The Role of Linguistic Knowledge in the Perception of English Stops after /s/ *

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ABSTRACT

Five sets of nonsense acoustical stimuli {[spɛ,stɛ,skɛ], [pɛ,tɛ,kɛ], [sbɛ,sdɛ,sgɛ], [bɛ,dɛ,gɛ], ['ɛbɛ,'ɛdɛ,'ɛgɛ]} were presented for identification of English stops to native speakers of English, Chinese, and Korean. The English speakers perceived stops after /s/ as /p, t, k/; in other contexts as /b, d, g/. In the languages where other distinctions exist, however, the evaluation was different. The results suggest that in English the cue for stops after /s/ was syllable structure constraint: After initial /s/ always /p, t, k/ follow; the cue for the initial stops was aspiration. On the basis of the results, it was concluded that in English we should classify the unaspirated voiceless stops in initial /s/-stop clusters into the phoneme where [p^h,t^h,k^h] are in, and that perception is not only language specific but also context specific.

Key words: perception, English stops after 's', Korean stops, Chinese stops.

1. Introduction

A review of the existing literature reveals that there are contrastive claims among phoneticians about the linguistic question of the classification of the English unaspirated voiceless stops after /s/: (1) the unaspirated voiceless stops should be grouped into the phoneme where the unaspirated voiced stop [b] is in (e.g. Lotz, et. al., 1960; Reeds and Wang, 1961; Davidsen and Nielsen, 1969; Ladefoged, 1993) and (2) the unaspirated voiceless stops should be grouped into the phoneme where the aspirated voiceless stop [p^h] is in (Kim, 1992).

Davidsen and Nielsen (1969), for example, conducted a perceptual experiment with a tape-splicing method. In the study, the test words {pat, team, cold, etc.} were constructed by cutting the word-initial /s/ from {spat, steam, scold, etc.}, and they were embedded in sentences in such a way that the items were placed post-initially and were stressed. The edited tape were played to 32 native speakers of British English and American English. The judgements of initial stops in the acoustical stimuli went generally (about in 92%) to the phoneme in which [b] is in. On the basis of the judgements and the physical similarities in

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aspiration [ʰ] and voicing between Ladefoged (1993) also stated that as in many cases, English spelling is misleading, and the stops the stops after /s/ and the initial stops of "bat", "deem", "gold", etc., they concluded that the voiceless unaspirated stops in question should be grouped into the phoneme where /b/ is in. that occur after /s/ are more like /b/, /d/ and /g/.

Kim (1992), however, claimed that the speech items used in the existing literature were improper for their claims due to the facts that the test persons had chances to respond only to the initial stops preceding a stressed vowel after the removal of the initial /s/, but not to the stops in utterance-initial /s/-stop clusters. The listeners were deprived of chances to respond to the stops after /s/. In English phonology, the stop consonants would occur in three different contexts: (1) #/C̲V/ as in {pen, ten, can}, (2) #/CC̲V/ as in {spy, sty, sky}, and (3) /VC̲/# as in {cap, cab, cat} where the underlined C̲ is a stop consonant. For a reasonable claim, thus, at least two types of test items, such as {[spæt], [sti:m], [skoʊld]} and {[pæt], [ti:m], [koʊld]} after the removal of [s], should have been presented to the subjects for the judgement. The stops in the third context would be produced either with the release of the oral closure or without the release, and it is well known that the duration of preceding vowel functions to differentiate the syllable-final stop consonants (e.g. Raphael, 1972; O'Kane, 1978). In a perceptual experiment, for example, Raphael (1972) reported that "the duration of preceding vowel is the only significant cue, at any rate, for phonological voicing in a following stop" (p.27).

