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A STUDY ON ENGLISH WORD-FINAL CORONAL STOP DELETION BY CHINESE EFL LEARNERS

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ABSTRACT

Based on the TIMIT corpus and the reading speech of Chinese who learn English as a foreign language (EFL learners), this study investigates the application of word-final *t/d* deletion by Chinese EFL learners and analyzes the differences of deletion by them and by American native English speakers. This study also examines the impact of English proficiency and Chinese transfer of Chinese EFL learners on the differences. It is found that the overall deletion of word-final *t/d* in Chinese EFL learners is less active than that in native speakers, and the following segments, parts of speech and gender have similar restrictive effects on both Chinese EFL learners and native speakers. Meanwhile, English learners with higher English proficiency have similar performance on deletion to native speakers of English in the restriction of the preceding segments and gender. Chinese transfer makes the discrepancy of deletion more significant between EFL learners and natives.

Index Terms— *t/d* deletion, phonological variation, Chinese EFL learners, English proficiency

1. INTRODUCTION

Production, a significant aspect in the process of language acquisition, is often regarded as an important scale to reflect and measure the language proficiency of individual learners. However, the variation in production that frequently appears during language learning affects language fluency and results in difficulties in both language acquisition and language comprehension [1].

Related to speech sounds, phonological variation is pervasive in languages and manifested in speech production. As an independent phoneme or a part of consonant clusters, coronal stops *t/d* can appear in the initial, medial, and final positions of a word [2]. The phonological characteristics of *t/d* also differ substantially under the influences of contextual, grammatical, prosodic constraints and so on. One of the most widely investigated variables of *t/d* is its reduction which is commonly realized as flap in American English and this reduction process exists in both casual conversation and careful speech [3]. Measured by both acoustic and articulatory data, the variation of *t/d* production can be regarded as gradient. Therefore, flapping is only a realization of reduced *t/d* which covers an interval of the whole continuous process of consonant reduction. When the variant features of *t/d* reduction reach to a certain extend of extreme, deletion occurs as an ultimate form of reduction [4].

Coronal stop deletion (CSD for short, also known as *t/d* deletion), as phonological variation, has attracted many scholars to examine the deletion by native speakers of standard English or English dialects. Since the 1960s, the linguistic and non-linguistic factors conditioning the deletion rate at final position and their effects on the rate have been fully identified across standard English and dialects [5-14]. The three linguistic factors most commonly found are the preceding and following phonological contexts and the morphological structure of the word [12].

A common finding of preceding phonological constraints is that word-final *t/d* deletion is related to the sonority of the preceding segment: obstruents (stops and fricatives) tend to favor deletion while sonorants disfavor it [11]. When a consonant precedes the word-final *t/d*, deletion is more likely to occur after /s/ than after other consonants. However, compared with the preceding segment, the phonological segment that follows the word-final *t/d* has consistently proven to be the most influential linguistic constraint [5]. Consonants induce higher rates of deletion than vocalic segments [5-7, 12, 13, 15, 16]. For morphological or grammatical constraints, monomer-phemic words would have a higher probability of deletion than past tense of ambiguous verbs, which would in turn have a higher probability than past tense of regular weak verbs [5]. In the analysis of non-linguistic constraints, large range of factors are involved, including rate of speech, style, age, sex, race, social status and so on. For example, Guy demonstrates that the possibility of deletion increases in faster speech [5].

CSD in Chinese EFL learners is also discussed by scholars in the studies of English consonants acquisition. Applying variable rule analysis, Guo and Wang investigates the variation of *t/d* deletion in EFL interlanguage and its linguistic and social constraints [17]. While in Standard Chinese, *t/d* function as initial consonants and are always followed by vowels. Such differences in the phonological rule of *t/d* between English and Chinese may affect the accuracy of consonant production for EFL learners. Typical errors appear such as the epenthesis of schwa after word-final plosives and wrong realization of voicing, for which the transfer of Chinese is speculated to partly account [18]. It is also universally observed that Chinese EFL learners with higher level of English proficiency have less mispronunciation and more deletion, which implies that the potential influence of proficiency on *t/d* deletion calls

for further research.

