Production and Perception of Single and Double Consonant Letters in English Words by Korean Learners of English

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Abstract

This study investigates how Korean students produce and perceive single and double consonant letters in English words. To this end, twenty-eight Korean learners of English participated in the production and perception tests of English consonants /p, b, s, d, k, g/ with single and double letters. The participants were first asked to produce English words with the target consonants spelled with a single or a double letter. Then, the same participants were asked to choose the same words they heard among the two productions of each native American English speaker' production: the original production and artificially lengthened production of the target consonant sound. The percentages of the correct production and perception for the target consonant sounds with single consonant letters and double consonant letters were calculated to compare the accuracy of single and double letters. The study results demonstrate three factors influencing the production and perception of English single and double consonant letters. First, the Korean participants' performance of the double letters was significantly worse than the performance of the single letters for both perception and production. This clearly shows that orthographic forms affect the learners' production and perception of English words. Second, modality effect was attested such that the participants' perception of the English single and double letters was significantly worse than the production of the same targets. Third, the participants showed worse performance for the voiceless targets than for the voiced targets both in perception and production, thus showing voicing effect. Further, the participants' production of the voiceless targets was significantly worse than the production of the voiced targets. Finally, pedagogical suggestions were provided.

Keywords: orthography, speech production, speech perception, voiceless consonants, voiced consonants

1. Introduction

1.1 Mismatch between Spelling and Sounds in English

The English language does not show spelling-to-sound correspondences. For instance, the same sound [□] is spelled by different letters (e.g., ***sh****op, o****c****ean, ma****ch****ine, **s**ure, mi****ss****ion, na****ti****on, con****sc****ience*) and the same letter <s> may represent different sounds (e.g., **s**ugar, vi**s**ion, **s**ale, re**s**ume). Thus, it is well-known that second language (L2) learners of English frequently have difficulties in matching letters with sounds in English, which lead to target-inappropriate pronunciation of a target sound. This happens because L2 learners are usually exposed to written input when they learn English.

In the modern English language double consonant letters do not represent consonantal length. Consonant length is, however, contrastive in the old English period whereby singleton and geminate consonants represent short and long sounds, respectively. Consequently, the length of consonants is contrastive in meaning, and this contrast is represented in spelling by means of single consonant letters for short consonant sounds and double consonant letters for long consonant sounds (e.g., *ra****c****a* 'rake' vs. *ra****cc****a* 'part of a ship's rigging') in Old English (Algeo, 2010: p.89).

If L2 learners of English are influenced by orthographic forms of English target consonants, English target consonants represented by double letters are expected to be produced as long consonant sounds in spite of the fact

that orthography do not affect consonantal duration in the modern English language. Research on the role of orthographic input in L2 acquisition has relatively recently begun (Hayes-Harb & Shannon Barrios, 2021). Thus, not many studies have investigated orthographic effects on Korean L2 learners of English in both modalities of production and perception, although there are some studies of orthographic effects on European L2 learners of English. Therefore, further research is needed for establishing a theoretical basis on the effects of orthographic input in English L2 learning.

1.2 Previous Studies

Recently, Bassetti (2017) conducted a series of experiments that investigated orthographic effects on the production of English words with single and double consonant spellings. Specifically, native English speakers and native Italian speakers were asked to produce English words with single consonant letters and double consonant letters, and the duration of the target consonant was compared. The results showed that the duration of the native English speakers' production of the target consonants was the same regardless of the targets' single and double letters. By contrast, the native Italian speakers produced the target consonants with double letters as longer (i.e., geminate consonant, e.g., *ki**tt**y*) than the target consonants with single letters (e.g., *ci**t**y*), thus showing orthographic effects.

Motivated by Bassetti's findings, the current study investigates whether single and double consonant spellings can cause Korean learners of English to make a contrast in their production and perception of English words, which does not exist in Modern English, given that the Korean language does not adopt the Roman alphabet. Importantly, the current study expands the scope into both modalities of production and perception to see whether orthographic effects wield the same power over both modalities since little is known about the extent of orthographic effects on L2 speech perception. Studies on orthographic effects in L2 phonology mostly focus on L2 production, not on L2 perception. Further, most previous studies investigate orthographic effects targeting English learners whose native languages are European languages. Specifically, Bassetti and Atkinson (2015) showed orthographic effects on Italian learners of English who produced English words with silent letters and vowels with double letters and single letters. Bassetti (2017) found orthographic effects on the production of English words with double and single consonant letters by Italian learners of English. Burki et al. (2019) showed that orthographic information facilitates the production of English pseudo-words by French learners of English. Given that most previous studies focus on L2 production and on native speakers of European languages, the current study aims to investigate orthographic effects on both modalities of production and perception targeting Korean learners of English.

