, as well as lip rounding (Alwan & Narayanan, 1996: 1085). Indeed, the AE /r/ is reported to have three cavities: "one between the glottis and the pharyngeal constriction, another between the pharyngeal and dorsal or apical constrictions, and the third in front of the dorsal or apical constrictions, including the space underneath the tongue" (Thomas, 2010: 132). For American English rhotics, Dalston (1975) found average F_2 frequencies of 1061 Hz for male and 1165 Hz for female adults and for F3 frequencies respectively 1546 Hz and 2078 Hz. Thomas (2010) provides an F_3 value for English rhotics ranging from 1300 Hz to 1950 Hz, i.e. much lower than Ladefoged and Maddieson's average Standard German F_3 frequency of between 2500 and 3000 Hz for male speakers (1996 : 226).

METHODOLOGY

Stage 1 of this study was an impressionistic analysis of /r/ in all of the late consecutive bilinguals from de Leeuw's (2009) original study. Thereafter, FS' language use was examined and compared with the other participants of stage 1 in order to determine whether language use played a role in his L1 speech production of the rhotic. Finally, an acoustic analysis of specifically FS' /r/ realisations occurred. Note that in the acoustic analysis, only tokens which were impressionistically identified as being the AE rhotic were measured. This was done in an attempt to obtain clear resonatory formant frequencies in the acoustic analysis, which are not evidenced to the same extent in trills and fricatives as they are in approximants.

DATA COLLECTION

Ten late consecutive bilingual German immigrants to Canada were interviewed at the Interdisciplinary Speech Research Laboratory at the University of British Columbia in Vancouver in December, 2006 (see de Leeuw et. al 2010; 2011; 2012 for more information regarding data collection). At the time of interview, all participants completed a questionnaire examining their language backgrounds, conducted to ascertain more information about their language use. Languages were separated during data collection to ensure the participants were producing one language with the least influence from the other. Instead of the participants filling in the questionnaires, it was the experimenter who first read the questions out and then took note of the corresponding answers. After answering all questions in the questionnaire, participants were asked to read the word list eliciting /r/ in onset position. This word list contained distracters as well as other words containing phonemes for additional analysis (see de Leeuw et al. 2011 for more information regarding elicitation of the word lists). Appendix A provides a list of all 26 German /r/ tokens in onset position which were analysed in this study.

PARTICIPANTS

The group was made up of ten German L1 - English L2 bilinguals, who had moved to Canada in late adolescence or early adulthood and lived there for 18 years or more (see Table 1). German native speakers' sex, age of arrival to Canada, i.e. age of English acquisition (AOA), LOR in Canada and age at time of recording (AAR) are shown in Table 1, with FS at the very top of the table.

Table 1. Gender, AOA, LOR and AAR of all participants.

Participant	Sex	AOA	LOR	AAR
FS	Male	21	53	73
BG	Male	16	48	72
CL	Female	19	22	41
DZ	Male	24	55	79
GB	Female	32	29	61
IKH	Female	29	18	47
ID	Female	20	49	69
MZ	Female	32	48	80
MB	Female	23	38	61
RMW	Female	23	40	63

IMPRESSIONISTIC ANALYSIS

Before the impressionistic analysis was conducted, the words with initial /r/ were extracted from each individual participant's interview. For each participant a single sound file was created, containing all of their /r/ tokens, to aid the analysis process. The impressionistic analysis was conducted by two native English speakers, one male and one female, who both had German as an L2 and respectively AE and British English as an L1. This stage of the analysis was conducted in order to ascertain whether the subject of the study, FS, was perceived as different from the other late consecutive bilinguals. Those words which were perceived to be English realisations were marked 1 and those which were perceived to be German-like were marked by 0. Note that the analysis was skewed in that only those German tokens which were perceived to be completely English (with no trace of a German accent) were marked as 1. During this process, the raters were able to listen to the tokens as often as needed and a general judgement was made afterwards. In cases in which neither of raters could make a judgement with certainty, the token was classified as German-like (0) to ensure the genuineness of all English-like tokens. As discussed in the results, based on this preliminary impressionistic analysis, participant FS stood out as displaying a greater number of English /r/ tokens in a German speaking context.

