Simple graphical “wave addition” model for L2 acquisition order of initial obstruents

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ABSTRACT

There has been a wide body of research and models that aim to describe acquisition order of obstruent phonemes in the second language and how it follows that of the first language and universal grammar. This research proposes a new and simple graphical “wave addition” model based on Wode’s notion that the L2 is “filtered through the grid” of the learner’s repertoire to obtain the interlanguage (IL), that is, L2 obstruent acquisition order. Analysis shows that when a “UG Wave” is constructed for the L2 with peak height for each obstruent approximating relative markedness, is superimposed with percent correct data used as the “grid”, the L2 obstruent order for a given L1 to L2 pair (“L1 → L2” Wave) can be obtained. The model was able to successfully represent three cross-sectional studies examined: Korean to English, Icelandic to English, and Cantonese to French. These studies are: five beginning level Korean speakers of English living in the US for 6 months reading an English word list and text containing initial obstruents voiced: /b/, /d/, /g/, /v/, /z/, /ʒ/, /dʒ/ and /ð/ and voiceless /p/, /f/, /k/, /t/, /s/, /ʃ/, /tʃ/ and /θ/; and two other studies from the literature of an Icelandic child learning English, and Cantonese speakers of French. Picturing L2 acquisition process as a filter, results showed L1 elements in the L2 mostly transferred (went through) easily, while those not in the L2 filtered according to other factors such as markedness, similarity, or tones. Initial obstruents, as opposed to medial and final were examined since they are the first ones learned by children. This study is applied to a small corpus of 5 Korean speakers of English; however, chi-squared per cell was 0.73, within statistical reliability range below 1.5, and it clearly demonstrates that a workable model is possible to obtain L2 acquisition order of linguistic elements for individuals, small groups, and other language pairs. This is with the aim of contributing to phonological research and language education.

Key words: Linguistics, second language acquisition, phonology, obstruents, Korean, English, language education, pronunciation.

INTRODUCTION

From the mid-20th century, several subfields of linguistics have been studied to determine how elements are acquired in the L1 and L2 (first and second language) and their interactions. These include: natural order (Krashen, 1977; Eckman, 1977; Kim and Go, 2018), discourse and functional syntax (Givón, 1984), writing (Karim and Nassaji, 2013), prosodic structure (Gussenhoven, 2019; Amaro, 2017; Steele, 2002), accent (Riad, 2019), tones (Ioup and Tansomboon, 1987), syllable structure (Karimi, 1987; Anderson, 1987) and phonology (Altenberg and Vago, 1983; Broselow, 2018; Broselow and Kang, 2013; Brown, 2009; Eckman, 1977; 1981; Flege, 1987, 2008; Major, 2008).

Several studies have focused on obstruent acquisition (Broselow, 2018; Broselow and Kang, 2013; Brown, 2009; Cichocki et al., 1993; Eckman, 1977, 1981, 1984; 2008; Faudree and Fujimaki, 2020; Hansen, 2001, 2004; Hecht and Mulford, 1987; Macken and Barton, 1980; Major, 2008; Schmid, 2012; Wang, 1995; Yazawa et al., 2015; Ladd and
Schmid, 2018) to name a few.


Various graphical models for L2 acquisition are found in literature. Dickerson (1987) used a type of “Wave Mechanism” to describe developmental patterns in Japanese acquiring Japanese /l/; Harley (2000) described a dynamic oscillator type model of phoneme sequences in naturalistic speech. Colatoni and Steele (2008) constructed a model based on a perception–production process that compares L1-L2 phonemes classifying them as “old,” “similar” or “new”. Major (1987b) put together a simple graphical Ontogeny Model (OM) that proposes through time transfer processes decrease; while developmental processes increase then decrease. Later, Major (2008) elaborated his OM with the Ontogeny Phylogeny Model (OPM) that states through time L1 processes decrease, L2 processes increase, while a third factor, U representing developmental forms not in the L1 or L2, increase and then decrease. Park and de Jong (2017) constructed perceptual category mapping between English and Korean obstruents in non-CV positions. This list is not all inclusive.

The goal of this study is to produce a model with simple easy-to-understand output based on Wode’s (1977, 1978) notion that the L2 is “filtered through the grid” of the learner’s repertoire to obtain the interlanguage (IL), in this case, L2 acquisition order of initial obstruents. The rendering is shown in Figure 1 where “waves” will be constructed to approximate the “UG wave”, “Grid” and “L1→L2 wave” whose action will be referred to here as the “wave addition” model. This is a cross-sectional study. The model is based on 5 native Korean speakers of English at beginning level of English pronunciation living in the US for 6 months. Although a larger corpus is recommended, gathering more participants under the same conditions was not possible due to COVID-19 situation. Nevertheless, Korean NSs’ data showed statistical reliability by VARBRUL analysis with Chi-squared per cell of 0.73 within statistically reliable limit of less than 1.50 (Sankoff 1982; Faudree and Fujimaki, 2020). Moreover, error types were consistent with other studies of Korean NSs of English (Pyun, 1987; Major and Kim, 1996; Park and de Jong, 2017). To test other language pairs, data from the literature of an Icelandic child learning English (Hecht and Mulford, 1987) and Cantonese speakers learning French (Cichocki et al., 1993) were fit to the model.

Initial obstruents were chosen since they are the first ones learned in the L1 being related to onset of acquisition. Also, initial position is least affected by neighboring phonemes as compared with medial or final positions that can show more...
scatter in the data (Park and de Jong, 2017). This investigation is on L2 of American English. A brief background is first given of basic L2 acquisition theories applied to phoneme acquisition.

**Background**

**Transfer**

One of the earliest theories used to predict phonological errors is the Contrastive Analysis Hypothesis (CAH) (Lado 1957) based on transfer (Major, 2008) from the L1 (first language) to the L2. The CAH simply predicts that elements in the L2 not in the L1 will be difficult, and those present will be easy. However, in cases of linguistic elements in the L2 having less or equal markedness than that of the L1, the CAH would wrongly predict difficulty. For example, English has word-initial-ʃ/ but not initial-ʒ/. The CAH predicts initial-ʒ/ is more difficult than initial-ʃ/ since ʒ/ is voiced. However, English NSs of French pronounced French initial-ʒ/ perfectly indicating low markedness in that position (Flege, 1987).

