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# VOT Patterns in the Acquisition of Third Language Phonology

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## **Abstract**

The paper aims at investigating the phenomenon of cross-linguistic influence in the acquisition of third language phonology by exploring the interaction between three phonological systems of multilingual subjects based on their productions of voice onset time patterns. It presents the results of two parallel studies involving different language combinations; (1) L1 Polish, L2 English, and L3 French; (2) L1 Polish, L2 English, and L3 German. The participants (N=64) were recorded reading lists of words in carrier phrases in the three respective languages (L1, L2 and L3) and the recordings were subsequently analyzed for the degree of aspiration of voiceless stops in stressed onset positions. The results revealed unique interlanguage VOT patterns as the multilingual subjects contrasted between VOT length in all three language systems. The L3 values corresponded to compromise VOT values and were intermediate between the L1 and L2 mean VOT. The findings corroborated the co-existence of the L1 and L2 effect, and substantiated the assumption of a combined cross-linguistic influence in L3 acquisition.

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Investigations into the acquisition of second language phonology have a well grounded research tradition, however, scholars have recently started to differentiate between the acquisition of the L2 and other subsequent languages (L3, Ln), thus Third Language Acquisition (TLA) has been

recognised as a separate field of inquiry (e.g. Cenoz, Hufeisen & Jessner, 2001; De Angelis, 2007; Rothman, Cabrelli Amaro & De Bot, 2013).

The acquisition of a third language (L3) phonology is a particularly young subdiscipline dating back to the late 20th and early 21st centuries with still limited research compared to that on L3 lexis and morphosyntax (e.g. Hammarberg & Hammarberg 2005; Gut 2010; Llama, Cardoso & Collins, 2010; Wrembel, 2010, 2012a, 2012b; Cabrelli Amaro & Rothman 2010).

The major difference between the second and third language acquisition is that L3 learners have already acquired their first foreign language (i.e., L2), and thus they can rely on some conscious linguistic knowledge as well as language-learning experience and strategies (cf. Cenoz & Jessner, 2000; De Angelis, 2007). Particularly noteworthy is that multilingual learners have a broadened phonetic repertoire, a raised level of metalinguistic awareness and perceptual sensitivity which may be an additional asset in the process of acquisition of third language phonology (cf. Wrembel, to appear). Furthermore, this new research perspective acknowledges the complexity of potential sources for cross-linguistic influence that may have an impact on multilingual speakers' language production and comprehension in an additionally acquired foreign language.

Cross-linguistic influence (CLI) is a broad term that generally refers to transfer or interference related phenomena (Sharwood-Smith, 1983). In the SLA literature it has been traditionally portrayed as a one-to-one type between the source and the target language, resulting in a primary research focus on the influence of the native language (L1) on a second language (L2). From the third language acquisition (TLA) perspective, the transfer phenomenon is more complex as a simultaneous influence of more than one previously acquired languages is acknowledged, thus resulting in a combined cross-linguistic influence, as suggested e.g. by De Angelis (2007).

## LITERATURE REVIEW

The issue of native vs. non-native transfer has received some attention in the area of L3 acquisition of phonology. In the earlier studies the L1 transfer has been widely attested as the major factor affecting third language acquisition while the non-native sources of CLI have not been recognised as significant (Ringbom, 1987; Pyun, 2005). More recent research, however, has focused on the role of the first foreign language

(L2) in L3 phonological acquisition. The findings of a number of studies identified the so called L2 status or 'foreign language effect' as an equally important if not prevailing source of influence in additional language learning (Hammarberg & Hammarberg, 2005; Llama et al., 2010; Wrembel, 2010). For a more thorough overview of research on third language phonological acquisition see Wrembel (2012b).

In the SLA literature the acquisition of L2 aspiration patterns of voiceless stops has been studied extensively with a lot of evidence for transfer of L1 VOT values in the production of L2 stops (e.g. Flege, 1987; Flege & Hillenbrand, 1987). More advanced learners were found to be able to approximate native speaker norms and to differentiate L1 and L2 with respect to VOT (e.g. Caramazza, Yeni-Komshian, Zurif, & Carbone, 1973; Flege, 1987, 1991). According to the Speech Learning Model (SLM), as proposed by Flege (1995), late L2 learners are more likely to create a new "merged" L2 category, which may deflect away from both L1 and L2 categories in order to maintain the phonetic contrast between the two languages. Such "compromise" or "hybrid" VOT values for both languages were reported in some SLA studies (Flege, 1987; Flege & Eefting, 1988; Major, 1992). The production of L1 VOT values may also be affected by the shift towards more native-like values in the L2 (i.e., a regressive transfer) as shown, for instance, by Waniek-Klimczak (2011). Few studies to date, however, have explored VOT patterns in the acquisition of third language phonology (Tremblay, 2007; Llama et al., 2010; Wunder, 2010; Wrembel, 2011).