In short, application rules of word-final *t/d* deletion and its constraints are well-identified in standard English and English dialects by researchers. For deletion by Chinese EFL learners, the main focus is the universality and systematicity of word-final *t/d* deletion in interlanguage. And the factors that resulted in the differences of deletion and deletion constraints between Chinese EFL learners and native English speakers are not fully examined. More in-depth and comparative research is needed on the application of *t/d* deletion by Chinese EFL learners and its underlying factors.

2. RESEARCH METHODOLOGY

2.1. Research questions

The questions involved in this study focus on the word-final *t/d* deletion by Chinese EFL learners including:
(1) what are the features of the application of deletion by Chinese EFL learners?
(2) how do conditioning effects of various constraints on CSD differ between Chinese EFL learners and native speakers of English?
(3) what are the related factors that account for the differences of CSD between Chinese EFL learners and native speakers of English?

In the following study, we pay attention to both the deletion by Chinese EFL learners and the comparison of it to the deletion by native English speakers. Our anticipation about the influence of English proficiency of Chinese EFL learners on CSD is examined in the following and other effects are also possible to be observed.

2.2. Research methods

Participants for the production experiment are 12 Chinese EFL college students (gender-balanced) aged 19 to 23. They all get 80 or above in Putonghua Shuiping Ceshi (PSC) and do not speak dialect in their daily communication. Chinese EFL learners (CEL) are divided evenly into Intermediate Chinese EFL learners (ICE) and Advanced Chinese EFL learners (ACE) according to their English proficiency. In group ICE, students are all Chinese students with intermediate proficiency in English whose scores of College English Test Band Four (CET-4) are all above 470 and under 530. And students in group ACE are English majors who have passed Test for English Majors Grade Four (TEM-4).

Sentences for reading are selected from the scripts of Texas Instruments/Massachusetts Institute of Technology (TIMIT) corpus [19]. Totally 45 phonetically-compact sentences are chosen and word-final *t/d* appear in each sentence at least once. After excluding *and* and *-n't* or their extremely high frequency of deletion and *t/d* in neutralizing environment for the difficulty to distinguish their deletion, there are altogether 74 word-final *t/d*. 270 tokens of reading speech from 48 male and 48 female native speakers are extracted from the corpus in total. The 12 Chinese participants read each of the 45 sentences once, giving 540 tokens together (2 groups×6 participants×45 stimuli).

Data is collected by recording the reading speech of Chinese participants in a quiet room with computer program SpeechRecorder 6.2.6 and headset microphone Plantronics C3220. The speech was recorded at a sampling rate of 16 kHz with 16-bit resolution. For comparison, the recordings of native speakers of English are also extracted from TIMIT.

Two English majors who are highly proficient in English are invited to judge whether the word-final *t/d* is deleted. Only those recordings that have been identified by the two judges to be deleted are counted as the "deleted tokens". After all the deleted words were identified, the number of deleted *t/d* under each constraint in different groups was recounted. In this study, the constraints involved are narrowed to four main categories: the preceding phonological segments, the following phonological segments, morphological class of the target words containing final *t/d* and gender of speaker. In addition, Gahl and Susan suggested that high frequency content words yield higher rates of word-final *t/d* deletion [20]. Therefore, the part of speech also is examined here to explore its influence on the deletion. Regarding deletion rates as an important measurement to identify the existence of potential effects of constraints, the average rates of deletion within group for each constraint were calculated.

To testify the predictions and estimate the effects of English proficiency, intermediate learners are compared to advanced learners using one-way ANOVA (Analysis of Variance) implemented through R programs that can identify the existence of significant differences between groups. For each type of constraint, we use Scheffe post hoc Test to examine which two groups differ significantly and compare the extent of significance.

3. RESULTS, FINDINGS AND DISCUSSION

3.1. Application of word-final *t/d* deletion by Chinese EFL learners

In Figure 1, results of deletion by native English speakers (NES) and Chinese EFL learners (CEL) are compared. Under four types of constraints, the deletion rates in each minor category and general tendency are presented through the line graphs, and the differences on deletion rates are shown by bars.