In a perceptual experiment (Kim, 1992) with 12 British English speakers and 5 Korean speakers and four sets of isolated test-items, such as (1) {[spɑ], [stɑ], [skɑ]}, (2) {[sbɑ], [sdɑ], [sgɑ]}, (3) {[pɑ], [tɑ], [kɑ]}, and (4) {[bɑ], [dɑ], [gɑ]}, it was found that the perception of stops was language specific; (1) In English, the perception of stops was context specific; the perceived stops after /s/ were equated generally (85%) with phonologically voiceless stops /p, t, k/, while the initial stops were perceived generally (97%) as phonologically voiced stops /b, d, g/, and in Korean the judgements were made from the phonetic point of view, regardless of the presence of initial /s/. Korean speakers perceived the English unaspirated voiceless stops generally as the Korean unaspirated tense stops and the English unaspirated voiced stops as the Korean unaspirated lax stops. For Korean subjects, there were acoustically significant differences in tensity between the English unaspirated voiceless stop and its voiced counterpart. But this was not the case with English speakers. In English, the perceptual cue for the plosives after /s/ was phonotactic constraint, that is, linguistic knowledge: After utterance-initial /s/ always the phonologically voiceless stops /p, t, k/ follow if the second one is a stop and the perceptual cue for the initial plosives was phonetic properties, i.e., aspiration, regardless of the feature [voice]. On the basis of results, it was claimed that in the English phonemic system we should classify the stops after initial /s/ into /p, t, k/, but not into /b, d, g/.

However, the test-materials used in previous studies (e.g. Lotz, et. al., 1960; Reeds and Wang, 1961; Davidsen and Nielsen, 1969; Kim, 1992) have been either real words or real word-like items. The real words and real word-like test items might have influenced the

subject's judgement. For example, the test-items [spɑ, stɑ, skɑ] used in a perceptual experiment (Kim, 1992) were acoustically similar to the real words {spa, star, scar}. The acoustical similarities might have directed English subjects to associate the perceived plosives in part with the plosives of the meaningful words. If this was the case, it cannot be said with confidence that linguistic knowledge, i.e. phonotactic constraint, was the dominant cue for forcing the evaluation of the perceived plosives after /s/ in the direction of /p, t, k/, and it is required to reconfirm Kim's claims (1992) with nonsense words so that the possible effects of the meaningful words on the judgements could be minimized. In this study, the fully voiced stops were used to determine whether or not the feature [voice] play a significant role in the perception of stops in /s/-stop- vowel context. According to the classification theory developed by D. Jones (1957), phoneme is a group or family of related [allophonic] sounds. This means that the phonetic manifestation of a phonemic segment varies in accordance with a given context where the sound occurs. The English phonemic segment /p/ is aspirated both in word-initial position and at the beginning of stressed syllables, whereas the same stop consonant /p/ is unaspirated after initial fircative /s/. Both the aspirated voiceless [p^h] and the unaspirated voiceless [p] are allophones (i.e, derived systematic phonetic segment in terms of generative phonology) of the phoneme (i.e. underlying systematic phonemic segment) /p/. If perception process is the reverse of production process, it can be assumed that the unaspirated voiceless stop [p] after /s/ will be identified perceptually with the aspirated voiceless stop [p^h] in other positions. The project originated with a problem of this assumption and relative significance of cue present in the acoustical stimuli within the frame of the phonemic system of other languages, such as Korean and Beijin Mandarin (i.e. standard Chinese). In the existing literature, there was a cross-language study (Lotz, et. al., 1960) to evaluate test persons' reactions to the perceived English plosives after /s/ with native speakers of American English, Puerto Rican Spanish, Hungarian, and Thai. However, systematic investigations to evaluate reactions to the perceived English plosives with Korean and Beijin Mandarin have been relatively neglected.

2. Method

2.1 Subjects

A total of forty three subjects (i.e., thirteen English native speakers, ten Chinese native speakers, and twenty Korean native speakers) served as test persons in the perceptual experiment with a computer editing method. Three of the thirteen English test persons were Canadian English speakers, and the rest were American English speakers. The Chinese test persons had a near Beijin Mandarin accent, i.e. standard Chinese, and the Korean speakers had a Pusan accent, except for two test persons with a near Seoul accent. None of the test persons had any reported hearing problems.

2.2 Materials and procedure

Two sets of nonsense words (1) {spe, ste, ske} and (2) {ebe, ede, ege} were constructed. The constructed speech items were recorded by a male American English native speaker on an Inkel DD-3010C using a condenser microphone. The male American speaker had a fully voiced stop in intervocalic position. The stops in the first set of speech-items were unaspirated voiceless stop consonants, and the stops in the second set of speech-items were fully voiced unaspirated stop consonants. Five sets of test-items were obtained from the two sets of nonsense words. The following matrix sums up five sets of acoustical stimuli:

(1) {[spɛ], [stɛ], [skɛ]},
(2) {[pɛ], [tɛ], [kɛ]},
(3) {[sbɛ], [sdɛ], [sgɛ]},
(4) {[bɛ], [dɛ], [gɛ]}.
(5) {['ɛbɛ], ['ɛdɛ], ['ɛgɛ]}