To this end, Korean learners of English were presented with English words spelled with a single versus double consonant letter to see whether they would target-inappropriately produce and perceive geminates in the double letter words despite no length difference between single and double consonant letters in English. If Korean learners produce and perceive an English word with double letters as a long consonant sounds while an English word with single letters as a short consonant sound, this will indicate that the Korean learners are influenced by the number of consonant letters in English words.

2. Method

2.1 Materials

The stimulus words were composed of thirty words containing target consonants spelled with either a single consonant letter or a double consonant letter, as in *su**p**er* and *su**pp**er* (both /p/). The target consonants were /p, b, s, d, k, g/ counterbalancing the voiceless and voiced consonants within the same place of articulation. The stimulus words with one-to-one correspondence between the target consonant sound and the consonant letter were chosen except double spelling. The current study tested orthographic effect by controlling the number of consonant letters (single versus double). Thus, single and double consonant letters were provided for each target consonant, as in Table 1. Voiceless alveolar stop /t/ was not included since /t/ mostly becomes a flap sound [□] in unstressed intervocalic position in American English, thus lacking sound-spelling correspondence. The stimulus words were selected from the familiar English word list for the secondary school curriculum. All the stimulus words were bi-syllabic and the target consonants occurred intervocalic position. The list of the stimulus words is provided in Appendix.

Table 1. Target Conant Sounds with Orthographic Forms

sounds	/p/		/b/		/s/		/d/		/k/		/g/	
letters	<p>	<pp>	<b>	<bb>	<s>	<ss>	<d>	<dd>	<k>	<kk>	<g>	<gg>

For the perception task, the stimulus words were recorded by one female native speaker of American English. Further, the native speaker's production of the stimulus words was manipulated to lengthen the duration of the target consonants twice using the Praat application program. Both the original production by the native speaker and the manipulated version of the original production were given to the participants in the perception task. If the participants choose the manipulated version for the words with double spelling, this indicates that orthographic forms impact on L2 perception. If the participants choose the original production regardless of spellings, this indicates that orthographic forms do not affect L2 perception. Figure 1 shows the original production by the native speaker and the length-manipulated version for the stimulus word 'abbey'. In the lower panel, the duration of the target consonant /b/ was elongated to be heard as [ˈːˑb.bi] instead of [ˈːˑbi].