From Figure 1 (a), for native English speakers, preceding segments favoring deletion at rates of the highest to the lowest are: other fricatives> /s/> stop> vowel> nasal> liquid. The percentages of deleted tokens by Chinese EFL learners are all lower than those by natives. Generally, the differences between native English speakers and Chinese EFL learners reduce with the order of the preceding segments favoring deletion. As Figure 1 (b) presents (where pause as a following segment refers to the following environment of t/d which is at end of the sentence), when obstruent or nasal follows the final *t/d*,

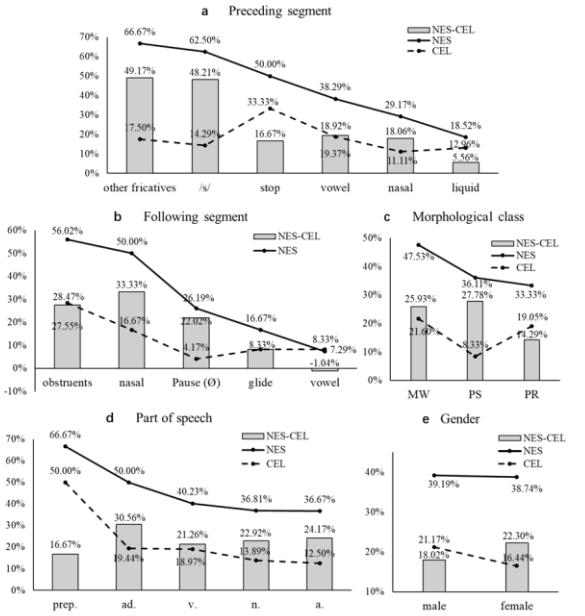

Figure 1: Influence of constraints on deletion rates by Chinese EFL learners and native speakers of English

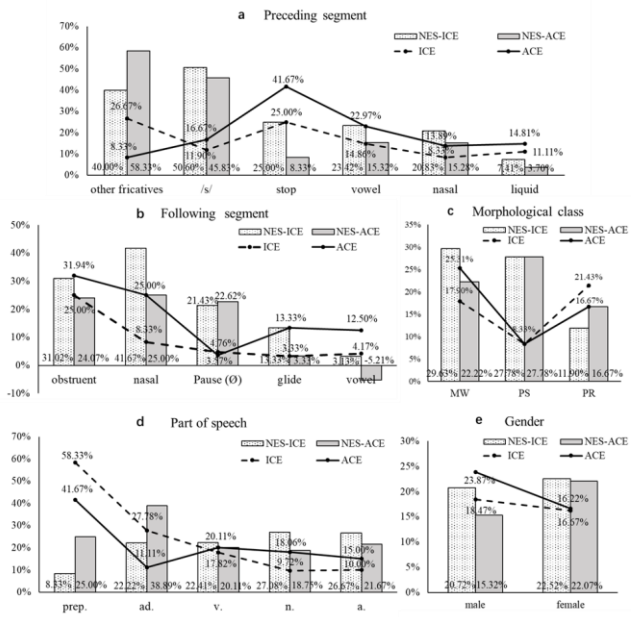

Figure 2: Influence of English proficiency on deletion rates by Chinese EFL learners

native speakers delete *t/d* at high percentage of 56.02% or 50.00% respectively. The following segments from the most favoring deletion to the least are ranked as: obstruent> nasal> pause (Ø)> glide> vowel, which differs from the previous findings of other researchers on the effects of pause [9, 15, 16]. There is also a tendency of the narrowing differences on the deletion rates between natives and EFL learners under each following environment.

As to the order of morphological classes of the target words promoting deletion, the order by native speakers of English in Figure 1 (c) complies with the findings of Guy [9-11]. Paying attention to the role of part of speech, we find from Figure 1 (d) that for native speakers, they have the same favoring order of parts of speech on deletion as Chinese EFL learners: prep.> adv.> v.> n.> adj, though their deletion rates are still higher than EFL learners'.

From Figure 1 (e), males in the two groups are more active than females in deletion, which implies men are more likely to delete the word-final *t/d*. The deleted proportions of male and female Chinese students are both around 20%, lower than those of native English speakers which are close to 40%. But their difference is more significant than native speakers, for male Chinese participants delete 4.73% more than females while the delete rate of female natives is only 0.45% lower than men.