**Markedness**

Eckman’s (1977, 2004, 2008) pioneering markedness differential hypothesis (MDH) therefore was constructed to take into account order of difficulty. It conforms with Krashen’s Input Hypothesis (1985) that rules of a language are learned in a predictable order. Many findings have supported the MDH such as Altenberg and Vago (1983), Anderson (1987), Cichocki et al. (1993), Eckman (1981, 1984), Piper (1984), Schmid (2012). Linguistic elements of low markedness such as /p/, /t/ and /k/ are typically thought of as more basic and common across the world’s languages, and perceived easier than more “marked” elements (Kager, 1999; Rice, 2007). The MDH predicts linguistic elements with low markedness will be easier and earlier acquired than those of high markedness; for example: initial before final word position, shorter consonant clusters (CCV) before longer (CCCV); voiceless obstruents before voiced; and stops before fricatives and affricates (Major, 2008). For L2 acquisition, interlanguage elements not in the L1 or L2 are reported to mostly follow a “developmental” learning pattern generally conforming to universal preferences for low markedness (Major, 2008).

Markedness universals themselves have been considered within the framework of grammatical parameters with rules or constraints. Theories of grammar have included markedness encoding looked upon as a series of parameters with various possible settings (Mennen et al., 2010) which may be “on” or “off”. For example, a parameter permitting higher marked voiced obstruents in coda position could be dormant or activated. Optimality Theory (OT) is based on these parameter settings with markedness encoded in universal constraints favoring low markedness (Prince and Smolensky, 2004). The constraints are considered to exist across all languages and can be deactivated by more highly ranked constraints. One possible example is a constraint prohibiting consonant clusters in onsets could be outranked by that stressing lexical forms realized correctly. Exposure to the L2 could induce resetting (Archibald, 1994) or reranking of parameters (Broselow, 2004; Eckman, 2004; Hancin-Bhatt, 2008), allowing formally inactive constraints to come alive. An example would be Korean NSs successfully acquiring the difficult dental fricative /θ/.

**Similarity**

Another well-researched effect of L2 acquisition is similarity with the L1. Similarity can explain cases of obstruents with low markedness causing more difficulty than those of higher markedness (Major, 1987a). In his Speech Learning Model, Flege (1995) demonstrated the tendency to categorize an L2 sound which is highly similar to but not exactly equivalent to a phoneme category in the L1, describing it as “equivalence classification”. This has been explained by the Similarity Differential Rate Hypothesis (SDRH) proposed by Major and Kim (1996) where a phoneme close in similarity to the one in the L1 is learned at a slower rate than that which is dissimilar.

A well-cited example illustrating the SDRH is pronunciation of French /u/ and /y/ by English NSs (Flege, 1987). French /u/ is very similar to that of English /u/, but /y/ is dissimilar having no counterpart in English. However, native English speakers at advanced level in French were reported to pronounce French /y/ no different than French monolinguals; but had much less accuracy pronouncing the more similar /u/. Flege (1987) explained this as “equivalence classification” illustrating L2 learners concentrate more on a dissimilar phoneme than a very similar one.

Another example of SDRH is that of Korean learners of English. Korean has no voiced obstruent phonemes in any word position, but has an intervocalic voicing rule where lenis obstruents become their voiced counterparts between voiced phonemes. The English obstruent /dʒ/ has a similar counterpart in Korean as an allophone of /ʃ/ due to this intervocalic voicing rule, while the English /z/ is dissimilar to any Korean obstruent since /s/ does not become voiced [z] in any situation. Pyun (1987), Major and Faudree (1996) and Major and Kim (1996) reported that Korean speakers at beginning level in English had 98.6 and 10.4% correct pronunciation of /dʒ/ and /z/, respectively; whereas advanced level had 88.6 and 69.2% correct for /dʒ/ and /z/. Therefore, the learning rate of the dissimilar /z/ was higher than that of /dʒ/. In fact, advanced learners had a slight drop in accuracy for /dʒ/ from 98.6 to 88.6% correct, and evidence advanced learners tend to ignore the less apparent difference of similar sounds, concentrating on dissimilar sounds.

Since the driving force is successful communication, beginning learners inherently concentrate on what is different; while advanced learners do not need to pronounce the similar phonemes perfectly to get the message across. For the Korean speakers of English, markedness cannot explain /z/ being learned at a faster rate than /dʒ/ since affricates are typically more marked than fricatives.
A strong argument for the SDRH is Korean speakers’ pronunciation of English /f/ since it has high similarity with /p/. Korean does not have /f/ so it cannot transfer. Moreover, /f/ has low markedness since it is one of the first obstruents learned in the L1 by English speaking children as early as 3 years old. (Wellman et al., 1931; Templin, 1957; Olmstead, 1971) But Korean NSs often pronounce /f/ as [p], and /p/ as [f] or [f] (Chu and Park, 1979; Robson, 1979; Pyun, 1987), the /p/ and /f/ existing in free-variation. As a result, a higher marked obstruent such as /q/ may reach a higher acquisition level before that of /p/ or /f/.

Teaching methods and exposure

Other factors strongly influencing L2 acquisition are teaching methods and content exposed to. For example, if an English teacher focuses on pronunciation of the highly marked interdental fricative /θ/, students can advantageously have a higher than expected accuracy, differing from acquisition order predicted from the above theories (Faudree and Fujimaki, 2020; Adamson and Regan, 1991; Nogita, 2010).

Background on language universals of L1 acquisition order of obstruents in children

The term "language universal" describes cross-linguistic patterns that occur generally, but they are not without exceptions (Faudree and Fujimaki, 2020; Macken and Ferguson, 1981). Universals in the structuralist tradition have been formulated by Jakobson (1941), who composed a highly detailed and influential study of phonological acquisition order. Greenberg et al. (1978) surveyed implicational hierarchies in terms of glottalized consonants, and word-position, that is, acquisition order is: initial > medial > final, with initial the least marked position. Voicing as a function of word position across many of the world’s languages was elaborated by Eckman (1977); whereas voiceless obstruents are documented to generally occur before voiced in children learning their L1 (Wellman et al., 1931; Jakobson, 1941; Templin, 1957) and in the L2 (Eckman, 1977; Faudree and Fujimaki, 2020; Major and Faudree, 1996; Schmid, 2012).

A universalist/nativist approach was applied by Chomsky and Halle (1968) that included a generative phonology paradigm of common developmental patterns in children learning their L1. As for rules, Krashen’s (1985) Input Hypothesis includes the assertion that, rules of a language are learned in a particular order with some tending to appear early and others late.

This study will focus mainly on the structuralist approach by Jakobson (1941) who proposed a universal hierarchy of phonemes based on contrasts, where some contrasts have to be present before others can be learned. For example, in the case of obstruent acquisition, a child will not have phonemic contrast between /k/ and /t/ (velo-palatal vs. labial and dental) before contrasting dentals and labials, /t/ and /p/ (dental vs. labial). The portion of this hierarchy for obstruents is shown in Table 1, which is basically [front] -> [back]. Long-standing, this universal theory has been difficult to refute and therefore has been widely accepted (McNeill, 1970).