INDEXING LANGUAGE USE AND MIXING

A further question addressed in this project was whether the potential attrition of the German rhotic in FS' speech was linked to his amount and type of language use. In order to investigate this question, a way of quantifying amount and type of language use was necessary. Information regarding language

use was obtained through the language background questionnaire; only selected portions of this questionnaire are discussed here.

Amount of L1 and L2 use was an averaged variable which focused on the present language network of the participants. This predictor variable was calculated based on responses to both the German and the English language background questionnaires. For example, in the English questionnaire, the following question was posed: "Could you please indicate to what extent you use English with the following people? Also, to what extent do these people speak English with you?" Various members of the participant's potential language community were (1) my partner; (2) my children; (3) my grandchildren; (4) my relatives (aside from the above); (5) my partner's relatives (aside from the above); (6) my friends in Canada; (7) my friends in Germany; (8) my colleagues in Canada; and (9) my colleagues in Germany. For each category, the option of choosing between 'Always', 'Usually', 'Sometimes', 'Rarely', or 'Never' was given. The participant therefore indicated not only the extent to which he or she spoke English, but also the extent to which English was spoken to him or her. When a category was not applicable to the participant, for example because he or she had no children, it was left empty. In the corresponding German questionnaire, a translation of the same categories was completed by the participants with the option of choosing between '*Immer'*, '*Meistens'*, '*Manchmal'*, '*Kaum'*, or '*Nie'*. As with the English translations, in their quantification, these responses were allocated respectively 1, 0.75, 0.5, 0.25, and 0.

Thereafter, two scales were created from each questionnaire. The first scale represented the amount, or quantity, of language use the participant had with either German or English for each category (denoted as respectively AmountGUse and AmountEUse). The second scale represented the amount of mixing, or quality of use, the participant had with either English or German. If participants noted that they 'Always' or '*Immer'* spoke either English or German with the specified members of their language community, it was assumed that no mixing occurred with these individuals. The same was true if the participants noted that they 'Never' or '*Nie'* spoke that language with the specified members. On the other hand, 'Usually', or '*Meistens'* and 'Rarely', or '*Kaum'* indicated somewhat more language mixing. 'Sometimes', *or* 'Manchmal', was interpreted as the most language mixing. When investigating quantity of German language use, each category which was completed by the participant was given a value according to the scale. For example, if a participant marked that she always spoke German to her partner, but that he usually spoke German to her, the average of 0.88 was calculated for this category (1+0.75 / 2 = 0.88). This procedure was carried out for each completed category by the participant in each language. In all but two cases, the amount of German use plus the amount of English use was more than 1.0. This meant that participants tended to over-assess the amount of language use, since, theoretically, AmountEUse + AmountGUse = 1should hold for each category. In order to solve this problem, the normalised total amount of language contact was obtained for each category (AmountGNormalisedUse and AmountENormalisedUse), which was derived from the absolute total amount, as shown in the equations below.

AmountGNormalisedUse = AmountGUse / AmountEUse + AmountGUse

AmountENormalisedUse = AmountEUse / AmountEUse + AmountGUse

This gave rise to the normalised amount of use for each participant for each language for the given category. Generally, the assessment of the language input (the extent of English or German spoken to the participant) and language output (the extent of English or German spoken by the participant) was the same. In some cases, however, the language input and language output were not identical for the same category. Once each of the maximum of nine categories had been normalised, an average amount of language use was obtained for each participant (AGermanNormalised and AEnglishNormalised). The following equations describe this process for both German and English with n denoting the number of answered categories (n = 9).

$$\text{AGermanNormalised} = \frac{1}{n}\sum_{c=1}^{n} \text{AmountGNormalisedUse}$$

$$\text{AEnglishNormalised} = \frac{1}{n}\sum_{c=1}^{n} \text{AmountENormalisedUse}$$

As already mentioned, amount and type of German language use were used as predictor variables in order to determine whether they affected the results from the impressionistic analysis. Other information about the participants was documented through the questionnaire, such as frequency of visits to Germany and contact with German media. Moreover, a high amount of mixing in German, quality, was attained if, for example, a participant noted that he 'sometimes' spoke German with his children, and that they 'sometimes' spoke German with him. In order to determine the amount of mixing in German for each bilingual, the average from all categories (according to the quality scale) was calculated. Note that this data was not normalised and it did not necessarily correlate with amount of language use. A low amount of mixing was assumed if 'Always' or 'Never' were chosen, whilst the former would have indicated a high amount of language use, and the latter was indicative of a low amount of language contact.