The first and fifth sets of stimuli were from the constructed nonsense words, and the second set of stimuli {[pɛ], [tɛ], [kɛ]} were obtained from the first set of stimuli {[spɛ], [stɛ], [skɛ]} by cutting off the initial [s] in the words. The fourth set of stimuli {[bɛ], [dɛ], [gɛ]} were obtained from the fifth set of stimuli {['ɛbɛ], ['ɛdɛ], ['ɛgɛ]} by cutting off the initial vowel ['ɛ]. The third set of stimuli were obtained by combining the fourth set of stimuli {[b ɛ], [dɛ], [gɛ]} and the initial [s] from the first set of stimuli {[spɛ], [stɛ], [skɛ]}. The editing of test-items was made on the Macintosh Quadra 650 personal computer using a SoundScoupe II/16 (GW Instruments, Computer Instrument Co.). The third set of speech items are ungrammatical in English since after utterance-initial /s/ the voiced stops never occur. The isolated test items were used since the temporal or spatial effects of coarticulation on the judgement is not yet precisely known.

A total of thirty test-items (15 items x 2 repetitions) were divided into three sessions according to the place of articulation in order to avoid confusion of the place of articulation. The linguistic question of classification was focused on the manner of articulation, but not on the place of articulation. At each session the test-items were presented in random order at three second intervals between items. The subjects were asked to identify a set of English plosives in acoustical stimuli with plosives in their native phonemic systems.

The native speakers of English were asked to equate the perceived plosives in nonsense acoustical stimuli with the sound image of the first element of either "pill," ("till," "kill") or "bill," ("dill," "gill"). Their task was to put a circle mark under the initial sound /p/ of the word "pill" when they heard a /p/ sound in the acoustical stimulus. When they heard a /b/ sound, they were to put a circle mark under the initial sound /b/ of the word "bill". If not clear, they were to put a circle mark under the letter Q. The example words were as follows: /p/ pill, /b/ bill, /t/ till, /d/ dill, /k/ kill, /g/ gill. For session one, for example, /p/ pill, /b/ bill, and Q were arranged in the first row on the answer sheet with numbers 1 to 5 in the first column. It may be clained that the listeners simply would apply spelling

conventions to sound categorization in this test because the subjects were given othorgraphic guidance for their responses. In order to make the claim acceptable, however, the plosives in the stimuli should be optical. Otherwise, it is impossible to equate the perceived plosives in the nonsense acoustical stimuli with the optical spelling because the acoustical stimuli and the optical spellings are completely different from each other. This means that the subjects would work with the sound image of the first element of either "pill" or "bill". If the sound image of spelling is not formulated in the speaker's brain, people could not read loudly what is transcribed in alphabetic symbols. I also have confirmed the appropriateness of test procedures by asking some of the English subjects to transcribe with alphabetic symbols what they hear from the edited tape. The nonsense acoustical stimuli [spɛ], [sbɛ], etc. were transcribed as "spe," "spe," etc., and the stimuli [pɛ] after the removal of /s/, [bɛ], etc. as "be," "be,", etc.

In the Korean phonemic system, there is a three-way distinction among lax unaspirated, tense unaspirated, and tense aspirated stops and, in addition, an opposition among three places of articulation: labial, alveolar, and velar. For Korean subjects, nine Korean characters corresponding to the lax unaspirated stops /p, t, k/, tense unaspirated stops /p',t',k'/ and tense aspirated stops /p^h,t^h,k^h/ and the letter Q were used. For session one, /p, p^h, p'/ and Q were arranged in a row at the top of the answer sheet with numbers from 1 to 5 in the first column.

On the other hand, Chinese stops are characterized by the presence or the absence of aspiration. The physical properties, i.e. voice and tensity, have no value in the perception of stops in Chinese, and the same example words as those for the speakers of English were used for Chinese subjects. Before the perceptual experiment started with the acoustical stimuli with Chinese speakers, I had confirmed their ability to distinguish between the sound image of the first element of "pill" and "bill". They associated the first element of "pill" and "bill" with the Chinese aspirated and unaspirated stops, respectively. The example words of English used in the study were simple and familiar to the Chinese speakers.