As for manner of articulation, it is common that children master stops before fricatives and voiceless consonants before voiced (Demuth and McCollough, 2009; Wellman et al., 1931; Jakobson, 1941; Templin, 1957; Olmsted, 1971; Locke, 1983; Owens, 1984; Oller and Steffens, 1993; McCune and Vihman, 2001; Rose and Wauquier-Gravelines, 2007; Yamaguchi, 2012; Prince and Durand, 2015). In terms of phoneme type, general patterns in acquisition order by children (Wellman et al., 1931; Templin, 1957; Olmsted, 1971) are listed in Table 2. As for manner and point of articulation, the compiled results of Wellman et al. (1931), Templin (1957), and Olmsted (1971) as cited in Owens (1984) show that a rough order of acquisition exists as shown in Table 3. Thus, while /m/, a labial nasal, is expected to be one of the first consonants acquired, /dʒ/, a
Table 3: Approximate obstruent order by English speaking children according to manner and point of articulation (Owens, 1984: 179).

<table>
<thead>
<tr>
<th>Manner:</th>
<th>nasals &gt; glides &gt; stops &gt; liquids &gt; fricatives &gt; affricates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point:</td>
<td>labials &gt; velars &gt; alveolars &gt; dentals &gt; palatals</td>
</tr>
</tbody>
</table>

Table 4: Acquisition order of voiced and voiceless obstruents for children learning English as their L1.

<table>
<thead>
<tr>
<th>Age</th>
<th>Voiced</th>
<th>Voiceless</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>/b/, /d/, /g/</td>
<td>/p/, /f/</td>
</tr>
<tr>
<td>4</td>
<td>/b/, /d/, /g/</td>
<td>/p/ /k/</td>
</tr>
<tr>
<td>5</td>
<td>/v/</td>
<td>/s/, /ʃ/, /θf/</td>
</tr>
<tr>
<td>6</td>
<td>/z/, /ʒ/, /ðj/, /ð/</td>
<td>/s/, /ʃ/, /θf/, /θ/</td>
</tr>
<tr>
<td>7.8</td>
<td>/v/, /z/, /ʃ/, /ð/, /ðj/, /ð/</td>
<td></td>
</tr>
</tbody>
</table>

palatal affricate is expected to be one of the last. Furthermore, the highly marked dental fricative /θ/ found in English would be expected to be acquired later.

Table 4 shows a summary of notable studies of acquisition order of voiced and voiceless obstruents for children age 3 to 8 learning English as their L1 (Wellman et al., 1931; Templin, 1957). For voiced obstruents, both studies show that stops appear prior to fricatives: /b/, /d/, /g/ were acquired by 4 years old; while /z/, /ʒ/, /ðj/, /ð/ were acquired later. Templin found /v/ was the first fricative acquired at 6 years old, but this was considerably later than voiced stops. Both studies found that highly-marked interdental fricative /θ/ was acquired later.

For voiceless obstruents, Table 4 shows no clear order according to stops and fricatives. Both studies found that /p/, /f/ and /k/ were acquired by 4 years old, prior to the other fricatives. The /θ/ was acquired later at 6 probably due to appearance of front incisors. As expected, the marked /θ/ was acquired latest in both studies. The studies differ in that Templin (1957) found that /s/, /ʃ/ and /θʃ/ were acquired earlier at age 5; as compared with that of Wellman et al. (1931) at 7 to 8. This is probably due to front incisors appearing earlier from advances in nutrition in the 1950s.

Construction approximate wave representations

Voiced obstruents

To concisely summarise the acquisition order of obstruents from the L1 literature search in Table 4, an approximate simple wave representation is constructed. As shown in Figure 2, this “wave” aims to show the relative order of difficulty of each English obstruent; higher peak heights represent higher difficulty levels. Each phoneme is represented by a wave period, containing a peak and valley.

Note first of all, stops /b/, /d/, /g/ are assigned the lowest peaks since they are well-documented as being the first voiced phonemes acquired in children learning their L1 (Wellman et al., 1931; Jakobson, 1941; Templin, 1957; Olmsted, 1971; Vihman and DePaolis, 2015). Next, fricatives /v/, /z/, /ʒ/ are set with higher peaks since they are usually learned later and at similar rates. This is followed by the affricate /dʒ/. Finally, highly marked in both L1 and L2 acquisition, the interdental fricative /θ/ is assigned the highest peak.

Note that peak heights are not assigned absolute values, they are only relative approximations. For more accurate peak heights, highly controlled and extensive studies would be needed including: variation between speakers of English, variations such as age, speaking speed, and dialect (Jacewicz et al., 2010); idiolect (Aslan, 2017); variation between types of English such as American or British (Khan and Soleman, 2018), nuances in each phoneme, formality, tones, intonation, phonological environment (Major, 2008), and teaching received (Nogita, 2010). Moreover, although this is a cross-sectional study, the relative peak heights may change with time. Obviously, a considerable amount of research needs to be done, but this wave representation gives a general overview.

Voiceless obstruents

As in Figure 2, Figure 3 shows an approximate acquisition
order for L1 voiceless obstruents. Here again, stops are assigned relatively lower peak heights than fricatives, with the exception of /t/, which is documented as being acquired at least as early as /k/, and earlier than /t/ in children (Wellman et al., 1931; Templin, 1957). The /t/ is assigned a lower peak than expected from Figure 3 since L2 learners studied here are above 6 years old with front incisors. Next is fricatives /s/ and /ʃ/ acquired at similar rates; followed
by /tʃ/ and highly marked /θ/.

Although the voiceless obstruent peak heights in Figure 3 should probably be much lower than those in Figure 2 (voiceless obstruents are generally acquired before voiced), they were made higher for clarity.

Moreover, as shown in Figures 2 and 3, the bar graphs could have been easily implemented, but since physical sounds are being represented, waveforms appear more suitable.

**Korean phonology: Initial obstruents**

As this study involves the Korean language, it is advantageous to present a background on Korean obstruent phonology before stating the hypothesis. Korean was chosen because it has only voiceless obstruents (Pyun, 1987; Park and de Jong, 2017), therefore lending itself particularly well for comparative studies in L2 acquisition (Major and Faudree, 1996).

Korean initial obstruents are listed in Table 5. Note that Korean has three types of phonemic distinctions that English does not have: lenis (voiceless unaspirated obstruents); voiceless aspirated obstruents, and fortis (voiceless glottalized obstruents). Each of these behaves differently.

In the English language, lenis stops do not typically occur in syllable-initial position CV if V is the stressed vowel (Pyun, 1987). For instance, the word ‘tone’ in English will usually be pronounced [tʰon] with an aspirated /tʰ/. (Akmajian, 1990). However, in Korean or French, a lenis stop will occur under these conditions.