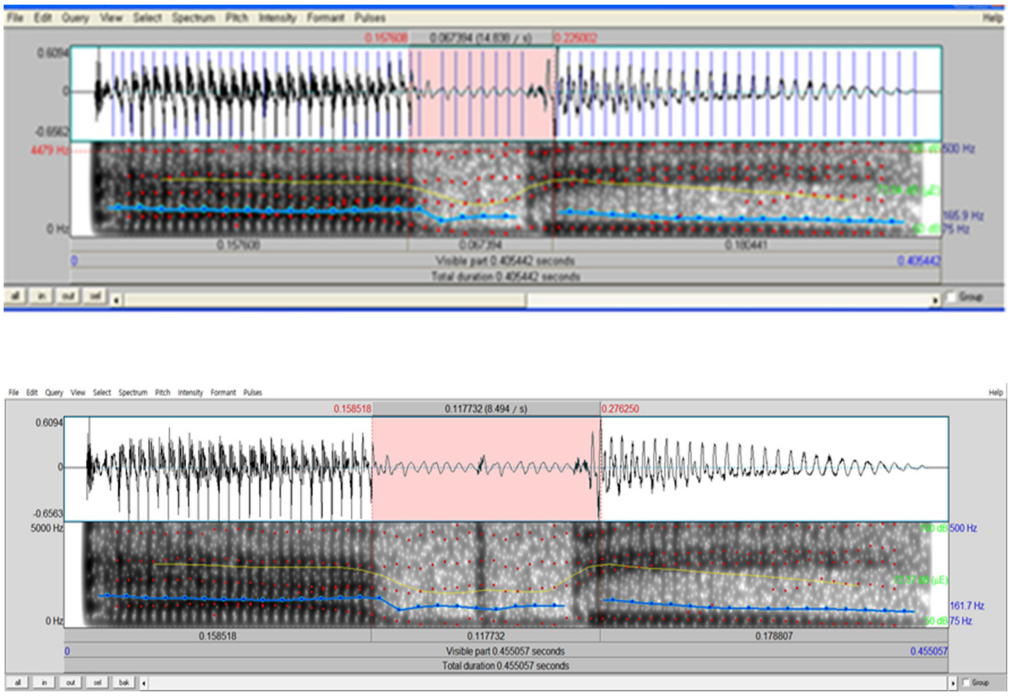

Figure 1. Native Speaker'S Production of *abbey*. The Upper Panel is the Original Production of the Native speaker and the Lower Panel is the Manipulated Version in Which the Target Consonant /b/ Is Artificially Lengthened

2.2 Participant

The participants of this study were twenty-eight Korean learners of English (seventeen males and eleven females) with a mean age of 22.1 years (ranges: from nineteen years to twenty-six years). They were all recruited from an English class for freshmen at a university located in the metropolitan area of Seoul, Korea. The participants had been learning English for more than nine years at school at the time of testing given that the onset of English teaching begins in the third grade at primary school according to the curriculum in Korea. As is normal in Korean classrooms, the participants were learning English as a foreign language (EFL) environment and had been usually exposed to written input in learning English mostly with non-native English teachers. Further, the participants self-reported their English proficiency as either intermediate or low-intermediate in a questionnaire before testing. None of the participants had experience living in English-speaking countries for more than one year and had any speech or hearing problems. Information regarding the participants kept confidential in an archive.

2.3 Procedures

The production task was conducted before the perception task. Prior to the production task, the participants were familiarized with the procedure through a practice session. For the production test, participants received a randomized written list of stimulus words on paper and produced the words orally within the carrier sentence of 'Say ___ again' in a sound-attenuated room. Responses were recorded using the Goldwave application program with a Sony ECM-MS907 microphone. The recordings were digitized at 44.1000 Hz and stored at a laptop computer as wave files.

The perception task was a paper-and-pencil test administered in a forced-choice format. The participants were presented the two productions of each native American English speaker' production in a random order (i.e., the original production and artificially lengthened production of the target consonant sound) and asked to choose the production they heard by circling among two alternatives on a paper response form (e.g., message ① ②; usage ① ②). The thirty stimulus words were randomly presented to the participants via over-the-ear type headphones (Samsung SHS-150V/W) connected to the laptop computer in the same room where the production task was conducted. The inter-stimulus-interval was five seconds which was enough to decide for the answer.

2.4 Coding

For the production test, the participants' recordings were acoustically analyzed by using the Praat program. Only the duration of the target consonants was calculated for coding. Specifically, the duration of the target consonants was measured and compared with that of the native speakers. If the duration of the participants is longer more than two times of the duration of the native speaker, as in Figure 2, it was coded as 0 (i.e., target-inappropriate). Otherwise, it was coded as 1 (target-appropriate). For the perception test, it was coded as 0 if the participants choose the length-manipulated production of the native speaker. If the participants choose the original production of the native speaker, it was coded as 1.

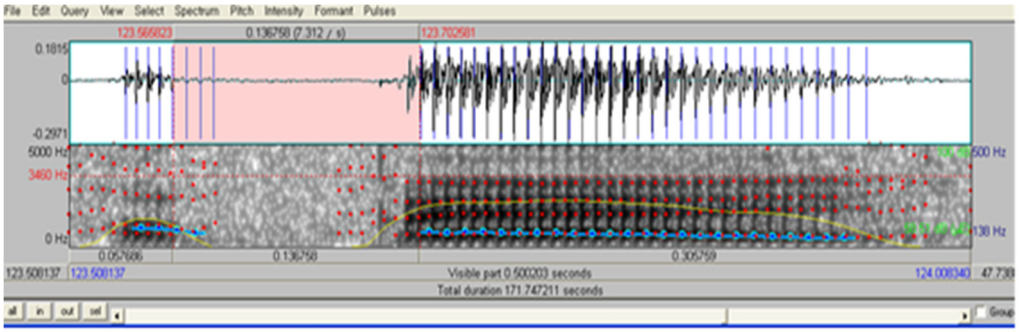

Figure 2. Korean Participant'S Production of *abbey*. The Duration of the Target Consonant /b/ Is Longer More than Two Times of the Duration of the Native Speaker's Target Consonant Production