3. Results and discussion

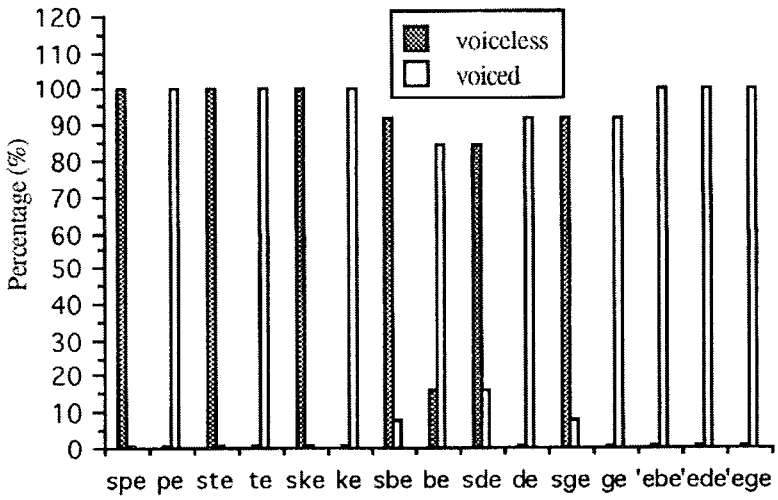
3.1 Responses of speakers of English

Figure 1 shows that in 100% of the cases the English subjects equated the perceived unaspirated voiceless stops after /s/ with the sound image of the first element of "pill," ("till," "kill"), and in 89% of the cases the same subjects equated the unaspirated voiced stops after /s/ with the sound image of the first element of "pill," ("till," "kill"). The results were generally agreeable with Kim's findings (1992) although they are not directly comparable due to differences in test-items, subjects, etc. In general, the unaspirated voiceless stops after /s/ and their voiced counterparts were judged to be the same perceptually as the aspirated voiceless stops in word-initial positions. Thus, the assumption that the unaspirated voiceless stop [p] after /s/ will be identified perceptually with the

aspirated voiceless stop [pʰ] in word-initial positions has been verified. This means that although the stops after /s/ are more like the initial stops /b, d, g/ from the phonetic point of view, we should classify the stops after /s/ into /p, t, k/, but not into /b, d, g/ in English phonemic system. This is contrastive with the previous studies (e.g. Lotz, et. al., 1960; Reeds and Wang, 1961; Davidsen and Nielsen, 1969; Ladefoged, 1993). This is because in the previous studies the subjects had chances to respond only to the initial stops preceding a stressed vowel after the removal of the initial /s/, such as {pat, team, cold, etc.}, but not to the stops after /s/.

Although he did not take a perceptual experiment, Sapir (1921) stated that "--- the 't' of 'time' is indeed noticeably distinct from that of 'sting', but the difference, to the consciousness of an English speaking person, is quite irrelevant. It has no value" (54-56). In the perception of stops after /s/, the native speakers of English used linguistic knowledge, that is, phonotactic constraint: After initial /s/ always the voiceless stops follow if the second one is a stop. The initial fricative /s/ contributed, on the whole, the evaluation of the unaspirated voiceless and voiced stops after /s/ in the direction of the aspirated voiceless stops in word-initial positions.

Figure 1. Percent responses of English speakers



On the contrary, however, the same subjects of English equated the perceived unaspirated voiceless plosives after the removal of /s/ without exceptions with the first element of "bill," ("dill," "gill"). This was agreeable with previous studies (e.g. Lotz, et. al., 1960; Reeds and Wang, 1961; Davidsen and Nielsen, 1969; Kim, 1992). On the other hand, in the same context the subjects' judgements of the perceived initial unaspirated voiced stop showed 89% /b, d, g/ identification. The results suggest that in initial stop-vowel context judgements depended mainly on the physical properties of a stop consonant, i.e., aspiration, regardless of the feature [voice].