A Korean phonological rule which applies to this study is intervocalic voicing, e.g., when a voiceless lenis obstruent lies between two voiced phonemes, it becomes voiced (Faudree and Major, 1996; Park and de Jong, 2017):

\[-\text{CONT, TENSE, ASP}] \Rightarrow [+\text{VOI}] / [+\text{VOI}] \_ \_ [+\text{VOI}]\]

That is, /p/, /t/, and /k/ become /b/, /d/, and /g/. Note that the affricate /tʃ/ becomes voiced as [dr] (Carey, 2002) or /dʒ/ and the Korean affricates are reported to have place of articulation further back than English (Carey, 2002). Sohn (1994) claims that Korean /tʃ/, /tʃʰ/ and /tʃ’/ are actually not affricates but plosives.

The intervocalic voicing rule is applied when /k/ and /tʃ/ are lenis /kʌŋ#kʌm# tʃa/ roast potato becomes [kʌŋ#gʌm#dʒa]. Note this rule does not apply to fortis or aspirated voiceless obstruents: /kʌl#t’uk/ chimney remains as [kʌl#t’uk], and /k’aŋ#p’e/ hoodlum remains as [k’aŋ#p’e]. Moreover, the intervocalic voicing rule does not apply to /s/: /s/ remains as /s/ between voiced phonemes.

**Hypotheses**

The hypotheses of this study deal with processes of transfer, markedness universals, and interaction between the L1 and L2 and then approximating these processes with a graphical “wave addition” model.

**Hypothesis 1:** Hypothesis 1 predicts that the transfer from the L1 will be the dominant process for initial obstruent acquisition in the L2 for the three language pairs examined. This is because the initial are the first obstruents learned in the L1 by children and least affected by phonological environment as compared with medial and final. Moreover, the obstruents non-existent in the L1 that cannot transfer will follow language universals.

**Hypothesis 2:** Hypothesis 2 predicts that a graphical “wave addition” model, based on Wode’s (1977, 1978) notion can represent L2 acquisition order of initial obstruents for different L1→L2 pairs. The model will show transferred elements “filter through the grid” easily, and L2 elements not in the L1 will “filter through” according to other processes.

**METHODOLOGY**

**Participants and tasks**

Five Korean native speakers (NSs) aged 25 to 35
participated in the study. Although all had studied English reading and writing prior to arriving in the US, they were at the beginning level in English conversation having received little or no English pronunciation practice in Korea. At the time of the study, all participants had been in the US for 6 months or less and their contact with English NSs was limited to essential communications. Although there were only five participants, chi-squared per cell of the data was within statistically reliable limits.

Each participant was presented the word list and asked whether they knew the meanings of the words. All participants indicated they knew all the meanings. Then into a tape recorder they read the word list, each word 3 times in a row, and were instructed to leave an audible pause (approximately one second) between words. Then they read the text 3 times in a row. Keywords were identical in the text and word list (see Appendix) containing initial voiced: /b/, /d/, /g/, /v/, /z/, /ʒ/, /s/, /ʃ/, and /ð/ and voiceless /p/, /f/, /k/, /t/, /s/, /ʃ/, /j/ and /θ/ obstruents. Note that initial-/ʒ/ does not occur in English, so its voiceless counterpart /ʃ/ was not tested. No consonant clusters (CCV... or CVCV...) were included; all tokens were singletons of CV structure. However, in the text there were some cases where obstruent + obstruent occurred across word boundaries. This was a cross-sectional study, where data were taken at one point in time.

Initial obstruents were transcribed using the International Phonetic Alphabet (IPA). The resulting total number of tokens was approximately 420: 14 obstruents (voiced plus voiceless) x2 (reading text plus word list) x3 (each word was read 3 times) x5 (5 participants). All target words were transcribed by two trained phoneticians who were native English speakers.

Independent variables

The independent variable evaluated here is obstruent phoneme. “Factors” will refer to constituents within the independent variable. For instance, the independent variable of obstruent phonemes has 14 factors voiced /b/, /d/, /g/, /v/, /z/, /ʒ/, and voiceless /p/, /f/, /k/, /t/, /s/, /ʃ/, /j/ and /θ/ obstruents. The voiced and voiceless obstruents were evaluated separately in two data sets.

Dependent variable

The dependent variable was the percent correct (%C) pronunciation of each obstruent. For instance, /v/ was pronounced [b], [t], [f], or any variation thereof as [pf] it was tagged as incorrect. Only if /v/ was pronounced /v/ it was tagged as correct. This is different than a previous study by Major and Faudree (1996) which evaluated %C for voicing feature only.

Data analysis

VARBRUL (GoldVarb 2.0) multivariate analysis program was used on a Macintosh computer to analyze the data. It statistically calculates the probability (p-factor) that a linguistic variable and its factors will be produced (Preston, 1989). If p is greater than 0.5, the factor in question favors correct pronunciation. If p is less than 0.5, it favors incorrect pronunciation. A hierarchy of p values from 0.0 to 1.0 can be obtained for the factors in a data set similar to Weibull analysis. To measure how well the analysis fits the data, VARBRUL calculates “Chi-squared per cell” to determine the degree at which interactions between factors play a role. It should be no greater than 1.50 and less than 1.00 for a good fit (Sankoff, 1982). A more detailed explanation is given in Faudree and Fujimaki (2020).

RESULTS and DISCUSSION

Korean learners of English: Voiced initial obstruents

Table 6 shows the results for Koreans learning English voiced obstruents with Varbrul analysis showing Chi-squared per cell of 0.73 indicating statistical significance (Sankoff, 1982). Initial /b/, /d/, /g/, and /dʒ/ had nearly perfect success rates in the initial position, hence the conclusion is that positive transfer was the dominating factor. At first glance, this finding may appear contrary to what one might expect since /b/, /d/, /g/, and /dʒ/ do not exist as phonemes in the Korean language. But they do exist as allophones in medial position (...VCV...) via the Korean intervocalic voicing rule, (Pyun, 1987) hence they were easily transferred to the L2.

But why would allophones [b], [d], [g], and [dʒ] transfer so easy from medial position in Korean to initial position in English? English speakers of French described earlier may explain this. In initial position, French has /ʒ/, while English does not; it has /ʒ/ only in medial and final positions. But despite the notion that initial-/ʒ/ should be difficult for English learners of French, English speakers had no difficulty (Flege, 1987). However, this may be a weak argument since widely-used household French names have initial-/ʒ/ such as 'Jacques' /ʒak/ or 'Jean-Luc' /ʒan-lyk/. A stronger argument is Eckman’s (1977) Voice Contrast Hierarchy which states that the presence of word-final voice contrast in a language implies both word-medial and word-initial. Furthermore, it states that word-medial voice contrast implies word-initial. In fact, the easy transfer of allophones [b], [d], [g], and [dʒ] by the Korean NSs supports the CAH.