In the earliest study of this kind, Tremblay (2007) analysed the acoustic measurements of voice onset time of four L1 English/L2 French bilinguals at the early stages of acquisition of L3 Japanese. The results showed similar VOT values for the L2 French and L3 Japanese which were much lower than for the long-lag L1 English VOT. The findings were interpreted as an indication of the L2 effect on L3 phonological acquisition, although the L3 VOT values approximated L2 French and, at the same time, native Japanese target norms. Moreover, the participants' sample was very limited. Interestingly enough, no task effect was found as the VOT patterns in L3 did not differ significantly irrespective of the task performed, i.e. word list reading or delayed repetition.

Llama et al. (2010) investigated whether the 'L2 status' or language typology was the determining factor in the production of voiceless stops in stressed onset position in L3 Spanish. The experiment was based on target word list reading and involved two groups of learners; one with L1 English and L2 French, the other with L1 French and L2 English. The

results indicated that the cross-linguistic influence from the L2 rather than typological proximity or the L1 transfer alone seemed to be the stronger predictor in the acquisition of VOT patterns in L3. However, the findings were not unambiguous as to the prevailing source of CLI pointing to the interaction of both native and non-native influences on the third language phonology. Particularly noteworthy is the application of a mirror-design methodology which allowed for a reliable verification of the research hypothesis. However, the lack of data in the participants' L1s and the reliance on the literature reference values as a baseline instead appears to be a shortcoming of this valuable study.

Along the same lines, Wunder (2010) analysed text reading samples of eight L1 German speakers with respect to the VOT values in their L2 English and L3 Spanish. Her findings were mixed pointing to either L1 effect or combined L1 German and L2 English cross-linguistic influence on the aspiration patterns in L3 Spanish. The largest pool of VOT measurements was assigned to the category of 'hybrid' values in which it was not possible to determine whether the source of influence on L3 VOT were the L1 German or native Spanish values. In conclusion, Wunder stated that her results contradicted previous research demonstrating a prevailing L2 influence on L3 phonology (e.g. Hammarberg & Hammarberg, 2005).

The present author has also started to investigate VOT patterns in trilingual acquisition as a selected phonetic dimension of foreign accentedness in an attempt to broaden the research perspective provided by L3 accent ratings studies (cf. Wrembel, 2012a, 2012b). The preliminary results of the first from a series of the planned studies (Wrembel, 2011) demonstrated that the multilingual subjects contrasted between VOT length in their L1 Polish, L2 English and L3 French. The reported L3 French values for /p/, /t/, /k/ were significantly longer than those of the French monolinguals and they corresponded to intermediate L1 and L2 mean VOT. The findings were interpreted as indications of combined cross-linguistic influence on L3 phonology. It was concluded that further research on different multilingual groups with various linguistic repertoires was necessary to provide more evidence for these preliminary findings.

## **THE EXPERIMENT**

In order to fill the gap in the L3 literature reviewed above, the major objective of the present contribution was to further investigate the

complexity of transfer of voice onset time (VOT) patterns in trilingual acquisition. In particular, it aimed to explore the sources of cross-linguistic influence (CLI) in the acquisition of VOT in L3 French and L3 German by L1 Polish learners with an advanced competence in L2 English. Finally, the paper was intended as a comparative analysis of VOT acquisition patterns based on the findings of Study 1 on L3 French vs. Study 2 on L3 German.

This contribution is part of a larger scale research into third language phonological acquisition based on a series of studies on foreign accentedness and VOT patterns in different language combinations. The preliminary results of Study 1 on L3 French were presented in Wrembel (2011). The present paper elaborates further on this research and expands the perspective to Study 2 on L3 German.

The languages involved in both studies make a phonological distinction between two categories of stops, however, their phonetic realisation differs. On the one hand, English and German belong to the category of the so called aspirating languages (cf. Lisker & Abramson, 1964), which differentiate between voiceless aspirated and voiceless unaspirated plosives, whereas French and Polish are voicing languages, in which there is a distinction between voiced and voiceless unaspirated. In English /p/, /t/, /k/ are implemented as long-lag stops with VOT around 60-80 ms (Lisker & Abramson, 1964), while in German the average VOT values are said to be between 30-50 ms (Angelowa & Pompino-Marschall, 1985). On the other hand, in French and Polish /p/, /t/, /k/ are implemented as short-lag stops with mean VOT values around 20-30 ms (Caramazza et al., 1973; Keating et al., 1981).