ACOUSTIC ANALYSIS

The acoustic analysis of FS' word initial /r/ phonemes was conducted in order to determine whether the /r/ tokens, impressionistically analysed as AE realisations in his German speech, actually fit within the range of AE /r/ phonemes. Using Praat, F_2 and F_3 frequencies were measured in these tokens. A number of conventions were followed in order to ensure consistency across the analyses. The start of the articulation of the /r/ phoneme was carefully measured at the onset of periodicity at the point at which the waveform crossed the 0-axis. A second marker was then automatically inserted at 50ms

after the onset of the phoneme and the exact point of measurement was inserted at the point that was visually closest to this 50ms mark, but where the waveform crossed the 0-axis. In all cases, it was ensured that this measurement was taken before the increase in amplitude characteristic of the following vowel. Note that alternative points of measurement, e.g. 40ms and 60ms after the start of the onset, were trialled, but 50ms most effectively consistently captured formant measurements within a steady state of the /r/ realisation.

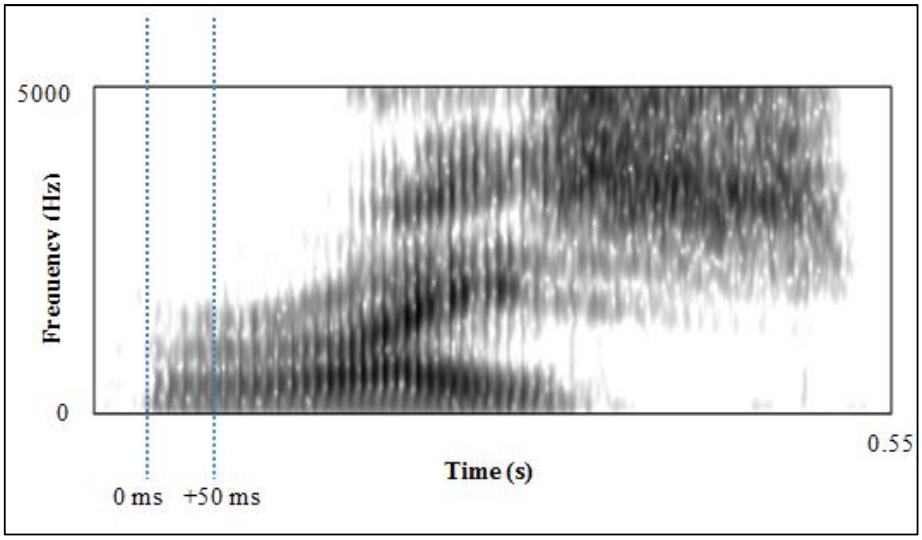


Figure 1. The word *Reis* as articulated by FS. In this example, F_2 is 1000 Hz and F_3 is 1540 Hz.