Now, one may ask a question: What are your independent grounds for attributing phonetic cues to one perception environment of plosives, but phonotactic cues to another? There is no opposition after /s/ in English. No opposition after /s/ means that only the single type of plosives /p/ can occur after /s/ (for the convenience of discussion, from now on I will take bilabial stops because the same result holds for alveolar and velar stops). As a result, it is unnecessary to distinguish phonetically between /p/ and /b/ in that context, and phonetic properties, i.e. aspiration and voicing, becomes perceptually valueless. What you need in that context is the phonotactic cue: After initial /s/ always /p/ follows if the second one is a stop. Initial fricative /s/ functioned as a triggering factor for listeners to equate the following stop with phonologically voiceless stop /p/, regardless of its phonetic properties. The phonotactic constraint, which is internalized in the English speaker's brain in the form of linguistic knowledge, may result in part from the experiences of the English orthographic system in which after initial spelling "s" never "b, d, g" follow, but generally "p, t, k" (Kim, 1992). In the initial stop-vowel context where there is opposition, however, the listeners have to differentiate /p/ from /b/ from the phonetic point of view since the CV context has no room for perceptual cues such as the phonotactic constraint. Thus, it can be assumed that the phonemic representation, i.e., phonemic sound image, of plosives would be perceived through either the syllable structure cue or the phonetic properties of the sounds. This means that there is not always one to one relationship between perception and phonetic properties. If there is no opposition in a given context, such as initial /s/-stop clusters, the phonemic representation of the plosives would be perceived through the phonotactic cue, whereas in initial stop-vowel context it would be perceived through the phonetic properties, i.e., aspiration. This means that the perceptual cues for English plosives is context specific.

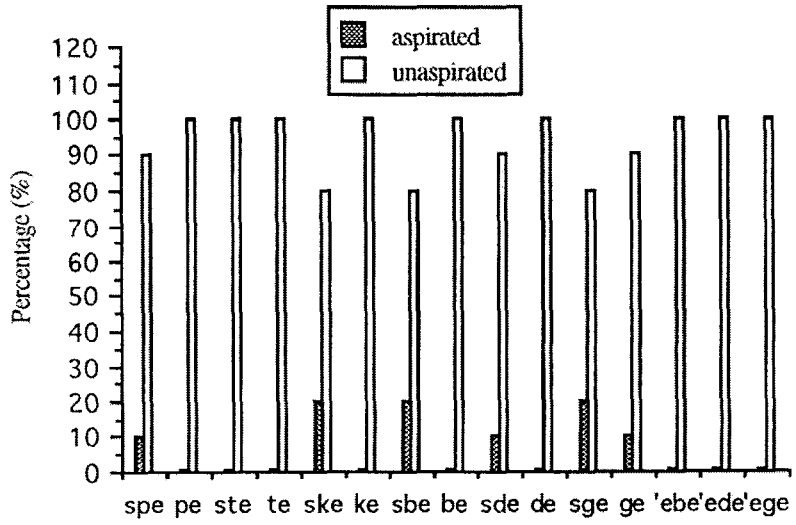
In intervocalic position, fully voiced stops were judged to be unaspirated voiced stops without exception (see Figure 1). This may be due mainly to the sufficiently short oral closure interval of the stops, that is, 51 to 71 ms. According to the existing literature, the perceptual cue for intervocalic stops is the duration of the oral closure, but not voice (e.g. Lisker, 1957; Port, 1979); the AmEng. phoneme boundary of the oral closure interval between voiced and voiceless stops is 75ms. The production aspects of intervocalic stops of British English also showed that the amount of variability in the duration of the vocal fold vibration as percentage of the oral closure interval, i.e. + 31%, was too large to be used as a cue to characterize phonologically voiced stops (Kim, 1989).

The results and the existing literature suggest that perceptual cues for stops of English appears to vary with their context: (1) in initial /s/-stop clusters, linguistic knowledge, i.e. syllable structure constraint, is used, (2) in word-initial stressed position, the physical property, [aspiration] is used, (3) in word-final unstressed position, the duration of preceding vowel is used, and (4) in intervocalic unstressed position, the oral closure interval is used. Thus, the perception of stops of English is context specific, and the feature [voice] appears to be linguistically insignificant both in production and in perception, regardless of context.

3.2 Responses of speakers of Chinese

In Beijin Mandarin, i.e. standard Chinese, stops are differentiated by the presence or the absence of aspiration. In other words, Chinese has a two-way opposition among aspirated and unaspirated stops, and in addition a distinction among three places of articulation. As can be seen in Figure 2, the English unaspirated voiceless and voiced plosives were perceived as the Chinese unaspirated plosives. 90 % judgement of the English unaspirated voiceless plosives after /s/ went to the Chinese unaspirated plosives, and 83 % equation of the perceived English unaspirated voiced plosives after /s/ went to the Chinese unaspirated plosives. Both in word-initial position and in intervocalic position, however, in 99% of the cases Chinese subjects identified the perceived English plosives with the Chinese unaspirated stops. The initial /s/-stop clusters-related less percent identification resulted mainly from the facts that two of a total ten Chinese speakers who can speak English had a tendency to use English phonotactic constraint in the perception of stops in initial /s/-stop clusters.