To address the above mentioned objectives, the study posed the following research questions:

- 1) Do multilingual subjects differentiate between their L1, L2 and L3 with regard to VOT values?
- 2) Do L3 VOT patterns approximate the participants' L1 Polish, L2 English or the L3 native norms?
- 3) Is there a proficiency group effect on VOT measurements in L3 based on the amount of L3 exposure?
- 4) Does the typological proximity between language repertoires influence the VOT patterns in L3 acquisition?

Based on the current literature on third language acquisition, three potential general outcomes were hypothesised: (1) native L1 Polish would

be a prevailing source of cross-linguistic influence for the acquisition of VOT patterns in L3 French or German; (2) the influence of L2 English, the so called 'foreign language effect' would override the native language in shaping L3 VOT values; (3) both the native and non-native languages would have an impact on the VOT values in the L3, thus substantiating the assumption of a combined cross-linguistic influence.

## STUDY DESIGN

### Participants

Both studies involved a total of 64 participants who were Polish university students of the English philology and who have been learning an additional foreign language, i.e. French or German (see Table 1 for the participants' profiles).

Study 1 included 32 participants (24 female and 8 male) whose mean age was 19.8 years. Their competence in L2 English was very high (C1 level according to CEFR). The length of formal training in English (YFT) was 11; whereas the mean age of onset of learning (AO) equaled 9 years. The participants were further subdivided into two subgroups according to the length of the learning experience in L3 French; Group 1F (N=15) was less proficient (A1 level) and have been learning French as their L3 for 2 years (YFT=2, AO=17) while Group 2F (N=17) was at a more advanced proficiency level (B1 level) and their average exposure to French equaled 5 years (YFT=5, AO=14).

Study 2 involved also 32 participants (19 female and 13 male) with a mean age of 20.4 years. They were fairly homogeneous with the group in Study 1 as far as their competence in L2 English was concerned; with C1 proficiency level, 11 years of formal training and the mean age of onset being 9.5. They were also subdivided into two groups according to their length of learning of L3 German. Group 1G (N=17) was less proficient (A2/B1 level) and have been learning German as L3 for an average of 5 years (YFT=5; AO=13.5), whereas Group 2G (N=15) was more advanced (B1/B2 level) and have been exposed to German for over 7 years (YFT=7, AO=13).

**Table 1.** Participants' profiles (YFT – years of formal training, AO – age of onset)

Group	N	L2 English			L3 French or German			
		Proficiency	YFT	AO	Proficiency	YFT	AO	
French	1F	15	C1	11	9	A1	2	17
	2F	17				B1	5	14
German	1G	17	C1	11	9.5	A2/B1	5	13.5
	2G	15				B1/B2	7	13

## Procedure

The data were collected in all the three language systems of the multilingual participants, i.e. L1 Polish, L2 English and L3 French in Study 1 and L1 Polish, L2 English and L3 German in Study 2. The stimuli consisted of three word lists with 12 target words in the respective languages. The target words included voiceless plosives /p, t, k/ in stressed onset positions in the following context of high vs. non-high vowels, in mono- and disyllabic words, thus generating a total of 12 items per language list. The words were randomized and embedded in carrier phrases in particular languages (i.e., *I am saying ...*, *Mówię teraz ...*, *Je dis ...*, *Ich sage ...*). The recordings were made in a clearly specified language mode in the natural order of acquisition of the languages involved, with Polish as first, English as second and French or German as third. The participants were asked to read the lists at a natural speed with a few minutes' break interval between the recordings. The interaction with the researcher was carried out in the language of the subsequent recording to promote the activation of respective languages. Finally, a language background questionnaire was administered to tap the subjects' language history and use.

The stimuli were recorded using CoolEdit 96 as 16-bit mono files at 16 000Hz sampling frequency. Tokens were excluded from the analysis if the target words were mispronounced. A total of 2304 tokens was subject to an acoustic analysis performed using PRAAT 5.2.15 (Boersma & Weenick, 2010). Voice onset time was measured in milliseconds (ms) as the interval between the release burst and the beginning of the regular vocal cord vibrations.