3. Results

3.1 Overall Results

The percentage of the total correct production for single consonant letters (91%) was higher than that for double consonant letters (76%), and this trend was also observed in total perception (single letter perception: 81%, double letter perception 70%). Further, the total production accuracy was higher than the total perception accuracy both for single and double consonant letters (single letter production: 91%, single letter perception: 81%; double letter production: 76%, double letter perception: 70%). Figure 3 illustrates the mean percentage of the correct by consonant letter type and modality for each consonant letter along with the total mean correct percentage.

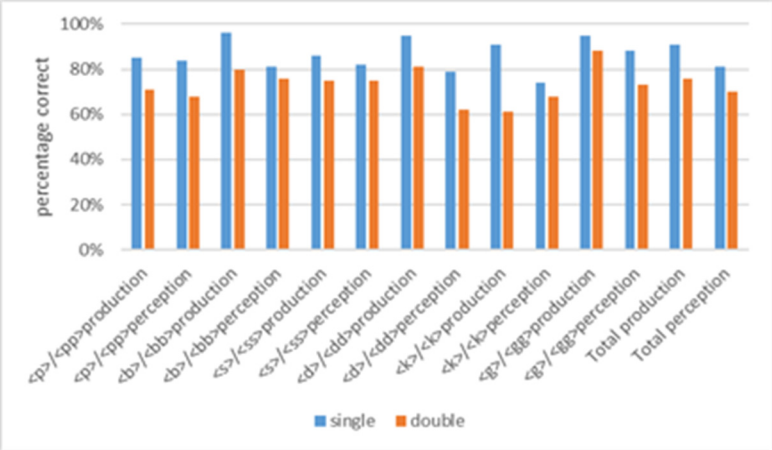

Figure 3. Mean Percentage of the Correct Production and Perception by Single and Double Consonant Letters

As for the result of each consonant letter, the same trend as the total result was observed. That is, higher mean percentage of the correct production and perception for single consonant letters than double consonant letters across modalities and tokens (<p, pp, b, bb, s, ss, d, dd, k, kk, g, gg>) were attested, although the accuracy of the individual consonant letters varied. Also, production accuracy tended to be higher than perception accuracy for individual consonant letters. In particular, production accuracy of <b>, <d>, and <g>, which are voiced targets, turned out to be very high.

In order to find out whether accuracy varied according to consonant letter type (single/double), modality (production/perception), and voicing(voiceless/voiced), an analysis of variance (ANOVA) with repeated measures was carried out as an omnibus analysis. The three variables were letter type, modality, and voicing and the dependent variable was mean accuracy rates. The results are presented in Table 2.

Table 2. Results of an ANOVA with Repeated Measures by Letter Type, Modality, and Voicing

Source of Variance	F	Sig
letter type	35.046	.000*
modality	12.217	.001*
voicing	7.623	.006*
modality * voicing	4.783	.029*
letter * modality	1.053	.305
letter * voicing	.138	.710
letter * modality * voicing	.862	.353

*p<.05

As shown in Table 2, there were significant main effects of letter type (F[1, 664]=35.046, p <.05), modality (F[1, 664]=12.217, p<.05), and voicing (F[1, 664]=7.623, p<.05). However, no significant interactions were found except the interaction between modality and voicing (F[1, 664]=4.783, p<.05). The results indicate that consonant letter types impact on Korean students' production and perception of English words such that Korean students' production and perception abilities of the English words with single consonant letters were better than those of the English words with double consonant letters. This is because the Korean students tended to produce the English words with target double consonant letters long due to the spelling, which is target-inappropriate. Likewise, the Korean students tended to choose the English words with target double letters the long pronunciation, which is target-inappropriate. This clearly shows the influence of orthographic forms that the Korean students had more difficulties in both producing and perceiving the English words with double consonant letters than the words with single consonant letters.