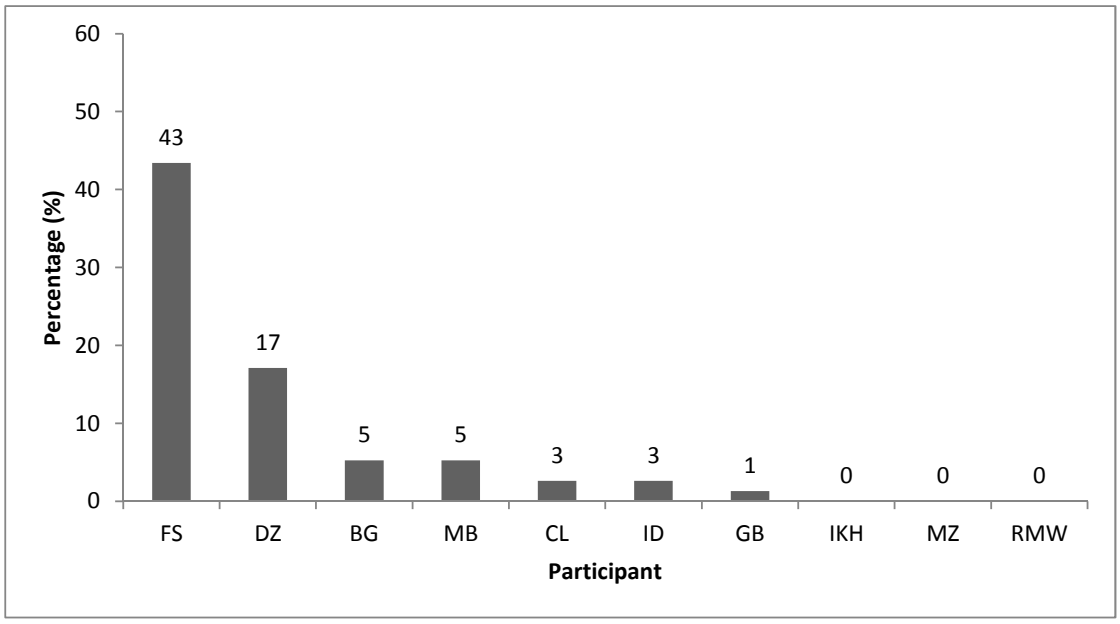
Using the automatic Praat analysis of formants as a guide, visual measurements of the formant frequencies were taken in Hertz (Hz) for F_2 and F_3, as illustrated in Figure 1. For each formant measurement, the frequency was rounded to the nearest 10 Hz in order to ensure consistency and avoid drawing out major inferences from what may in fact be minor differences in the data (Foulkes, Docherty & Jones, 2010). Again, F_2 and F_3 frequencies were measured in the German tokens rated as English realisations in the impressionistic analysis and in FS' parallel English elicitation task (see Appendix A and B respectively for list of German and English words).

RESULTS

RESULTS FROM THE IMPRESSIONISTIC ANALYSIS

Results of the impressionistic analysis on all participants are shown in Figure 2, in which the percentage of the English realisations in the German rhotics is shown. As displayed below, the results from the impressionistic analysis indicated that FS was the most salient of all participants in his English production of the German rhotic.

Figure 2. Percentage of German tokens pronounced with English realisation.



Thirty-three of 76 tokens produced by FS were perceived to be English-like, and this percentage (43%) was much higher than that of any other participants (ranging from 0% to 17%). Among other participants, IKH, MZ and RMW had zero English realisations of the German rhotics, while five other participants had some English-like tokens: 1% for GB, 3% for CL and ID and 5% for BG and MB respectively. It was also noticeable that participant DZ came second in the production of English-like realisations of German /r/ having 13 English realisations (17%). Although this percentage was much higher than other eight speakers, it was nonetheless much lower than FS' results. A chi-square test revealed that there was a significant difference between the different participants' realisations of German rhotics, $X^2 = 180.75$, df = 9, $p = 0.001$.

RESULTS FROM LANGUAGE USE AND MIXING ANALYSIS

Results from the language use and mixing analysis can be seen in Table 2, which displays that FS used German much less frequently than English, similar to participants BG, CL, FS, IKH, and ID. In

contrast, participants DZ, and GB had an average of more German use than English use whilst participants MZ, MB and RMW had approximately an equal amount of English and German use.