As for /v/, /z/, and /ʒ/, the Korean NSs pronunciation is 33, 33 and 20% correct, respectively. Korean does not have these phonemes, so they could not transfer from the L1. This supports the CAH due to the negative transfer; while the MDH is also supported since /ʒ/ has higher markedness than /v/ or /z/. Further analysis showed that virtually none of the errors in these obstruents were from incorrect voicing, the [+/VOI] feature was maintained. Errors were due to point and/or manner of articulation, for example,
Table 6: Voiced initial obstruents: Korean speakers of English. Probabilities (p), percent correct pronunciation (%C), and ratio of number correct over total (C/N) for combined data sets of reading text and word list. Chi-squared per cell is statistically significant at 0.73.

<table>
<thead>
<tr>
<th>Obstruent</th>
<th>p</th>
<th>%C</th>
<th>C/N</th>
</tr>
</thead>
<tbody>
<tr>
<td>/b/</td>
<td>-</td>
<td>100</td>
<td>30/30</td>
</tr>
<tr>
<td>/d/</td>
<td>-</td>
<td>100</td>
<td>30/30</td>
</tr>
<tr>
<td>/g/</td>
<td>-</td>
<td>100</td>
<td>30/30</td>
</tr>
<tr>
<td>/v/</td>
<td>0.341</td>
<td>33</td>
<td>10/30</td>
</tr>
<tr>
<td>/z/</td>
<td>0.341</td>
<td>33</td>
<td>10/30</td>
</tr>
<tr>
<td>/ʒ/</td>
<td>not in English</td>
<td></td>
<td></td>
</tr>
<tr>
<td>/dʒ/</td>
<td>0.936</td>
<td>93</td>
<td>28/30</td>
</tr>
<tr>
<td>/ð/</td>
<td>0.205</td>
<td>20</td>
<td>6/30</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>69</td>
<td>144/210</td>
</tr>
</tbody>
</table>

frequently /v/ was pronounced as [b]; /z/ was pronounced as [dz]; and /ð/ was pronounced as [d]. In these cases, developmental learning patterns common to L1 acquisition occurred when a fricative was substituted with a stop (Smith, 1973; Chu and Park, 1979; Robson, 1979) and when /z/ was substituted with [dz], that is, affrication (Note that So and Dodd (1995) document affrication as a developmental process common in Cantonese children, but not in English children).

Interestingly, Table 6 shows %C for /dʒ/ and /z/ were 93 and 33% correct, respectively for the beginner level participants. This is between that of the Major and Kim (1996) study of 98.6 and 10.4% correct for advanced; and 88.6 and 69.2% correct for the beginners. This would support the SDRH with a clear trend of decreasing accuracy for similar phoneme /dʒ/; with increasing accuracy for the dissimilar /z/. However, Major and Kim (1996) had their participants read a 20-word list with /dʒ/ and /z/ in initial position, most words differing from this study in Appendices A and B. Nevertheless, the data in Table 6 along with that of Major and Kim supports the SDRH.

Action of the wave addition model: Korean to English, voiced obstruents

To obtain a simple and easy to understand representation of L2 acquisition order ("L1→L2 Wave"), Figure 4(a-d) shows action of the wave addition model for the voiced obstruent data set of beginner level Korean speakers of English.

Figure 4(a) shows the "UG Wave" in Figure 2 representing the approximate L2 acquisition order in English speaking children graphically added (filtered through the 'Grid') of the Korean L2 learners' repertoire in Figure 4(b). The repertoire is set according to the %C the Korean NSs pronounced each individual obstruent (dotted curves) as approximate percent of area under the curves in the "UG Wave".

Note in Figure 4(b) /b/ /d/ /g/ were successfully acquired, hence they were assigned peak areas of 100% of the "UG Wave" peak areas, but out of phase. The /dʒ/ was assigned a peak of approximately 93%. Similarly, initial /v/, /z/, /dʒ/ and /ð/ were assigned peak areas (approximately) of their respective %C of 33, 33 and 20%.

Figure 4(c) shows the superposition of the "UG Wave" and "Grid" where unshaded areas cancel out. Therefore, the graphical output of the wave addition model, "L1→L2" Wave in Figure 4(d), can represent L2 acquisition order in a simple manner as

/b/ /d/ /g/ > /dʒ/>/v/ /z/ >/ð/ for the point in time of the cross-sectional study. Peak heights are arbitrary, they represent a trend, not absolute values. Figure 4(a) shows an approximation for the group of Korean participants evaluated. Of course, other groups could have different peak heights and distributions
Figure 4 (a-c): Action of the "Wave Addition" model for beginning level Korean speakers pronouncing English initial voiced obstruents showing: (a) "UG Wave", (b) "Grid" of percent correct (%C), (c) Superposition, and (d) resultant "L1 → L2 Wave", Korean to English acquisition order.

Figure 4(d): Resultant "L1 → L2 Wave", Korean to English L2 acquisition order for English initial voiced obstruents.

Korean learners of English: Voiceless initial obstruents

Table 7 shows the results for %C the Korean NSs pronounced initial voiceless obstruents. They caused significantly less errors than the voiced supporting the MDH. As expected, obstruents /k/, /t/, /s/, and /tʃ/ were all pronounced 100% correct since they were easily transferred from Korean, supporting the CAH.

On the other hand, /f/ and /p/ were 80 and 83% correct despite their low markedness. The errors may be due in part to high similarity between /f/ and /p/, supporting the SDRH.

Interestingly, Table 7 shows that the voiceless dental fricative, /q/, highly marked in L1 and L2 acquisition, had successful acquisition at 93% correct; higher than either the low-marked /f/ or /p/. This would be strong evidence in support of the SDRH since /f/, a similar phoneme (to /p/) with low markedness was learned at a slower rate than /q/, a highly marked, and different phoneme than any sound in Korean. Moreover, both /f/ and /q/ do not exist in...
Table 7: Voiceless Initial Obstruents: Korean speakers of English. Probabilities (p), percent correct pronunciation (%C), and ratio of number correct over total (C/N) for combined data sets of reading text and word list.