## RESULTS

### Mean VOT values for L1, L2 and L3

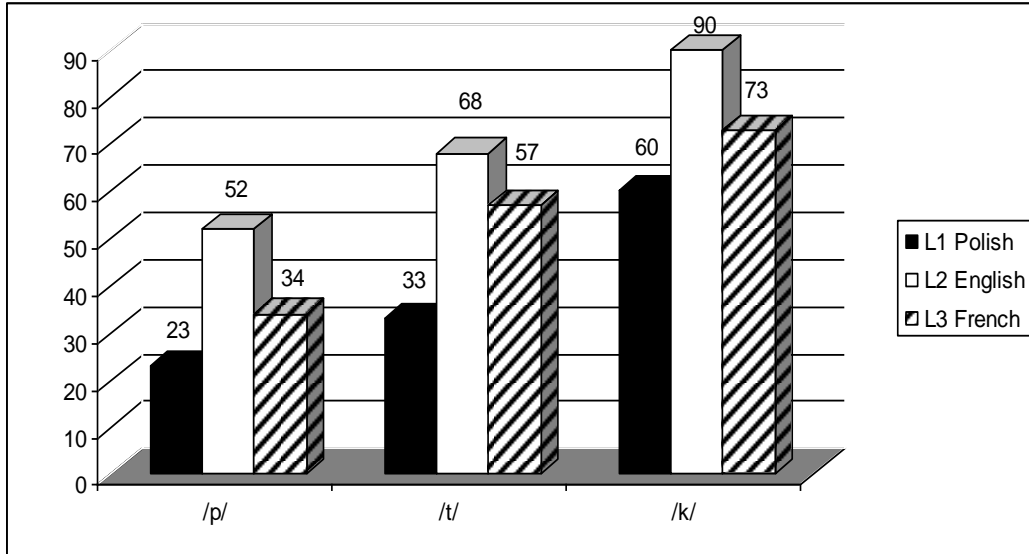
The results of the acoustic measurements of mean voice onset time of the target words read in the carrier phrases in L1 Polish, L2 English, L3 French or German are presented in Figure 1 (Study 1) and Figure 2 (Study 2). In Study 1 the Polish participants produced voiceless plosives in stress onset positions with mean voice onset time values that were the shortest in L1 Polish (/p/= 23 ms, /t/= 33 ms, /k/= 60 ms), intermediate in L3 French (/p/= 34 ms, /t/= 57 ms, /k/= 73 ms) and the longest in L2 English (/p/= 52 ms, /t/= 68 ms, /k/= 90 ms). In Study 2 the mean VOT values in all three languages followed the same pattern, with the shortest lag for L1 Polish (/p/= 22 ms, /t/= 34 ms, /k/= 57 ms), intermediate for L3 German (/p/= 45 ms, /t/= 54 ms, /k/= 72 ms) and long-lag values for L2 English (/p/= 53 ms, /t/= 70 ms, /k/= 92 ms).

The first series of statistical tests was conducted in order to investigate the language and group effect. As far as the language effect is concerned a pairwise comparison of means generated significantly different mean VOT values for /p/, /t/ and /k/ ( $p < 0.01$ ) for L1 Polish, L2 English and L3 French in Study 1 as well as for L1 Polish, L2 English and L3 German in Study 2.

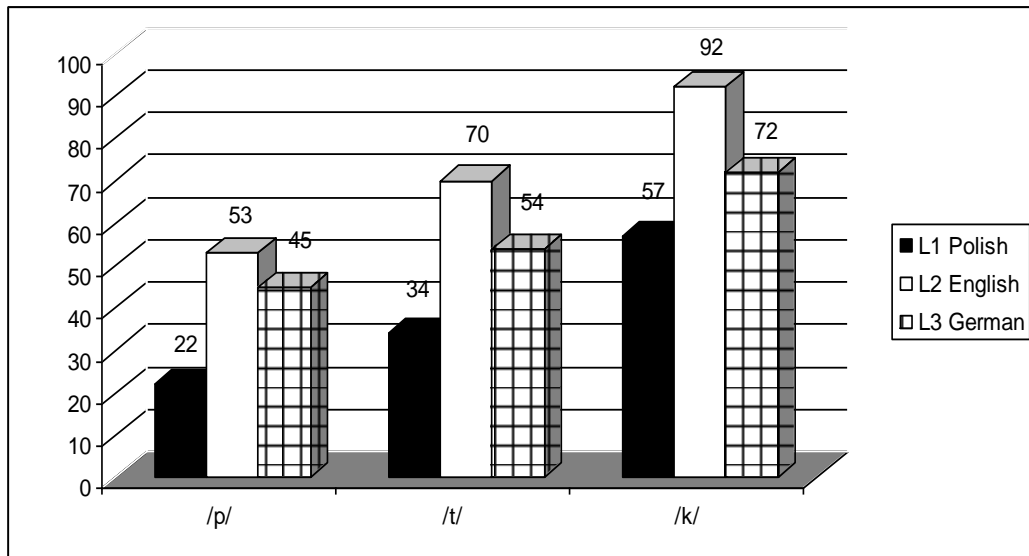
Interestingly enough, a cross-study comparison of the VOT mean values for L3 French vs. L3 German indicated a significant difference only for the bilabial /p/ ( $p < 0.01$ ), whereas the differences for alveolar and velar plosives /t/ and /k/ were found to be non-significant.

In order to examine the language proficiency group effect on VOT acquisition a series of independent t-tests was run in both studies in two conditions; (1) for each target word separately in L1, L2 and L3, and (2) for mean VOT values for /p/, /t/, /k/ in L1, L2 and L3. The results of the analyses showed no significant differences between VOT values with respect to language proficiency group either in L3 French (Study 1) or L3 German (Study 2) in the two conditions.