Further, there is effect of modality whereby Korean students' production accuracy of the targets was better than the perception accuracy of the same targets. Also, voicing effect was witnessed in which the accuracy of the voiced targets was better than the accuracy of the voiceless targets. Moreover, there is an interaction between modality and voicing (i.e., the effect of modality differs depending on the voicing of the target sound) in such a way that production accuracy of voiced targets was better than that of voiceless targets. Given that there are effects of consonant letter type, modality, voicing and that there is an interaction between modality and voicing in the omnibus analysis, further statistical analyses are granted to be conducted to assess individual comparisons within the datasets.

3.2 Orthographic Effect

This study examined in detail the influence of individual orthographic forms since pairwise comparisons are justified by the data in the omnibus analysis. As the consonant letter type had a main effect as illustrated in Figure 4, the individual mean accuracy rates of single consonant letters and double consonant letters were submitted to paired, two-tailed t-tests. The result of a series of the t-tests on the mean accuracy differences between single vs. double consonant letters in production and perception is given in Table 3.

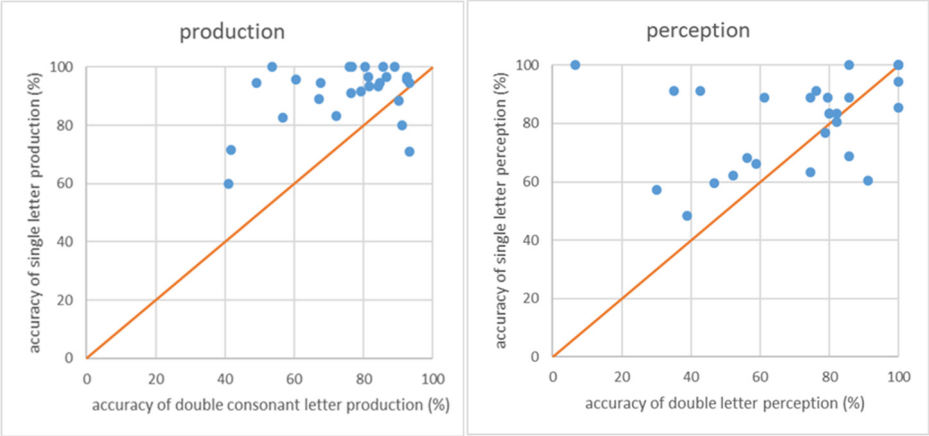

Figure 4. Scatter Plots of Single Letter Accuracy Percent Against Double Letter Accuracy Percent for the Production (left panel) and Perception (right panel) Tasks. The diagonal line (y=x) represents an outcome where the single letter accuracy fits the double letter accuracy

Table 3. T-tests on Accuracy of Single and Double Consonant Letters

Comparison	Pairs	t	df	p	Mean difference
single vs. double	<p> vs. <pp> production	2.731	27	.001*	14.286
	<p> vs. <pp> perception	2.819	27	.009*	15.71429
	<b> vs. <bb> production	4.653	27	.000*	16.071
	<b> vs. <bb> perception	.855	27	.400	5.23810
	<s> vs. <ss> production	1.140	27	.264	10.714
	<s> vs. <ss> perception	.626	27	.537	7.14286
	<d> vs. <dd> production	3.057	27	.005*	14.286
	<d> vs. <dd> perception	2.260	27	.030*	16.66667
	<k> vs. <kk> production	4.753	27	.000*	29.762
	<k> vs. <kk> perception	.694	27	.494	5.95238
	<g> vs. <gg> production	1.441	27	.161	7.143
	<g> vs. <gg> perception	2.295	27	.030*	14.28571
	single total vs. double total production	5.202	27	.000*	14.782
	single total vs. double total perception	10.23810	27	.033*	2.248