Figure 2. Percent responses of chinese speakers



The results indicates that there are not syllable structure cues such as the English syllable structure constraint in the Chinese phonemic system and that Chinese subjects reactions to a set of stops in stimuli were dependent mainly on the physical properties, i.e. aspiration, but not on voicing or tensity.

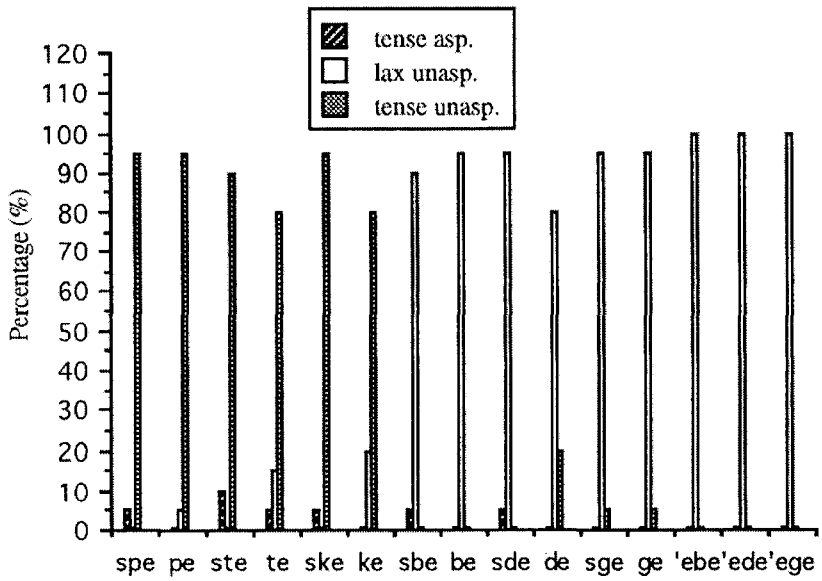
3.3 Responses of speakers of Korean

In the Korean phonemic system, there are three types of stops; tense unaspirated stops, tense aspirated stops, and lax unaspirated stops, and in addition there are three places of articulation; bilabial, alveolar, and velar. They are characterized as follows:

	tense aspirated stops /pʰ, tʰ, kʰ/	tense unaspirated stops /p', t', k'/	lax unaspirated stop /p, t, k/
aspiration	+	-	-
tensity	+	+	-

As seen in Figure 3, in 94% of the cases Korean subjects heard the English unaspirated voiceless stops after /s/ as Korean tense unaspirated stops, and in 95% of the cases they equated the perceived English unaspirated voiced stops after /s/ with Korean lax unaspirated stops, while in 6% of the cases the perceived English unaspirated voiceless stops after /s/ were judged to be Korean tense aspirated stops and in 5% of the cases the evaluation of the English unaspirated voiced stops after /s/ was in the direction of Korean tense unaspirated stops.

Figure 3. Percent responses of Korean speakers



In 86% of the cases, the English unaspirated voiceless stops after the removal of /s/ were perceived as Korean tense unaspirated stops, and in 90% of the cases the English initial unaspirated voiced stops were perceived as Korean lax unaspirated stops, whereas in the same context they identified in 13% of the cases the English unaspirated voiceless stops with Korean lax unaspirated stops and in 1% of the cases the reaction went to Q (i.e. not clear), and in 10% of the cases they heard the English unaspirated voiced stops generally as Korean tense unaspirated stops. There was considerable confusion about the [k] and [d] (in 20% of the cases, Fig 3). This may be attributable to differences partly in phonetic properties between the acoustical stimuli and the related sounds in Korean, for example, differences in the degree of aspiration, the pattern of intensity build-up of vowels following the plosive

release, etc. In word-initial position, one of the perceptual cues for the Korean tense unaspirated stops is considered to be the abrupt rising of amplitude of vowels following the stop release (Han and Weitzman, 1970).