<table>
<thead>
<tr>
<th>Obstruent</th>
<th>p</th>
<th>%C</th>
<th>C/N</th>
</tr>
</thead>
<tbody>
<tr>
<td>/p/</td>
<td>83</td>
<td>25/30</td>
<td></td>
</tr>
<tr>
<td>/f/</td>
<td>80</td>
<td>24/30</td>
<td></td>
</tr>
<tr>
<td>/k/</td>
<td>100</td>
<td>30/30</td>
<td></td>
</tr>
<tr>
<td>/t/</td>
<td>100</td>
<td>30/30</td>
<td></td>
</tr>
<tr>
<td>/s/</td>
<td>100</td>
<td>30/30</td>
<td></td>
</tr>
<tr>
<td>/ʃ/</td>
<td>not tested</td>
<td></td>
<td></td>
</tr>
<tr>
<td>/tʃ/</td>
<td>100</td>
<td>30/30</td>
<td></td>
</tr>
<tr>
<td>/θ/</td>
<td>93</td>
<td>28/30</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>94</td>
<td>197/210</td>
<td></td>
</tr>
</tbody>
</table>

Figure 5 (a-c): Action of “Wave Addition” model for beginning level Korean speakers pronouncing English initial voiceless obstruents showing: (a) “UG Wave”, (b) “Grid” of percent correct (%C), (c) Superposition, and (d) resultant “L1 L2 Wave”, Korean to English acquisition order.

Action of the wave addition model: Korean to English, voiceless obstruents

Action of the wave addition model for Korean NSs pronouncing voiceless obstruents is shown in Figure 5(a-d), their superposition in Figure 5(c) with Figure 5(d) representing L2 acquisition order in a simple manner as: /k/ /t/ /s/ /ʃ/ >/tʃ/ /p/ /q/

Figure 5(d) takes into account CAH, MDH and SDRH as described for this data set in previous section. Namely: for /k/, /tʃ/, /s/, and /ʃ/ the absence of peaks reflects transfer according to the CAH. The SDRH is taken into account with presence of /p/ and /tʃ/ peaks by free-variation despite their low markedness, and the unexpected low peak for the highly marked /q/ in comparison. Note that for the “UG Waves”, peak heights for voiceless obstruents were made lower than voiced to set agreement with the MDH.
Studies from the Literature

Icelandic learner of English (Hecht and Mulford, 1987)

Other studies in the literature as well showed that transfer played a significant role in L2 acquisition of initial obstruents. One is a longitudinal study of a 6-year-old Icelandic child, Steiner, learning English fricatives and affricates (Hecht and Mulford, 1987). Steiner was tape recorded for one-hour periods over the course of about 8 months in a naturalistic environment with a native English speaker who had no knowledge of Icelandic. Every word that contained the fricatives /s/, /z/, /f/, /v/, /θ/, /ð/, /ʃ/, /ʒ/, and affricates /tʃ/ and /dʒ/ was transcribed. The week at which he correctly pronounced the obstruent with 85% accuracy was noted.

Icelandic obstruents are listed in Table 8 (Árnason, 2011; Hecht and Mulford, 1987), having several present in English, for example fricatives /f/, /v/, /θ/, /ð/, /ʃ/, /ʒ/ and the affricate /tʃ/. Note, English has the voiced post-alveolar affricate /dʒ/, while Icelandic has the approximant /ʃ/ (Thrúður, 1994) similar to /j/ in English.

For this longitudinal study to be adequately compared with the cross-sectional results of the Korean NSs, a "snapshot" of Hecht and Mulford’s data had to be taken at a single point in time chosen to be Week 5 of their study. This was done by assigning peak heights of zero (no difficulty) to the significant number of obstruents Steiner had acquired by Week 5. As for obstruents acquired later, a portion related to their week acquired was subtracted from the English “UG Wave” peaks in Figure 6(a), giving a rough approximation for the “Grid” in Figure 6(b) made from the Hecht and Mulford (1987) data.

The output “L1→L2 Wave” applied to Hecht and Mulford’s (1987) voiced obstruent data (superposition wave not shown) is shown in Figure 6(c). Firstly, /ð/ was acquired after 5 weeks, while /dʒ/ had not yet reached their 85% criteria after Week 14 indicated by an asterisk (*). Icelandic has an interdental fricative /θ/, whose allophones depend on word-position: in initial position it is the voiceless [θ], in medial position it is voiced /ð/, and in final position it is half-voiced [ð] (Hecht and Mulford, 1987; Greenburg et al., 1978). Implicational universals would predict /ð/ in medial position implies no difficulty in initial, however, since it did not completely transfer due to its high markedness, a peak is represented in the wave addition model.

Secondly, English alveolar /dʒ/ does not exist in Icelandic and has higher markedness. This illustrates Hecht and Mulford’s conclusion that transfer was a dominating factor, supporting the CAH. Note that initial /v/ and /z/ had rare output by Steiner (indicated by ‘c’) and subsequently could not be analyzed. Therefore, Figure 6(c) shows wave representation of the output of L2 acquisition order for the voiced fricatives:

/ð/ > /dʒ/

with /ð/ being acquired earlier than /dʒ/ by its lower peak, and the /v/ and /z/ not included due to their low output.

As for the voiceless obstruents, Figures 7 (a,b) indicate a
Table 8: Icelandic obstruents (Árnason, 2011; Hecht and Mulford, 1987).

<table>
<thead>
<tr>
<th></th>
<th>Unaspirated</th>
<th>Aspirated</th>
<th>Fricatives</th>
</tr>
</thead>
<tbody>
<tr>
<td>p</td>
<td>p</td>
<td>pʰ</td>
<td>f</td>
</tr>
<tr>
<td>t</td>
<td>t</td>
<td>tʰ</td>
<td>θ</td>
</tr>
<tr>
<td>k</td>
<td>k</td>
<td>kʰ</td>
<td>δ</td>
</tr>
<tr>
<td>tʃ</td>
<td>tʃ</td>
<td>tʃʰ</td>
<td>s</td>
</tr>
<tr>
<td>θ</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>x</td>
<td></td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>h</td>
<td></td>
<td></td>
<td>glottal</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>palatal</td>
</tr>
</tbody>
</table>

Figure 6 (a-c): Action of the “wave addition” model for an Icelandic child pronouncing English initial voiced obstruents adapted from data of Hecht and Mulford (1987) study showing: (a) “UG Wave”, (b) “Grid” of %C, and (c) resultant “L1 → L2 Wave”, Icelandic to English L2 acquisition order for English initial voiced obstruents (Superposition not shown.) Note /ð/ was successfully acquired after 5 weeks while /dʒ/ was not acquired after 14 weeks (*).