*p<.05

Table 3 shows that the total accuracy of single letters was significantly better than the total accuracy of double letters both in production and perception. However, this trend is not observed for all the individual tokens. In production, only four pairs <p-pp, b-bb, d-dd, k-kk> among six pairs showed significant differences between single versus double letter accuracy. Thus, it can be considered that the significant difference between single letters and double letters for the production task was induced by low accuracy of the double letters <pp, bb, dd, kk>. Namely, a significant number of the Korean participants target-inappropriately produced the pronunciation of <pp, bb, dd, kk> letters long in the production task due to the spelling. In the perception task only three pairs of <p-pp, d-dd, g-gg> showed significant accuracy differences. Thus, it was low accuracy of the double letters <pp, dd, gg> that was responsible for the perception accuracy differences. The Korean participants tended to choose the long pronunciation for <pp, dd, gg> letters unlike the ambient language. To summarize, Korean participants' difficulties in producing <pp, bb, dd, kk> targets and perceiving <pp, dd, gg> targets can be accounted for by the influence of orthographic forms.

3.3 Modality Effect

Modality effect was found in the omnibus analysis in which the production accuracy was ahead of the perception accuracy, as shown in Figure 5. Thus, paired, two-tailed t-tests on the mean accuracy rates of production and perception were conducted to see whether the mean differences between production and perception accuracy of the individual pairs were significant. The result of a series of the t-tests on the mean differences between production and perception accuracy for the single letters and double letters is given in Table 4.

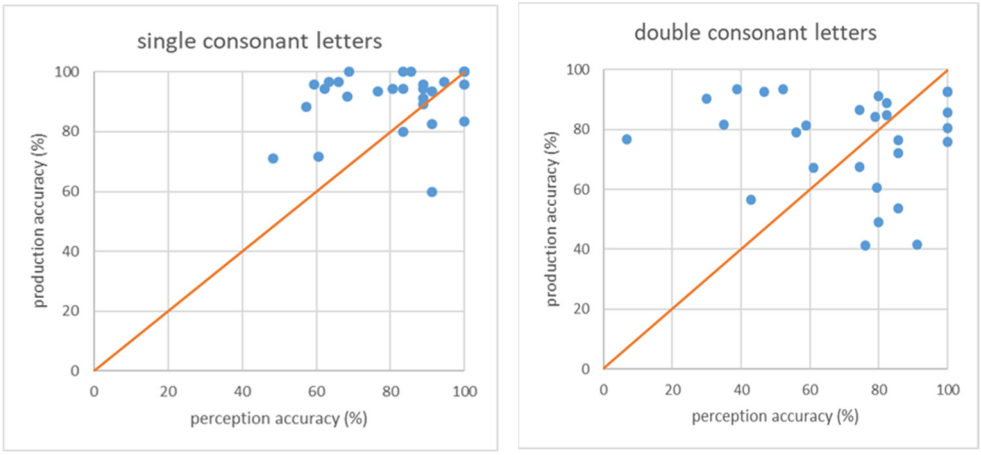

Figure 5. Scatter plots of production accuracy percent against perception accuracy percent for the single letters (left panel) and double letters (right panel). The diagonal line (y=x) represents an outcome where the production accuracy fits the perception accuracy

Table 4. T-tests on Production and Perception Accuracy

Comparison	Pairs	t	df	p	Mean difference
production vs. perception	<p>: production vs. perception	.297	27	.769	1.42857
	<pp>: production vs. perception	.406	27	.688	2.85714
	<b>: production vs. perception	2.763	27	.010*	14.58333
	<bb>: production vs. perception	.561	27	.580	3.75000
	<s>: production vs. perception	.372	27	.713	3.57143
	<ss>: production vs. perception	.000	27	1.000	.00000
	<d>: production vs. perception	3.334	27	.002*	16.66667
	<dd>: production vs. perception	2.458	27	.021*	19.04762
	<k>: production vs. perception	2.867	27	.008*	16.66667
	<kk>: production vs. perception	-.732	27	.470	-7.14286
	<g>: production vs. perception	2.121	27	.043*	7.14286
	<gg>: production vs. perception	1.492	27	.147	14.28571
	single total: production vs. perception	3.233	27	.003*	10.00992
	double total: production vs. perception	.935	27	.358	5.46627