**Figure 1.** Mean VOT values (ms) in Study 1



**Figure 2.** Mean VOT values (ms) in Study 2

**Comparison to VOT reference values**

In order to compare the acoustic measurements generated in both studies to VOT reference values in the respective languages a series of analyses was performed. The overall finding was that the VOT measurements in Study 1 and 2 for L1 Polish and L2 English did not differ significantly from the native norms as reported in the literature (Keating, Mikoś & Ganong, 1981; Lisker & Abramson, 1964), whereas the VOT values for L3 French and L3 German did not fall within the reported norms (see Tables 2 and 3). More specifically, the VOT values for voiceless stops in L1 Polish

in both studies were slightly higher than the reference values for Polish monolinguals (cf. Keating et al., 1981) yet still within the accepted 5-10 ms range. As far as L2 English is concerned, the VOT measures also fell within the accepted native English range (cf. Lisker & Abramson, 1964). Interestingly enough in Study 1 and 2, the acoustic measures for the bilabial plosive /p/ were realized with a slightly shorter lag than the monolingual reference values quoted in the literature, whereas the velar plosive /k/ was characterized by an overshoot of native English reference values. All in all, the aspirated English stops were implemented by the participants as long-lag and the L2 phonetic norms were approximated successfully.

However, the comparison of mean VOT for /p/, /t/, /k/ in L3 French and German demonstrated significant differences between the participants' values and the respective native reference values from the literature (cf. Caramazza et al., 1973 for French; Angelowa & Pompino-Marschall, 1985 for German). Considerable VOT lengthening was observed in Study 1 for L3 French (/p/  $t=7.4$ , /t/  $t=16.6$ , /k/  $t=14.6$ ,  $p<0.01$ ) and the findings involved 'compromise' values longer than typical Polish or French native values but shorter than the English ones (see Table 2). Some VOT lengthening was also reported in Study 2 in L3 German (/p/  $t=3$ , /t/  $t=5.3$ , /k/  $t=9.9$ ;  $p<0.01$ ), as compared to the target native German values. The results were intermediate between typical VOT German values as quoted in the literature (Angelowa & Pompino-Marschall, 1985) and the English norms (see Table 3).

**Table 2.** VOT comparison to reference values for Study 1 on L3 French (\*  $p<0.01$ ) (Reference VOT: <sup>1</sup> Keating et al., 1981, <sup>2</sup> Lisker & Abramson, 1964, <sup>3</sup> Caramazza et al., 1973)

	Polish		English		French	
	Ref. VOT <sup>1</sup>	Study 1	Ref. VOT <sup>2</sup>	Study 1	Ref. VOT <sup>3</sup>	Study 1
/p/	22	23	58	52	18	34*
/t/	28	33	70	68	23	57*
/k/	53	60	80	90	32	73*

**Table 3.** VOT comparison to reference values for Study 2 on L3 German (\*  $p < 0.01$ ) (Reference VOT: <sup>1</sup> Keating et al., 1981, <sup>2</sup> Lisker & Abramson, 1964, <sup>4</sup> Angelowa & Pompino-Marschall, 1985)

	Polish		English		German	
	Ref. VOT <sup>1</sup>	Study 2	Ref. VOT <sup>2</sup>	Study 2	Ref. VOT <sup>4</sup>	Study 2
/p/	22	22	58	53	36	45*
/t/	28	34	70	70	39	54*
/k/	53	57	80	92	47	72*

### Analysis of variance

The multivariate analyses of variance were performed to investigate whether there were interactions between (1) mean VOT measurements for /p/, /t/, /k/, (2) VOT values for individual target words, as well as (3) a combination of independent variables, including place of articulation (POA), languages (L1, L2, L3), a group proficiency level (1F vs. 2F; 1G vs. 2G), and the target words.

The results of the first ANOVA were found to be consistent for both studies as they demonstrated significant effects of POA (Study 1  $F=292$ ,  $p < 0.01$ ; Study 2  $F=274$ ,  $p < 0.01$ ), language (Study 1  $F=94$ ,  $p < 0.01$ , Study 2  $F=69$ ,  $p < 0.01$ ) and language and POA interaction (Study 1  $F=15$ ,  $p < 0.01$ ; Study 2  $F=6$   $p < 0.01$ ) on /p/, /t/, /k/ mean VOT values. Interestingly enough no L3 proficiency group effect was found in either of the study.