3.2. Effects of English proficiency

English proficiency is an important variable during the late learning of English as second language and is related to the production acquisition. Pae reports that L2 proficiency is one significant independent predictor of L2 reading and writing performance [21]. According to Leal, higher English proficiency of L2 learners accounts for their more similar behavior to native speakers [22].

The development of proficiency also plays a significant role in the increasing competence of speech production in terms of speed, accuracy, and efficiency [23, 24]. Therefore, in this study, we assume that the English proficiency of Chinese EFL learners also has effects on their word-final *t/d* deletion.

The deletion rates under each category of conditioning factors are demonstrated as lines in Figure 2. It can be seen from the data in Figure 2 that intermediate Chinese EFL learners (ICE) and advanced Chinese EFL learners (ACE) differ in the application of word-final *t/d* deletion, which implies the effects of English proficiency. However, not all deletion rates by advanced learners are closer to native speakers and it's ambiguous to recognize which group has greater similarity to natives merely from Figure 2. Therefore, ANOVA is necessary to investigate whether English proficiency has identical impact on the application of deletion for every type of constraint.

Table 1: Summary of ANOVA results
Dependent variable: deletion rate*100

Source	Sum Sq	Mean Sq	F value	Pr(>F)
Preceding segments	2775	1387	7.49	.0056**
Following segments	749	374	1.58	.2450
Morphological classes	1028	514	8.84	.0163*
Parts of speech	3390	1695	15.53	.0005***
Gender	550	275	28.86	.0110*

Note: Sum Sq = Sum of Squares; Mean Sq = Mean Squares. Significance codes: ***p< .001. **p< .01. *p< .05.

The Table 1 presents the results of ANOVA which show the significant effects of English proficiency on the conditioning impact of preceding segments [F=7.49, p=0.0056<0.01], morphological classes [F=1.58, p=0.0163<0.05], parts of speech [F=15.53,

p=0.0005<0.001] and gender [F=26.72, p=0.0110<0.05] on the *t/d* deletion by Chinese EFL learners and by native speakers. Scheffe Test is employed to measure difference between three groups (ICE, ACE, and NES) based on ANOVA and the results are presented in Table 2.

Table 2: Summary of Scheffe post hoc Test results

Source	Groups	diff	pval
Preceding segments	ICE-ACE	-3.41	.9106
	NES-ACE	24.47	.0238*
	NES-ICE	27.88	.0104*
Following segments	ICE-ACE	-1.87	.9816
	NES-ACE	13.96	.3862
	NES-ICE	15.84	.3017
Morphological classes	ICE-ACE	-0.88	.9900
	NES-ACE	22.22	.0329*
	NES-ICE	23.10	.0280*
Parts of speech	ICE-ACE	-11.06	.2837
	NES-ACE	24.88	.0093**
	NES-ICE	35.95	.0006***
Gender	ICE-ACE	-2.93	.6749
	NES-ACE	18.69	.0208*
	NES-ICE	21.62	.0138*

Note: ICE = Intermediate Chinese EFL Learners; ACE = Advanced Chinese EFL Learners; NES = Native English Speakers. Significance codes: ***p< .001. **p< .01. *p< .05.

In order to give a better visual presentation of the post hoc results, we plot Figure 3 using R program. Error bars indicate 95% family wise confidence level and the greater its distance to the average 0 line, the more significant the difference between the corresponding two groups. From Figure 3, the bars indicating the comparison between intermediate Chinese EFL learners and advanced Chinese EFL learners (ICE-ACE) all lie across the average 0 but the centers don't coincide with it. This signifies that English proficiency makes difference in the word-final *t/d* deletions by these two groups, however, the difference is relatively insignificant when two groups of Chinese EFL learners are compared with the group of native speakers at the same time.

In Figure 3 (a), (c), (d) and (e), the bars for NES-ICE and NES-ACE both do not intersect with 0 line. It represents that under the constraints of the preceding segments, morphological classes, parts of speech and gender, there are significant differences between intermediate EFL learners and native speakers and between advanced EFL learners and native speakers. Nonetheless, the differences between advanced EFL learners and native speakers are less significant, for the distance to 0 of the NES-ICE bar is longer than that of the NES-ACE bar. Therefore, advanced EFL learners delete *t/d* in more similar pattern as native speakers in terms of the conditioning effects of these four types of factors.