*p<.05

Table 4 shows that the modality effect in the omnibus analysis is not true for all the cases; while the production accuracy was significantly better than the perception accuracy for the total single letters, it was not the case for the total double letters. As for the individual pairs, the accuracy differences between production and perception of <b, d, dd, k, g> were significant. Thus, the Korean participants' production abilities were better than their perception abilities only for the 5 target letters of <b, d, dd, k, g> among 12 target letters. This shows that the precedence of production over perception varied with the individual target letters, and importantly the targets that revealed the significant accuracy differences between production and perception consisted of mostly single letters except for <dd> and voiced targets except for <k>. It is not surprising that the Korean participants better produced the voiced targets

than the voiceless targets given the significant interaction between modality and voicing in the omnibus analysis. It is also worth to note that the precedence of perception over production has been documented in the L1/L2 acquisition literature (Flege et al., 1997; Bradlow et al., 1997), which is the opposite results of the present study.

3.4 Voicing Effect

Voicing effect was also detected in the omnibus analysis in which the voiced target accuracy was better than the voiceless target accuracy, as shown in Figure 6. Paired, two-tailed t-tests on the mean accuracy rates of the voiced and voiceless targets were conducted to see whether the mean differences between voiced and voiceless target accuracy of the individual pairs were significant. The result of a series of the t-tests on the mean differences between the voiced and voiceless accuracy in production and perception is given in Table 5.

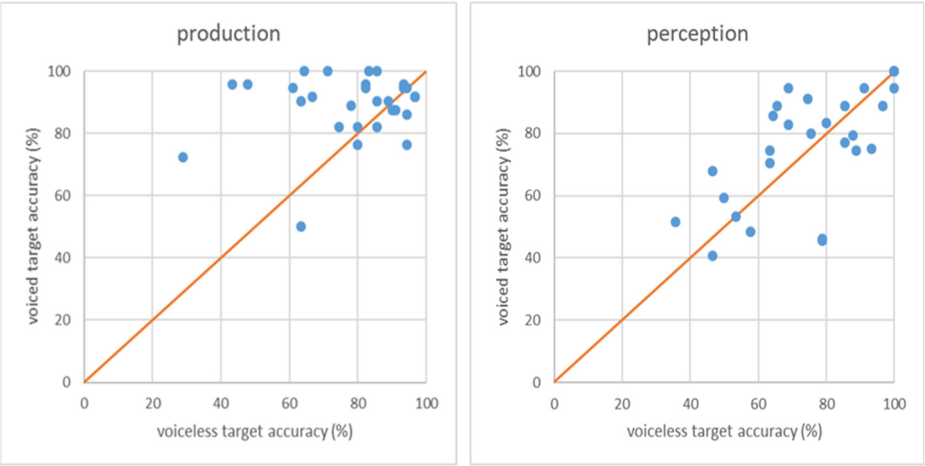

Figure 6. Scatter Plots of Voiced Target Accuracy Percent Against Voiceless Target Accuracy Percent for the Production and Perception Tasks. The diagonal line (y=x) represents an outcome where the voiced target accuracy fits the voiceless target accuracy

Table 5. T-tests on the Accuracy of Voiceless Targets and Voiced Targets

Comparison	Pairs	t	df	p	Mean difference
voiceless vs. voiced	<p> vs. <b> production	-2.735	27	.011*	-10.536
	<p> vs. <b> perception	.516	27	.610	2.61905
	<pp> vs. <bb> production	-1.378	27	.180	-8.750
	<pp> vs. <bb> perception	-1.890	27	.070	-7.85714
	<s> vs. <d> production	1.353	27	.187	9.524
	<s> vs. <d> perception	-.441	27	.663	-3.57143
	<ss> vs. <dd> production	.644	27	.525	5.952
	<ss> vs. <dd> perception	-1.387	27	.177	-13.09524
	<k> vs. <g> production	-.942	27	.355	-4.167
	<k> vs. <g> perception	-2.257	27	.032*	-13.69048
	<kk> vs. <gg> production	-3.443	27	.002*	-26.786
	<kk> vs. <gg> perception	-.622	27	.539	-5.35714
	voiceless vs. voiced total production	-3.053	27	.005*	-10.95238
	voiceless vs. voiced total perception	-.444	27	.660	-1.26984

*p<.05

Table 5 shows that the total voiced target accuracy was significantly better than the total voiceless target accuracy for the production task, but not for the perception task. When pairing the voiced targets with the voiceless targets (i.e., /p/-/b/, /s/-/d/, /k/-/g/), only the pairs of <p-b> and <kk-gg> showed significant accuracy differences in production. The Korean participants had more difficulties producing voiceless targets <p> and <kk> because they tended to pronounce <p> and <kk> longer than the voiced counterparts <b> and <gg>, respectively. In the perception task, the accuracy difference was significant only for the pair of <k-g>, which indicates that the Korean participants tended to choose the long pronunciation for the voiceless target <k> than for the voiced target <g>.