The second series of analyses involving mixed design ANOVAs ( $3 \times 12 \times 2$ ), i.e. 3 languages, 12 target words, 2 groups, were also performed to test individual VOT values in the target words. The findings were again fairly comparable in both studies as they indicated significant effects of the language (Study 1  $F=83$ ,  $p < 0.01$ ; Study 2  $F=69$ ,  $p < 0.01$ ), a target word (Study 1  $F=132$ ,  $p < 0.01$ ; Study 2  $F=61$ ,  $p < 0.01$ ), and the language and word interaction (Study 1  $F=41$ ,  $p < 0.01$ ; Study 2  $F=6$   $p < 0.01$ ). Nonetheless, no significant effects were found for the language and L3 proficiency group or the L3 proficiency group and the target word interactions in either of the studies.

Regression analyses were performed to measure the interdependence between L3 VOT values and independent variables including L1 Polish, L2 English, the language proficiency group effect as well as the place of

articulation (POA). In Study 1 the R squared result indicated that 51% of the variance is accounted for by the independent variables, the exact contribution to R squared being: 61% - the effect of POA ( $p < 0.01$ ), 32% - the effect of the Polish variable ( $p < 0.01$ ), 7% - the effect of the English variable ( $p = 0.05$ ). No significant effect of group on L3 values was found. The results of the regression analysis for Study 2 were to some extent comparable as the R squared pointed that 55% of the variance was accounted for by independent variables. However, the contribution to R squared displayed a different pattern than in Study 1 equalling in this case as follows: 57% - the effect of L2 English ( $p < 0.01$ ), 22% - the effect of L1 Polish ( $p < 0.01$ ), 16% - the effect of POA ( $p < 0.01$ ). As in the previous study, no effect of the group proficiency on L3 German VOT values was reported.

## DISCUSSION

The main goal of this study was to explore the interaction between three phonological systems of trilingual subjects based on their productions of voice onset time patterns and to investigate the sources and directions of cross linguistic interference in this area. To this end, VOT values in the subjects' L1 Polish, L2 English and L3 French (Study 1) and L1 Polish, L2 English and L3 German (Study 2) were measured acoustically and compared to one another as well as to the reference values for native Polish, English, French and German speakers. Distinct patterns of VOT acquisition were observed in the respective languages.

The first research question was concerned with whether the multilingual subjects differentiate between their L1, L2 and L3 language systems with regard to VOT values. The findings demonstrated that the subjects in both Study 1 and 2 distinguished between the VOT length in their respective language repertoires, i.e., they produced voiceless plosives in stressed onset positions with significantly different values in L1 Polish, L2 English and L3 French or German. Foreign language categories proved sufficiently dissimilar acoustically from the established inventory of L1 phonetic categories for the subjects to modify their realizations of /p, t, k/ in their respective foreign languages so that the implementations of voiceless plosives differed significantly across the language systems of the multilingual participants.

Particularly noteworthy is the fact that the L3 VOT intervals were not assimilated either to the L1 Polish values or the L2 English ones. The observed VOT values for L3 French and German were intermediate, i.e.,

longer than the values typical for L1 Polish and shorter than those typical for L2 English. If the participants had identified the foreign language phones in terms of the native L1 categories they would have used the established articulatory patterns for the production of L3 phones, i.e. /p, t, k/ would have been implemented as short lag in L3 French and German. However, the participants made articulatory modifications in their realizations of initial voiceless plosives in L3, most probably under the influence of the long-lag VOT categories established for L2 English, thus demonstrating increased metalinguistic awareness in learning a new phonetic system of the additional foreign language.

The participants showed some evidence of restructuring of their phonetic space. It appears that a modified category, different from the L1 Polish and L2 English systems was formed for /p, t, k/ in L3 French and German by adding different realizations thereof. This ability of learning new patterns of segmental articulation did not seem to diminish after a critical period as all the participants were late learners. This finding is in line with Flege's (1995) Speech Learning Model (SLM), which claims, among others, that the phonetic system of a learner remains adaptive throughout lifetime and open to modifications of phonetic categories.

As far as the performance in the first and second language systems is concerned, some interesting regularities were observed in both studies. The mean values for L1 Polish stops /p, t, k/ did not differ across the studies and fell within the established literature reference VOT values for Polish monolinguals. However, some VOT lengthening was observed compared to the reference Polish norms which could be due to the influence of the established long-lag values in L2 English. This phenomenon can be interpreted as an evidence for the bi-directional cross-linguistic influence or the so called 'regressive transfer' as attested earlier in the SLA literature (e.g., Flege, 1987; Waniek-Klimczak, 2011). However, the assumption of a facilitative L1 transfer in Study 1 was not substantiated. By means of transferring L1 Polish VOT values into their L3 French the participants should be able to produce French voiceless stops in a native-like manner, yet this was not found to be the case.