If we exclusively focus on the deletion with the following segments as the only factor, both NES-ACE bar and NES-ICE bar intersect with 0 in Figure 3 (b). So, there is no significant difference in the application of deletion by the three groups of participants and the effects of English proficiency on the improvement of deletion application are not distinctive.

Therefore, Chinese EFL learners at different level of

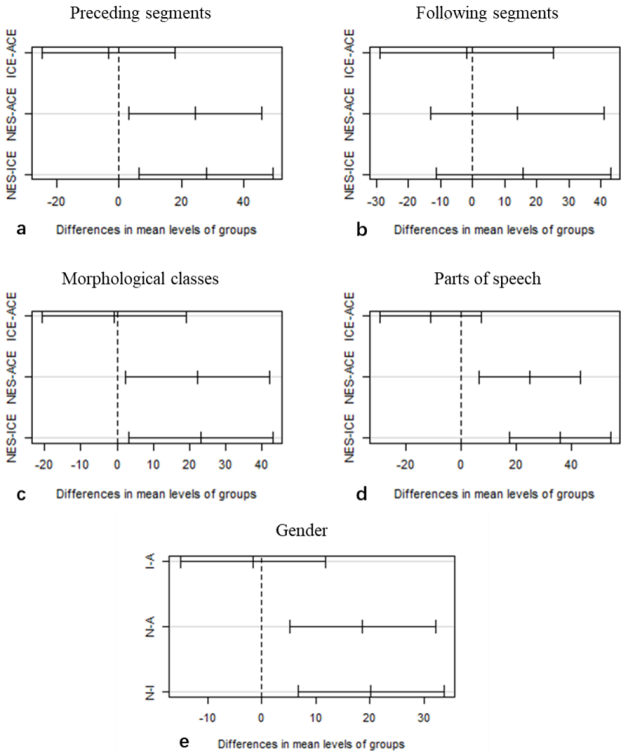

Figure 3: Significances of differences between groups

English proficiency differ in word-final *t/d* deletion. However, the effects of English proficiency vary with the types of constraints on deletion which is not consistent with the assumption. According to the distances between 0 and the center of error bar, we can summarize the order for the scale of effects of English proficiency of Chinese EFL learners on decreasing the discrepancy of the conditioning impact of constraints on deletion and increasing the similarity to natives: parts of speech > gender> the preceding segments> morphological classes> the following segments.

3.3. Effects of Chinese transfer

The differences of *t/d* production between English and Chinese may affect the accuracy of English pronunciation for Chinese EFL learners. Many previous studies find several common production errors of word-final *t/d* by Chinese EFL learners, among which epenthesis of vowel /ə/ is one of the most typical. According to Zhou et, al., the transfer of Chinese plays an important role in the epenthesis of /ə/ behind the plosive *t* [18]. Because epenthesis of /ə/ in the end of Chinese character is also frequent and makes no difference in meaning such as the attachment together with retroflex suffix in "*hua er*" (flower). Fan reports that Chinese English learners tend to add /ə/ at the end of CC# influenced by their interlanguage grammar [25]. In the aspect of Chinese syllable structure, *t/d* always appear as the initial consonant and is followed by vowels. Adding a vowel /ə/ to the word-final stop forms the accustomed CV# structure for Chinese EFL learners, which may be an unconscious behavior in their English production. Therefore, we speculate that the application of word-final *t/d* is also related to the transfer

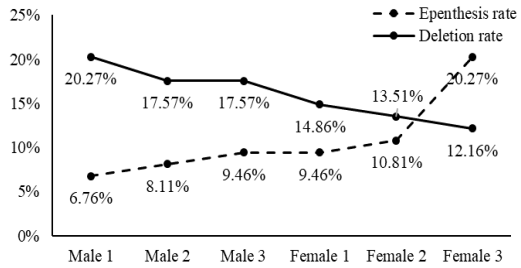

Figure 4: Rates of epenthesis and deletion by ICE

of Chinese, and the epenthesis behavior developed in speaking Chinese disfavor the deletion.