Table 2. L1 and L2 contact and language mixing for all participants

	Amount of German spoken in network	Amount of English spoken in network	German mixing total	English mixing total
FS	0.354	0.646	0.179	0.028
BG	0.269	0.731	0.250	0.188
CL	0.356	0.644	0.167	0.083
DZ	0.657	0.343	0.500	0.500
GB	0.593	0.407	0.286	0.214
IKH	0.250	0.750	0.167	0.250
ID	0.394	0.606	0.194	0.357
MZ	0.539	0.461	0.286	0.281
MB	0.504	0.496	0.250	0.179
RMW	0.426	0.574	0.350	0.200

In addition to total amount of English and German spoken on a daily basis by all participants of this study, Table 2 also displays the total amount of language use in which code-mixing was expected to occur. Evidently, some bilinguals had a similar amount of mixing in both languages (i.e, participants DZ, MZ and GB). FS, on the other hand, displayed a much lower score for mixing in English than in German. Taking into consideration FS' total reported use of English and German, it appears that English had not only become the dominant language in his daily life but that FS was very unlikely to mix languages when conversing in English, although this was not necessarily the case when speaking in German. Indeed, FS was unique in that he had one of the lowest German mixing indexicals and the lowest English mixing indexical, demonstrating that he rarely, if ever, mixed the two languages, and, when he spoke English, he essentially never used German. Moreover, his biographical data from the questionnaire indicated that, out of all the participants, he was among one of those who has been with their partner the longest (48 years). In addition, he was one of three participants whose partner was a native English speaker and with whom he claimed to speak only English. If this personal information is considered in light of his responses regarding his German usage rates and exposure to German media, it is apparent that FS actually received very little real world exposure to German. For example, he reported listening to German radio and reading German newspapers only once or twice a month, and although he had the highest rate of time spent telephoning German contacts and the second-highest rate of time spent writing emails to German contacts, he claimed to speak German only once a month, second only to one other participant, who claimed to never speak German with German contacts. Based on this data, it appears that FS not only received little to no German exposure from personal interaction, but that English – with no mixing from German, i.e. with English monolinguals - was the dominant language in FS' life.

RESULTS FROM ACOUSTIC ANALYSIS

In order to further analyse merging in FS' production of rhotics, an acoustic analysis was performed on his German and English speech. A comparison of mean frequency and standard deviation between German and English are given in Figure 3.

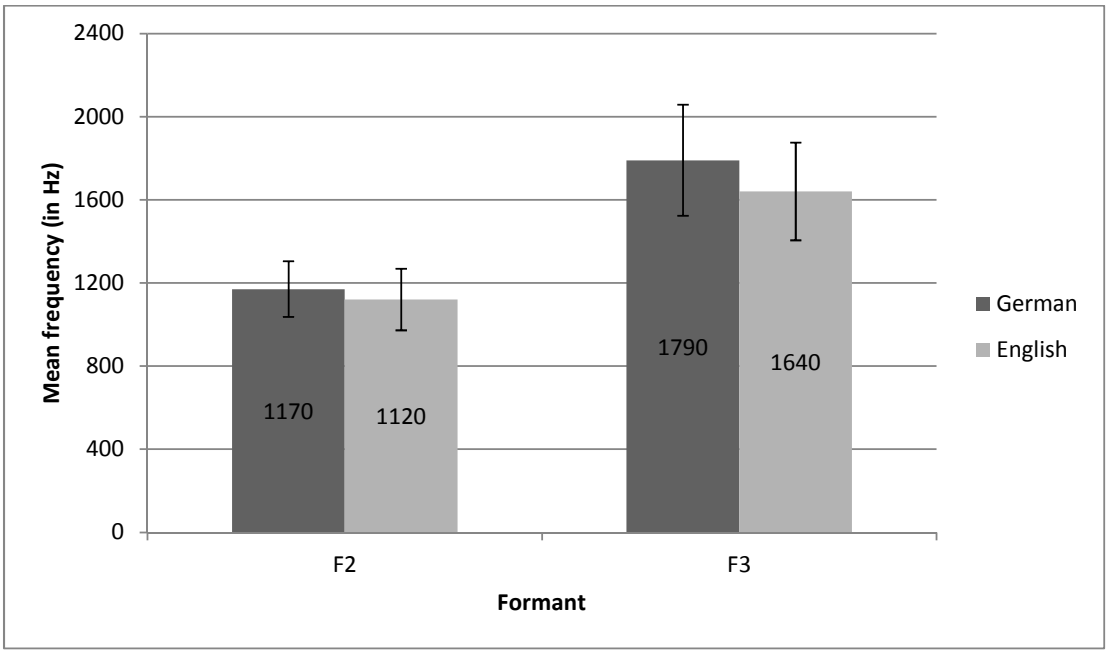


Figure 3. Mean F2 and F3 frequency (in Hz) for English-like German rhotics and English rhotics for FS (the vertical lines within the bars display standard deviations).