Both in Study 1 and 2 the participants produced L2 English voiceless plosives as long lag fully approximating or even exceeding native English reference values. This fact can be attributed to their high proficiency in English as well as to several other factors such as an early age of onset for L2 acquisition, a long exposure to the target language, the recency and intensity of L2 use and explicit phonetic training in English. Particularly noteworthy is the extent to which the L2 VOT values approximated the

English native norms with regard to comparable studies on L2 English acquisition by Polish advanced learners reported in the SLA literature (Waniek-Klimczak, 2011).

The second research question was aimed to explore if the L3 VOT patterns approximate the participants' L1 Polish, L2 English or the L3 native norms. Following Flege's (1995) SLM it was hypothesized that the VOT patterns in L3 French (Study 1) would approximate L1 Polish phonetic norms because of the similar realization of the voiceless/voiced plosives distinction due to the phenomenon of equivalence classification. However, the results contradicted the expected facilitative transfer of the L1 Polish VOT values into L3 French. On the contrary, it was demonstrated that the target words in L3 French were produced with mean VOT values that were intermediate to the phonetic norm for VOT in L1 Polish and L2 English. The most probable interpretation of the results is that the established L2 English values exerted some influence on the acquisition of the additional foreign language as the observed values were longer than the typical native Polish and native French VOT intervals.

The L2 learning was also found to influence the production of /p, t, k/ in L3 German (Study 2), although in this case no L1 positive transfer was hypothesized as the VOT values typical for native Polish and German speakers differ significantly. The findings of Study 2 also pointed to compromise or 'hybrid' VOT values in L3 German which were intermediate between L1 Polish and L2 English mean VOT. However, unlike in Study 1, the L3 German productions approximated more closely the German native VOT values which are higher than the French ones.

It appears that the L3 phones were most probably categorized as 'similar' but not 'identical' to the Polish /p, t, k/ as they were implemented with a different lag length in the L3 than their counterparts in the native Polish sound system. A lower proficiency level in L3 French and German and a relatively short period of exposure to the L3 prevented the learners from establishing target-like native VOT values in the third language, although they achieved this goal in their more advanced L2 English.

Both studies provided evidence for the co-existence of the L2 effect and underlying L1 interference in the acquisition of VOT patterns in L3. Furthermore, they substantiated the assumption of a combined cross linguistic influence (CLI) in third language acquisition as suggested by De Angelis (2007). The present findings are, to some extent, consistent with previous studies on L3 phonological acquisition (Wrembel, 2010; Llama et al., 2010; Wunder, 2010) which pointed to combined CLI from both native and non-native languages. The results contradict findings by Ringbom

(1987) or Pyun (2005) who observed the prevailing influence of the L1 phonology on L3 acquisition.

The category assimilation observed in the L3 VOT values varies from the one reported in the SLA literature, where it is commonly attested to occur between the L1 and L2 categories, thus forming a hybrid between the native and target values (e.g., Flege, 1987; Flege & Eefting, 1988). In third language acquisition this compromise is of a different, more complex nature because of the co-existence of three language systems in the multilingual participants' minds. In Study 1 and 2 the L3 VOT values were found to deviate both from the native Polish and target French or German norms. There is an evidence of an intervening variable of L2 English in both studies and the observed L3 values are intermediate between those of the native language (L1 Polish) and the previously acquired foreign language (L2 English). The potential impact of the target values of the additional foreign language that is currently being acquired (L3 French or German) does not seem to be so influential as the mean VOT values for L3 French and L3 German do not differ significantly across the studies and display very comparable patterns. They would be expected to vary significantly had the learners relied more on the target realizations of voiceless plosives in L3 French and L3 German. Therefore, it appears that the systems of the native tongue and the previously acquired foreign language exerted the greatest impact on the phonetic modification of L3 categories in both of the present studies.

The third research question hypothesised if there was any group effect on VOT measurements in L3 based on the length of exposure to the third language.

Nonetheless, the effect of group proved non-significant for the language and L3 proficiency group or the L3 proficiency group and the target word interactions in either of the studies. The analysis of the conducted ANOVAs did not find any significant effects of the subjects' level of advancement in L3 French or German in neither of the conditions, i.e. mean VOT values for /p, t, k/ nor the VOT values in the individual target words in the respective languages. All in all, the difference in the L3 proficiency level not found to be a significant predictor of the VOT production. This might be due to the fact that the difference in L3 French or German proficiency levels between the groups (1F vs. 2F, 1G vs. 2G) was not sufficient to guarantee a visible effect.

The lack of a significant difference between the two groups should not be regarded as a disconfirmation of the hypothesis that their L3 interphonology may be subject to further modifications. It difficult to

prove on the basis of the present data that it is a transition stage in their L3 interphonology which involves compromise VOT values between all the language systems of the multilingual subjects. However, an adaptation towards target-like VOT values is expected to occur in parallel with the degree of advancement in L3 so that they might gradually approximate the native French and German norms respectively. Although there is no evidence that the length of exposure to L3 significantly influenced the degree of approximation to the native target norm, there were some parallel patterns in the group performance in both studies.