During the perception of word-final *t/d* deletion by Chinese EFL learners, it is noticed that neither advanced Chinese EFL learners nor native English speakers added vowel to final *t/d* but intermediate Chinese EFL learners did add. Therefore, based on perception and articulatory analysis, the production of word-final *t* for this Chinese speaker is considered to be accompanied with /ə/ epenthesis. The rates of epenthesis after word-final *t/d* by 6 intermediate EFL learners are identified and demonstrated together with the total rates of deletion in the following Figure 4.

What can be clearly seen in Figure 4 is the steady decline of deletion rate with the increase of epenthesis rate. Both male and female, who add phoneme /ə/ to the end of *t/d* more frequently, delete fewer coronal stops. This tendency is in agreement with the previous prediction and it confirms that owing to Chinese transfer, Chinese EFL learners at intermediate level of English are easy to make the error of epenthesis after *t/d* in production.

4. CONCLUSION

The current study investigates the application of *t/d* deletion at the final position of word in English by Chinese EFL learners at college and compares it with native speakers of English. Based on the data from the TIMIT corpus, recording collection and identification experiment, the findings of this study demonstrate that the applications of word-final *t/d* deletion by Chinese EFL learners and native English speakers have different patterns with the different conditioning effects of constraints on deletion. The study also suggests that both the level of English proficiency of Chinese EFL learners and the transfer of Chinese play important roles in their deletion of word-final *t/d*.

The distinctive features of the application by Chinese EFL learners are first identified in this research. Chinese EFL learners are less active in word-final t/d deletion under almost all the constraints than natives. While from the comparison between the deletion by Chinese EFL learners and by English natives, similarities of the conditioning effects of constraints are found as well. Under one type of constraint such as the following segments, parts of speech or gender, the tendencies to deletion by EFL learners and by native speakers are similar in the same order.

The study further supports the idea that the differences between EFL learners and natives vary with the level of English proficiency of EFL learners. The effects of high English proficiency on narrowing the differences are significant considering constraints of preceding segments, parts of speech and gender and are implicit for morphological classes. The higher English proficiency, the more similar the application pattern of deletion to native English speakers. It is also confirmed that the transfer of Chinese has disfavoring influence on CSD and the differences between Chinese EFL learners and native speakers.

In general, the empirical findings in this study provide a description of the application of word-final CSD by Chinese EFL learners and the differences compared to the native speakers of English, which permits a better understanding of word-final *t/d* deletion as phonological variation and the production of coronal stops. Further studies are needed to explore deeper about CSD with more other linguistic and social factors considered and discussed such as lexical stress, style of speech and age of speaker. More participants of Chinese EFL learners and native Americans are expected to provide data through acoustic analysis of their spontaneous speech in order to draw more universal conclusions. Moreover, the present study can be extended to the deletion of *t/d* at the medial position of word and other phonological variations of *t/d* such as flapping to better understand the production of *t/d* by Chinese EFL learners and compare it to native speakers for comprehensive improvement strategies.

5. REFERENCES

[1] M. Eisenstein, and D. Berkowitz. "The effect of phonological variation on adult learner comprehension," *Studies in Second Language Acquisition*, Cambridge University Press, Cambridge, pp. 75-80, 1981.

[2] V. W. Zue. "Acoustic study of medial /t,d/ in American English," *The Journal of the Acoustical Society of America*, AIP Publishing, New York, pp. 1039-1050, 1979.

[3] N. Warner, B. V., and Tucker. "Phonetic variability of stops and flaps in spontaneous and careful speech," *The Journal of the Acoustical Society of America*, AIP Publishing, New York, pp. 1606–1617, 2011.

[4] B. Parrell, and S. Narayanan. "Explaining coronal reduction: prosodic structure and articulatory posture," *Phonetica*, De Gruyter, Berlin, pp. 151–181, 2018.

[5] G. Guy. *Locating language in time and space*. Academic Press, New York, 1980.

[6] G. Guy. "Explanation in variable phonology: an exponential model of morphological constraints", *Language Variation and Change*, Cambridge University Press, Cambridge, pp. 1-22, 1991.