As can be seen from the above figure, both formants had higher frequencies in German than in English. Tests of normality showed neither FS' F_2 (p = .001 with df = 107) nor F_3 (p = .000 with df = 107) were normally distributed. Therefore, Mann-Whitney U tests were performed on both FS' F_2 and F_3 frequencies in English and German to determine whether there were significant differences. The results revealed that the medians of the German and AE formants were very similar (see Table 3) and that they were within the AE norm values (recall for AE rhotics, Dalston (1975) found average F_2 and F_3 frequencies for males of respectively 1061 Hz and 1546 Hz whilst Thomas (2010) provides an F_3 value for English rhotics between 1300 Hz and 1950 Hz.). Nonetheless, the F_3 of FS' German rhotic was significantly higher than that of his English rhotic (65.45 vs. 48.89 in mean rank, $p < .05$). However, this effect size was fairly small (r = .247). A similar result was obtained regarding his F_2 frequency (63.18 for German vs. 49.91 for English in mean rank, $p < .05$). Here, however the effect size was even smaller, r = .189. More details of tests results on FS' English and German F_2 and F_3 are provided in Table 3.

Table 3

Mann-Whitney U tests on language differences for F_2 and F_3

	Md	Mean Rank	N	U	Z	*P*	r
F_2	1150	**63.18**	33	918	-2.049	.040*	.189
(German*English)	1110	49.91	74				
F_3	1840	**65.45**	33	843	-2.552	.011*	.247
(German*English)	1590	48.89	74				

*Notes: *p* < .05, higher ranks shown in bold type.

A scatterplot presented below (Figure 4) shows the distribution of F_2 and F_3 frequencies in the two languages. It can be seen that there is no visual separate clustering of English and German frequencies. Most of the F_3 frequencies in both languages fall in the range of between 1300Hz and 1950Hz and most of the F_2 frequencies fall in the range of between 900Hz and 1300Hz, suggesting a rather similar English-like realisation of /r/ in both languages.