Figure 7 (a-c): Action of the “wave addition” model for an Icelandic child pronouncing English initial voiceless obstruents adapted from data of Hecht and Mulford (1987) study showing: (a) “UG Wave”, (b) “Grid” of %C, and (c) resultant “L1 → L2 Wave”, Icelandic to English L2 acquisition order for English initial voiceless obstruents. (Superposition not shown.) Here ‘b’ indicates stops were not tested; ‘c’ indicates /tʃ/ occurred in the child’s speech very rarely. /ð/ / were acquired first at Week 5 with their 85% correct criteria. The palatal fricative /ʃ/, a phoneme which Icelandic does not have, was acquired later at Week 10. Figure 7(c)
Approximate “UG Wave” representation for L1 voiced obstruents (French).

shows the output of approximate wave representation:

\[
/f/ > /s/ > /q/ > /ʃ/
\]

This is in agreement with the CAH since obstruents in Icelandic /f/, /s/ and /ʃ/ transferred fairly easily having lower peak heights than /ʃ/ which does not exist in Icelandic. In addition, the model shows the agreement with the MDH since with obstruents not in Icelandic, relative peak heights follow markedness order of children’s L1: /f/ /s/ /ʃ/. Note again that data are taken for only one point in time. At a different week, the wave addition model describing Steiner would obviously look quite different.

From their results, Hecht and Mulford (1987) concluded that ‘neither the Transfer Position nor the Developmental Position alone provides an adequate explanation of L2 phonological development’. They went on to say, ‘transfer best predicts the order of difficulty of English fricatives and affricates, while the developmental hypothesis best predicts instruction in many (Hong Kong ceased to be a colony of the United Kingdom in 1997). Therefore, in fact, French was their L3. For simplicity however, here the language being focused on is always referred to as the L2 with effects of other languages being taken into account.

Approximate “UG Wave” representations for French L1 Demuth and McCollough, 2009; Yamaguchi, 2012; Prince and Durand, 2015) for example, plosives (stops) are sound substitutions for difficult segments'. This fits with the concept of the wave addition model. Moreover, analysis of Hecht and Mulford’s data show that the wave addition model can be applied to individual speakers.

Cantonese learners of French (Cichocki et al., 1993)

Another thorough study was conducted by Cichocki et al. (1993) involving NSs of Cantonese learning French. Here, 6 residents of Hong Kong read a passage and a word list containing the French obstruents /p/, /t/, /k/, /f/, /s/, /ʃ/, /b/, /d/, /g/, /v/, /z/, /ʒ/, and /R/. Their subjects were at the upper beginner to lower intermediate level in French. Although none of Cichocki’s subjects had ever been to a French speaking country, all had studied French in Hong Kong for 1.5 to 5 years. Moreover, all were fluent in English because at the time of Cichocki’s study English was taught in most Hong Kong schools and was the medium of voiced and voiceless obstruents are constructed in Figures 8 and 9 in congruence with relative peak heights for English shown in Figures 2 and 3. This is supported by several researchers having found children learning French as their L1 following Jakobson’s (1941) predictions for English children, (Rose and Wauquier-Gravelines, 2007; acquired before fricatives, and voiceless stops before voiced (Rose and Wauquier-Gravelines, 2007:374). French uvular
trill, /R/ is included in Figure 8 and assigned its low markedness (Léon and Léon, 1964, as cited in Cichocki et al., 1993). 

Table 9 shows Cantonese obstruent inventory having unaspirated /p/, /t/, /k/ aspirated /pʰ/, /tʰ/, /kʰ/ and labio-velar stops /kʷ/ /gʷ/ along with fricatives /f/, /s/, and affricates /ts/ and /tsʰ/. All are voiceless. 

Figure 10(a,b) shows addition of the French “UV Wave” in Figure 8 with %C Cantonese NSs pronounced French initial voiced obstruents as reported by Cichocki et al. (1993). 

Approximate wave representation of L2 order of voiced obstruents for Cantonese speakers of French is shown in Figure 10(c) as: 

/R/ /b/ /d/ > /g/ > /v/ /z/ /ʒ/
Like Korean, Cantonese does not have voiceless obstruent phonemes therefore transfer from the NL cannot occur. At first glance, this would seem to be a developmental order of acquisition. However, Cichocki et al. (1993) notes that transfer may have taken place from the participant’s English L2 to their French L3. Nevertheless, a pattern was found similar to that of children learning their L1 supporting the MDH, that is, stops were easier than fricatives, and front stops /b/ and /d/ were easier than the back stop /g/. As for the voiceless fricatives, Cantonese learned them at approximately the same rate (35% correct), agreeing closely with both LI acquisition findings (Owens 1984), and results from Korean speakers of English. Knowledge of English may have made accuracies higher.

Note that the voiced uvular trill /R/ in initial position was not noted by Cichocki et al. (1993) as causing difficulty. Closer examination of their data shows that Cantonese speakers did not pronounce /R/ as /R/, but either as the glottal fricative [h], its voiceless counterpart [f], voiceless velar fricative [x], or voiceless uvular fricative [χ]. Although this could be interpreted as non-acquisition, they attributed their acceptability of these variants to the fact that in French, there is only one /R/ and it could be phonetically realized in many different ways. What is more, /R/ is documented as being the most frequently occurring consonant in oral and written French (Léon and Léon, 1964, as cited in Cichocki et al., 1993). Owing to this, Cichocki et al. (1993) suggested that this segment has low degree of markedness. Figure 10(c) indicates “L1→L2” not “L1→L3” since the language being focused on is always set as the L2 taking into account any other effects of the speakers.

Figure 11(a-c) illustrates the model as applied by voiceless data of Cantonese speakers of French by Cichocki et al. (1993):

/f/ /s/ /ʃ>/ /p/ > /k/ > /t/

Most apparent is the unexpected result that the French voiceless stops /p/, /k/, and /t/ were difficult for the Cantonese speakers (50% correct in Figure 11(b)). Commonly reported as having low markedness, these phonemes also exist in Cantonese, so they should have been easy. Errors were stated as initial /p/, /t/, and /k/ being produced with ‘prevoicing and sometimes with a schwa-like vowel’. Cichocki et al. (1993) attributed this behavior to the aspiration/non-aspiration contrast in Cantonese, that is, a distinction between /p/, /t/, and /k/ and aspirated /pʰ/, /tʰ/, and /kʰ/. Furthermore, they inferred the Cantonese learners may not have differentiated Cantonese p/pʰ from French p/b; and there may be a characteristic rule specific to the Cantonese-French interlanguage. But Korean speakers of English pronounced English initial /p/, /t/, and /k/ with nearly perfect accuracies (Table 7), despite an aspirated/lenis/glottalized stop distinction in their NL. What was the difference then? Although not mentioned in the Cichocki report, Cantonese is a tonal language. Korean is not. Attached to every syllable, Cantonese has nine tones (Chan and Chor-Shing, 2000), six of which are contrastive, and three act as allophones.