4. Discussion

The results of the study demonstrate three factors influencing the production and perception of English single and double consonant letters. First, orthographic effects were found both in production and perception given that the accuracy of the double letters was significantly lower than that of the single letters across perception and production tasks. Second, modality effects were attested such that the perception accuracy of the English single and double letters was significantly worse than the production of the same targets. Third, voicing effects were revealed because the accuracy of the voiceless targets was lower than that of the voiced targets across the production and perception tasks.

Previous studies on the influence of orthography were mostly limited on production, but not on perception (Bassetti, 2017; Bassetti & Atkinson, 2015; Burki et al., 2019). The current study, however, expands the extent to which orthography influences performance in the L2 into the scope of perception by showing that the Korean participants' performance of the double letters was significantly worse than the performance of the single letters in perception as well as production. Further, the Korean participants overall had more difficulties perceiving single and double letters than producting them.

The present study shows the precedence relationship of production over perception in some of the targets, but not across all the targets. This is different from the traditional perspective that perceptive abilities are a prerequisite to productive abilities in the first language acquisition (Best, 1994; Jusczyk, 1997; Pater, 2004; Schiller & Meyer, 2003). Although quite a few previous studies argue for the precedence of perception over production (Flege et al., 1997; Bradlow et al., 1997), there are also a few studies that argue for the precedence of production over perception (Sheldon & Strange, 1982). Thus, the precedence relationship might vary with target properties and the stages of acquisition.

Investigating the relationship between production and perception is of importance because it could further inform different pedagogical approaches to English learning. Specifically, spelling pronunciation producing and perceiving double consonant letters longer than single consonant letters should be explicitly prevented. Also, perceiving English single and double letters should be more focused than producing them. Finally, more emphasis should be placed on voiceless consonants than voiced consonants in producing and perceiving English consonants.

5. Conclusion

The current study investigates how Korean students produce and perceive single versus double consonant letters in English words. Three factors influencing the production and perception of English single and double consonant letters were found. First, the Korean participants' performance of the double letters was significantly worse than the performance of the single letters for both perception and production, thus showing the effect of orthographic forms. Specifically, the orthographic effect was due to the low production accuracy of <pp, bb, dd, kk> letters and low perception accuracy of <pp, dd, gg> letters. Thus, the participants tended to realize the consonant sounds such as /p, b, d, k, g/ as longer in duration when they are spelled with double letters. Second, modality effect was attested such that the participants' perception of the English single and double letters was significantly worse than the production of the same targets. It was low perception accuracy of <b, d, dd, k, g> that was responsible for the production and perception accuracy differences. Importantly, the targets that revealed the significant accuracy differences between production and perception were mostly single letters except for <dd> and voiced targets except for <k>. Better production performance of the voiced targets <b, d, dd, g> is not surprising given the significant interaction between modality and voicing in the omnibus analysis. Third, the participants showed worse performance for the voiceless targets than for the voiced targets both in perception and production, thus showing voicing effect. The participants had more difficulties in producing voiceless targets <p> and <kk> than their voiced counterparts <b> and <gg>, respectively, and more difficulties in perceiving <k> than its voiced counterpart <g>.

This study has some limitations in that it only considered a part of English consonants, /p, b, s, d, k, g/. Thus, a

caveat regarding the three factors is in order, and future research that investigates orthographic effects on English fricative and sonorant consonant letters would help to validate the factors influencing the production and perception of English single and double consonant letters.

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Appendix

Stimulus word list

Single letters	Double letters
copy	happy
snoopy	puppy
super	supper
vapor	slipper
couple	apple
baby	abbey
ruby	cabby
robot	robber
cubic	rabbit
usage	message
reduce	adduce
noodle	coddle
moody	teddy
dragon	waggon
sugar	beggar