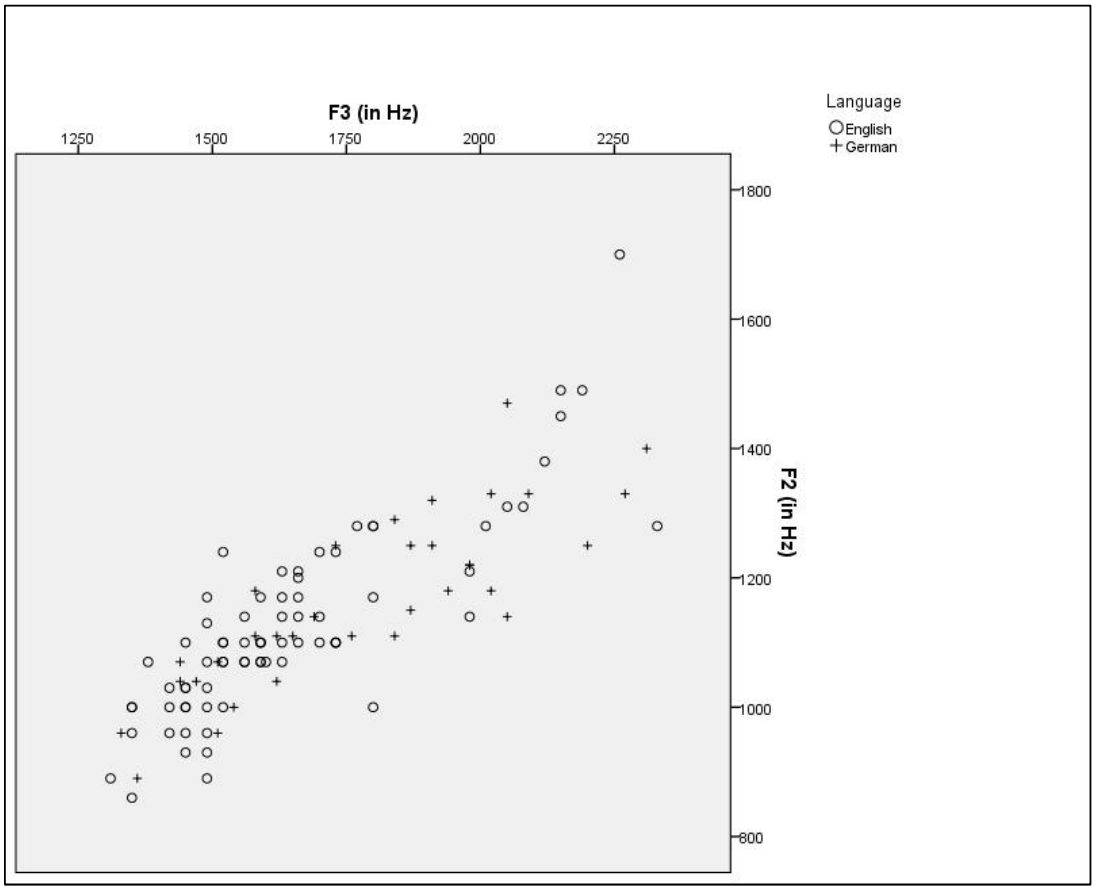


Figure 4. Scatterplot of F_2 and F_3 frequencies in American FS' English and German rhotics.

DISCUSSION

The results of the impressionistic analysis indicated that participant FS consistently performed more English-like in all of his phonetic tasks than any of the other experimental participants. FS was rated in the impressionistic analysis to have a significantly higher number of English-like realisations of the German rhotic /r/ (Figure 2). Accordingly, to a certain extent, these impressionistic results challenge a maturational constraints perspective on L1 speech development, which would not predict an English-like pronunciation in the German words of this late L2 acquirer. Alternatively, these impressionistic results support the SLM which acknowledges accommodation of the L1 speech system upon L2 acquisition *throughout* life.

In an attempt to explain FS' English-like pronunciation of the German rhotic, FS' language use was examined. Here, it was observed that FS had one of the lowest rates of German usage and one of the highest rates of English usage. Similarly, he had one of the lowest German mixing indexicals and the lowest English mixing indexical, demonstrating that he rarely, if ever, mixed the two languages. Moreover, it appeared that FS received very little real world exposure to his native German language: his exposure to German media was limited to radio and newspapers, involving little personal interaction. Having spoken English to a native English partner for 48 years, English – with no mixing from German, i.e. with English monolinguals – was the dominant language in FS' life. It may have been that this high rate of monolingual English use triggered the extreme phonetic attrition FS appeared to undergo. Recall that de Leeuw et al. (2010), found that the bilinguals who were not predicted to code mix to a large degree were more likely to retain their L1. In the present paper, FS may not have had the lowest rating of amount of code mixing in his German speech, but he reported to code-mix the least when speaking English and to have much more contact with English than with German.

An additional objective of this study was to conduct an acoustic analysis on FS' rhotics in order to determine whether FS produced two discrete categories for the rhotic, or whether they were "merged" into one category, as would be predicted by SLM. The results of this acoustic analysis lent empirical support to FS' English-like German pronunciation. As mentioned above, an analysis of the F_2 and F_3 frequencies was necessary in determining to what extent the German /r/ phoneme differed from its English counterpart, as the English /r/ is characterised by a low frequency in F_2 and F_3 whilst the German rhotic is not (Ladefoged & Maddieson, 1996). As shown in Figure 3, FS produced German rhotics with a significantly higher average F_2 and F_3 frequencies than his English rhotics, although this difference was very small. In particular, both the German and English F_2 and F_3 values were in line with those characteristic of AE norm values (i.e. compare Thomas' (2010) average frequencies for AE to those of Ladefoged and Maddieson (1996) for German). To a certain extent, the merging of FS' German and English F_2 and F_3 frequencies is indicative of the results of earlier studies by Flege, which found that high-proficiency bilinguals tended to "merge" the VOT of their two