The final research question was concerned with whether the typological proximity between language repertoires influenced the VOT values in L3 acquisition.

No conclusive evidence of the typology effect was observed as there were striking similarities between VOT patterns in L3 French (Study 1) & L3 German (Study 2) irrespective of the typological proximity between the language combinations involved. However, when the results of L3 productions were compared to the respective target values, slightly different conclusions could be reached. Mean VOT values showed no evidence (Study 1) or some evidence (Study 2) of approximating the target norms in French and German. An explanation for this partial approximation to German norms in Study 2 may be attributed to closer typological proximity between English and German. Thus L2 English facilitated to some extent the acquisition of aspirated voiceless plosives for L3 German, although the values still differed from those typical for native Germans as reported in the literature.

Moreover, the results of the conducted regression analysis pointed to fact that a higher percentage of the variance was accounted for by the influence of the L2 English variable (57%) on L3 German compared to L1 Polish (22%) in Study 2. On the other hand, in Study 1 a different proportion was generated with the L1 Polish influence accounting for a higher percentage of variance (32%) whereas the effect of L2 English on L3 French was less significant (7%). A possible explanation of these results may be closer typological proximity between pairs of languages involved with respect to the VOT dimension. The impact of L1 Polish seemed more noticeable in case of L3 French (Study 1) as these two languages are the so called 'voicing' languages which make a distinction between voiced and voiceless unaspirated stops, whereas the effect of L2 English prevailed in L3 German VOT patterns as these two languages can be categorized as 'aspirating' languages which distinguish between voiceless aspirated and voiceless unaspirated stops (cf. Lisker & Abramson, 1964).



The external validity of the studies was confirmed by looking at the expected language universal effects. The observed VOT patterns in all the languages in both studies revealed some universal effects of the place of articulation (POA) and the vowel context. The findings demonstrated progressively longer VOT values for velars when compared to alveolars and bilabials. As far as the vowel context is concerned, VOT tended to be longer when a plosive was followed by a high rather than a low vowel word length.

## CONCLUSION

The present contribution was expected to provide new insights into the phenomenon of cross linguistic influence in the trilingual acquisition of voice onset time patterns. The major finding was that the multilingual participants in both Study 1 and 2 differentiated between their respective language systems, i.e., L1 Polish, L2 English and L3 French or German with respect to VOT. Moreover, they created new 'merged' VOT categories for L3, which deflected away from both L1 and L2 categories, thus maintaining a phonetic contrast between the three language systems at their disposal.

On the whole, combined cross-linguistic influence was observed as the phonetic properties under examination were transferred from L1 Polish and L2 English into the third language interphonology, thus resulting in compromise VOT values for L3 French/German. Consequently, the present studies provided further evidence for L2 effect in phonological acquisition of a third language. Conversely, the results undermined the view that the mother tongue was the only source of potential cross linguistic influence in multilinguals acquiring another foreign language.

Admittedly, the study suffered from some limitations as the VOT measurements were taken in the reading style only. Furthermore, the validity of the monolingual reference values for particular languages may be questioned on the grounds of methodological heterogeneity, yet the observed VOT patterns for L1 Polish and L2 English in Study 1 and 2 showed a very close resemblance to the reference values as reported in the literature. Finally, the L3 proficiency group effect might be more visible had the studies allowed for a more diverse level samples. Further studies on various language combinations are needed to provide more evidence for the patterns of acquisition of VOT in a third or additional language.

A series of parallel studies by the present author are in progress with the view to investigating various language combinations with different

proficiency groups in order to tease apart the effects of language typology and language proficiency on the acquisition patterns in third language phonology. Future studies will involve also other phonetic features such as vowel quality and quantity.

In conclusion, this contribution aimed to shed more light on the growing area of L3 phonological acquisition by identifying unique interlanguage VOT patterns, however, more cross-linguistic studies are needed to investigate the complex interaction between several phonological systems in multilingual learners.

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**APPENDIX**

Target words in Study 1 and 2

Polish	Pan	Parki	Pik	Piknik	Tak	Tango
	Tik	Tiry	Karp	Kanon	Kij	Kino
English	Pan	Party	Peace	Picnic	Task	Tartar
	Team	Tiptoe	Cat	Carpark	Keep	Killer
French	Par	Palais	Pic	Piscine	Tache	Tabac
	Tien	Timide	Cave	Canal	Qui	Kilo
German	Paar	Panne	Pirsch	Pinsel	Tanz	Tasse
	Tier	Ticken	Kalk	Karte	Kiel	Kinder