[7] G. Guy. "Contextual condition in variable lexical phonology," *Language Variation and Change*, Cambridge University Press, Cambridge, pp. 223-239, 1991.

[8] W. Labov, and P. Cohen. "Systematic relations of standard and non-standard rules in the Grammars of Negro speakers", *Paper presented at the Seventh Project Literacy Conference*, Project Literacy Conference, Cambridge, pp. 1-17, 1967.

[9] W. Labov, P. Cohen, C. Robins, et al. *A study of the non-standard English of Nergo and Puerto Rican speakers in New York City*. Columbia University Press, New York, 1968.

[10] W. Labov. "Contraction, deletion, and inherent variability of the English copula," *Language*, Johns Hopkins University Press, Baltimore, pp. 715–762, 1969.

[11] W. Labov. "The child as linguistic historian," *Language Variation and Change*, Cambridge University Press, Cambridge, pp. 85–97, 1989.

[12] S. Tagliamonte, and R. Temple. "New perspectives on an ol' variable: (t,d) in British English," *Language Variation and Change*, Cambridge University Press, Cambridge, pp. 281–302, 2005.

[13] R. A. M. Temple. "(t,d): the variable status of a variable rule," Oxford University Working Papers in Linguistics, Oxford, pp. 145-170. 2009.

[14] M. Baranowski, and D. Turton. "TD-deletion in British English: new evidence for the long-lost morphological effect," *Language Variation and Change*, Cambridge University Press, Cambridge, pp. 1-23, 2020.

[15] K. Hazen. "Flying high above the social radar: coronal stop deletion in modern Appalachia," *Language Variation and Change*,
Cambridge University Press, Cambridge, pp. 105-137, 2011.

[16] J. Tanner, M. Sonderegger, and M. Wagner. "Production planning and coronal stop deletion in spontaneous speech," *Laboratory Phonology*, De Gruyter, Berlin, pp. 1–39, 2017.

[17] H. Guo, and M. Wang. "A study of (-t,d) deletion in interlanguage complex codas: variable rule analysis," *Foreign Language & Their Teaching*, Dalian University of Foreign Languages, Dalian, pp. 73-78, 2010.

[18] W. Zhou, Y. Bi, L. Dai, and H. Chen. "Pilot study on acquisition of English plosives by Chinese college students," *Journal of Jiangsu University of Science and Technology (Social Science Edition)*, Jiangsu University of Science and Technology, Zhenjiang, pp. 41-45, 2011.

[19] J.S. Garofolo, F.L. Lori, M.F. William, et al. *The DARPA TIMIT Acoustic-Phonetic Continuous Speech Corpus CDROM*,
NIST, Gaithersburg, pp. 18-19, 1986.

[20] S. Gahl, and G. Susan. Knowledge of grammar includes knowledge of syntactic probabilities. *Language*, Johns Hopkins University Press, Baltimore, pp. 405-410, 2006.

[21] T. I. Pae. "Effects of task type and L2 proficiency on the relationship between L1 and L2 in reading and writing: an SEM approach," *Studies in Second Language Acquisition*, Cambridge University Press, Cambridge, pp. 63–90, 2018.

[22] T. Leal, R. Slabakova, and T. Farmer. "The fine-tuning of linguistic expectations over the course of L2 learning," *Studies in Second Language Acquisition*, Cambridge University Press, Cambridge, pp. 493-525, 2017.

[23] M. Declerck, and J. Kormos. "The effect of dual task demands and proficiency on second language speech production," *Bilingualism: Language and Cognition*, Cambridge University Press, Cambridge, pp. 782-796, 2012.

[24] I. Pivneva, C. Palmer, and D. Titone. "Inhibitory control and L2 proficiency modulate bilingual language production: Evidence from spontaneous monologue and dialogue speech," *Frontiers in Psychology*, Frontiers Media, Switzerland, pp. 57, 2012.

[25] Y. Fan. "Epenthesis in L2 complex codas: An Optimality Theory and P-map account," *Journal of Foreign Languages*, Shanghai Foreign Language Education Press, Shanghai, pp. 53-61, 2008.