languages to produce a VOT that was strictly characteristic of neither their L1 or their L2, but rather formed a new category somewhere between those of the L1 and L2 (Flege 1987; Flege & Eefting 1987). However, based on the participant's F_2 and F_3 values for both languages, it appears that FS' German rhotic was produced within the monolingual norm of the AE retroflex. Consequently, the results indicated that the new German category was not "merged" *between* the German and English norms, but rather that it aligned more clearly *within* the English norm. In this way, the prediction based on SLM that an *intermediate* "merged" category would arise, was not verified. These findings are in line with earlier studies which examined the same participant's phonological merging behaviour. De Leeuw et al. (2012), for example, found that participant FS' realisation of the German /l/ in coda position adhered to the AE norms and that his realisation of the prenuclear rise in both German and English was "within the English monolingual norm, clearly indicating German L1 attrition." (2011: p. 9).

As a case study, the present investigation aimed to highlight one particular late bilingual who appeared to evidence extreme phonetic L1 attrition in that all examined phonetic variables in his speech displayed "merging" within the English monolingual norm (Flege, 1987: 62). His existence, therefore, to a certain extent challenges the maturational constraints model which offers no explanation as to why, actually, one such late bilingual *would* undergo phonetic L1 attrition to the degree evidenced and indeed does not predict such changes in the L1. As mentioned earlier, studies have found that phonetically the L1 and L2 are not cognitively isolated from each other and that they can mutually affect one another over an extended period of time (Flege 1980; Flege & Eefting 1987; Major 1987). In this process, described by the SLM by Flege (1995; 2003), proficient bilinguals will draw upon their knowledge of L1 and L2 phonological categories when producing similar L1 and L2 phones to realise an approximate phone that is wholly characteristic of neither languages' phonological categories. As a result, a new phonological category for these similar phones is created, one which is based on the qualities of the L1 and L2 categories for that phone. What is especially interesting about this participant is the fact that FS' native-German category aligned within the English monolingual norm. As such, the findings in part verified the SLM in that both the impressionistic and acoustic analyses verified that a late acquired L2 can indeed affect the production of the L1; alternatively, the findings also shed new light on the SLM in that the acoustic analysis showed that FS' German rhotic was not merged within German and English monolingual norms, but rather, in this extreme case of phonetic L1 attrition, F_2 and F_3 values for both languages, were within the monolingual norm of the AE retroflex.

This case study has contributed to the growing corpus of phonetic studies which have reported L1 attrition within the context of bilingualism, yet further work remains to be done in defining the factors responsible for attrition in those individuals in which it is displayed. Although it appears that a low amount of German language use coupled with a high amount of English use in a

monolingual setting may have accelerated FS' L1 attrition, more research is necessary in order to verify this claim.

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Appendix

A. List of German words used in the experiment

German word	English translation
Reis	Rice
Rülps	Burp
Rippe	Rib
Reh	Deer
Rang	Rank
Rhein	Rhine
riech	Smell
Rum	Rum
Rost	Grate
Riff	Reef
rein	Clean
rief	Called
Reim	Rhyme
ran	Ran
roch	Smelled
Rest	Rest
Ruf	Call
Rock	Skirt
Ross	horse (archaic)
Reiz	Charm
Ring	Ring
Riet	Reed
reit	Ride
Riss	Rip
reich	Rich
reif	Mature

B. English rhotics at onset words elicited from the experiment participants.

Rights
Reap
Roast
Ride
Ring
Rust
Reach
Rug
Rhyme
Reef
Rust
Ripe
Writes
Rock
Red
Ray
Rest
Rail
Rich
Rag
Rang
Read
Rice
Rum
Real
Ran
Roof

Reed
Ribs