Studies of the effect of tones on pronunciation of obstruents are rare in the literature, however, nearly a century ago, Beach (1938) along with later researchers (Maddieson, 1978; Forrest, 1965; Cheng, 1973; Sarawit 1973) reported that tones, in fact, have influence on voicing obstruents. Beach reported that in the Southern African Khoisan language Korana (iora) */g/ and possibly other voiced obstruents become voiceless when a higher tone follows. Maddieson (1978) reported that languages of China and South East Asia have numerous cases of changes in phonation type of initial consonants from tone of the following vowel. Maddieson stated “in Puyi dialects of the Tai family, original voiced obstruents have modern voiceless aspirated or unaspirated reflexes depending on the tones (Sarawit, 1973;” Maddieson, 1978: 329), and “in Mandarin and Yueh dialects of Chinese, the old voiced obstruents became devoiced but became voiceless aspirated if
preceding the ‘even’ tone (p’ing-sheng), and voiceless unaspirated elsewhere” (Forrest, 1965: 230; Cheng 1973 in Maddieson, 1978: 329).

From these, it is highly likely that transfer of tones in Cantonese acted to pre-voice voiceless stops /p/, /t/, and /k/ in French.

As for markedness, mastery of vowels and tones occurs earlier in Cantonese children than mastery of their consonant system (So and Dodd, 1995), so tonal contrast would be less marked than consonant acquisition.

The model shows other initial voiceless obstruents /f/, /s/ and /ʃ/ with zero peak height indicating successful acquisition. This is explained with positive transfer. Firstly, initial /f/ and /s/ exist in Cantonese. Secondly, Cantonese does not have initial /ʃ/ but it was pronounced at a high accuracy rate probably because the Cantonese subjects were fluent in English, French actually being their L3.

PEDAGOGICAL IMPLICATIONS

Pedagogical implications are discussed in terms of the wave addition model. To be of use to teachers as well as students, it outputs relative difficulty of obstruents in the L2 and illustrates the cross-linguistic processes involved with UG and the L1. For pronunciation teaching, tasks such as minimal pairs and chants are helpful. Songs and tongue twisters containing the target obstruents can be fun as well as valuable for students. Advancing pronunciation skill helps students be successful passing standard language tests, entering universities or academic programs, and finding a job that uses the target language.

CONCLUSIONS

This study investigated initial obstruent acquisition order in the L2 from Korean learners of English and analyzed two studies from the literature: an Icelandic child learning English, and Cantonese learners of French. The data were fit to a graphical wave addition model to output approximate L2 acquisition order of initial obstruents in a simple and easy to understand manner. The model is applicable to individual case studies or groups. The results suggested two main conclusions according to the hypotheses:

Hypothesis 1: Partially Supported: Transfer was found to be the dominant process for L2 acquisition of initial obstruents examined, explaining most deviations of L2 acquisition order from that of the L1. For the Korean participants in this study, transfer explains successful acquisition of English /b/, /d/, /g/ and /k, /t/, /s/, /ʃ/. In addition, the data of two studies in the literature were examined in detail and showed agreement. An Icelandic child learning English by Hecht and Mulford (1987) easily acquired initial /ð/ and /f/, /s/, /θ/; and Cantonese speakers of French by Cichocki et al. (1993) acquired initial /ʃ/, /ʃ/, and /ʃ/ quickly, the /ʃ/ being transferred from English which was their L3.

Hypothesis 1 is also supported since obstruents non-existent in the L1 that cannot transfer tended to follow language universals. For the Korean participants, highly marked /ʊ/ was more difficult than other voiced fricatives /v/ and /z/. Examination of Cichocki data showed voiced stops were easier than voiced fricatives for Cantonese learners of French; voiced fricatives other than /ʊ/ exhibited similar accuracy rates in both Cantonese learners of French and Korean learners of English; and voiced obstruents tended to be more difficult than voiceless obstruents in many cases.

However, Hypothesis 1 is refuted when other exceptions to transfer occurred due to intervening factors such as: phonological similarity in Korean NSs acquiring English /p/ and /ʃ/; and effect of tones in Cantonese learners of French /p/, /t/, /k/. These phenomena need to be examined in more detail.

Hypothesis 2: Supported: It is demonstrated that general patterns for initial obstruent acquisition in the L2 can be represented with a graphical "wave addition" model for
three different L1→L2 language pairs investigated: Korean to English, Icelandic to English, and Cantonese to French. The model's output is simple and easy to understand as relative peak height represents relative difficulty. Based on Wode's notion, the model represents transferred elements filtering through the grid easily, developmental elements according to markedness, and other elements according to degree of similarity or tones in the L1. The model is made to account for language learning processes occurring simultaneously as described by the CAH, MDH, and SDRH. Obviously, a considerable amount of research still needs to be done, but at least with data presenting the wave addition model to give a general overview of obstruct acquisition order in the L2 and its cross linguistic influences. This aims to be useful as resource for phonology research as well as language pedagogy in the classroom.

ACKNOWLEDGEMENTS

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REFERENCES


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Appendix

Appendix A: Word list (Initial obstruents)

<table>
<thead>
<tr>
<th>past</th>
<th>back</th>
</tr>
</thead>
<tbody>
<tr>
<td>tunes</td>
<td>deep</td>
</tr>
<tr>
<td>cool</td>
<td>going</td>
</tr>
<tr>
<td>fog</td>
<td>voice</td>
</tr>
<tr>
<td>sand</td>
<td>zoo</td>
</tr>
<tr>
<td>chant</td>
<td>jeep</td>
</tr>
<tr>
<td>thick</td>
<td>that</td>
</tr>
</tbody>
</table>

Appendix B: Reading text

The fog was so thick that evening he could not see the waves pounding on the sand below his feet. A cool breeze swept across the beach twisting the fog into beautiful spirals, which were carefully painted by the deep red glow of the sleepy sun. Although he could not see it, he could hear the sea wash the barren rocks underneath. Above, the seagulls were dancing in the wind, happily singing tunes before going to sleep. As the sun slipped over the horizon, the music seemed to fill the air with an unusual chant.

It was now dark. He kept running now, up the walkway, and back towards his house. He jogged past his buddy’s jeep, which was parked by the tall green bushes in the next yard. He was going to pass by the zoo, when he decided it would be quicker and safer to jog past the budget store, where he bought peaches every day. He remembered last month, when an ape escaped from his cage at the zoo and was caught while eating from nearby trees. When he saw the ape, he almost could not breathe. The ape was finally stopped when a rescue team shot it with muscle relaxer and brought it back to the zoo.

He then jogged past his old school, which was now an old abandoned building. He stopped to look in some of the rusty school windows, when he noticed he was looking into his old history classroom. He peered through the open window. The blackboard was still there, and there was something about the smell of that room which was strange. He then looked into the next room, where he learned geometry, which he thought was pretty tough. He remembered his teacher giving him a nudge on the shoulder when he used to fall asleep in the lab.

He then walked past the field, where he used to play football. He could still hear the voice of his high school sweetheart cheering as the cheerleaders threw their batons in the air. When he reached the end of the field, he put on his headphones and proceeded on his way home.