In intervocalic position, on the other hand, the perceived English unaspirated voiced stops were judged to be Korean lax unaspirated stops without exceptions. The oral closure interval of the English voiced stops in the stimuli ranged from 59ms to 71 ms, which is much shorter than the average duration, i.e. 85ms, of Korean intervocalic lax unaspirated stops (Kim, 1987). Considering this, it can be postulated that the perceptual results were attributed to the oral closure interval. Korean intervocalic lax unaspirated stop is differentiated from its tense cognate by the duration of oral closure. The data obtained from an informal perceptual experiment with Korean speakers showed that the phoneme boundary of the oral closure interval between the lax unaspirated stops and its tense counterparts was about 140 ms. An intervocalic unaspirated lax stop remained perceptually tense when the closure interval was lengthened (say, 160 ms), and when the closure interval was less than 120 ms, it was perceived as lax.

The majority of judgements of stops in stimuli went, on the whole, either to the Korean tense unaspirated stops or the lax unaspirated stops although there were average 5% another sound identifications, and the judgements were based mainly on the physical properties, i.e. aspiration, oral closure interval, and tensity, of stops in question, but not on linguistic knowledge cue such as the English phonotactic constraint. The results obtained were agreeable with Kim's findings (1992) although they are not directly comparable due mainly to differences in test-items, subjects, etc.

In summery, it was concluded that we should classify the English stops after /s/ into the phoneme where [p^h,t^h,k^h] are in although the stops that occur after /s/ are more like [b, d, g] of "bill", "dill", and "gill" from the phonetic point of view. In the perception of the English stops after initial /s/, the physical properties, i.e. aspiration and voicing, had no value. The perceptual cue for the English stops after /s/ was linguistic knowledge, that is, phonotactic constraint: After utterance-initial /s/ always phonologically voiceless stops /p, t, k/ follow if the second one is a stop. The initial fricative /s/ contributed, on the whole, the evaluation of the unaspirated voiceless and voiced stops in the direction of the phoneme where [p^h,t^h,k^h] are in.

The assumption that the unaspirated voiceless stop [p] after /s/ will be identified perceptually with the aspirated voiceless stop [p^h] in other positions has been verified.

In initial stop-vowel context, the perceptual cue was physical properties, that is, aspiration, regardless of the feature [voice].

The phonemic representation (i.e., phonemic sound image) of plosives was perceived through either the syllable structure cue or the phonetic properties of the sounds according to the context in which the stops occurs. This means that there is not always a one to one relationship between perception and phonetic properties.. The phonotactic constraint which is

formulated in the English speaker's brain in the form of linguistic knowledge may be from the English orthographic system in which after word-initial spelling "s" never "b, d, g" follows, but generally "p, t, k".

For Korean and Chinese subjects, the identification of the stops in acoustical stimuli varied with the physical properties of the sounds, regardless of the presence of initial fricative /s/. Korean speakers heard the English unaspirated voiceless stops generally as the Korean unaspirated tense stops and the English unaspirated voiced stops as the Korean unaspirated lax stops.

Chinese subjects' reactions to a set of stops in stimuli were dependent mainly on the physical property, i.e. aspiration.

The results showed clearly that the perception of stops in the stimuli was not only language specific but also context specific although the reactions to a set of stops in stimuli were somewhat less clear-cut for the foreign than for the English listeners. This may be because the perception of the stops were based on the relative significance of cue present in the acoustical stimuli within the frame of the phonemic system of each language. The results may be useful in programming for the computer controlled humanbeing-machine communication system.

REFERENCES

Davidsen; Niels-Nielsen. 1969. "English stops after initial /s/." *English Studies, 50(4),* 321-339.

Han, M. S. 1980. "Acoustic Features of Korean /P,T,K/, /p,t,k/ and /p^h,t^h,k^h/." *Phonetica, 22,* 112-128.

Jones, D. 1957. "The history and meaning of the term 'phoneme'." (IPA, Univ. College, London).

Kim, Dae-won. 1987. *Some Phonetic Aspects of Intervocalic Oral Stop Consonants in British English and Korean.* Ph.D. thesis, Univ. of Reading.

Kim, Dae-won. 1989. "The relationship between full voicing and the oral closure interval of lax intervocalic stop." *Journal of Phonetics, 17,* 239-243.

Kim, Dae-Won. 1992. "The role of linguistic knowledge in the perception of English stop in /s/-stop clusters." *In the proceedings of 14th ICA Vol./Band 3,* G3-7 (International Commission on Acoustics, Germany; S. Hirzel Verlag Stuttgart).

Ladefoged, Peter. 1993. *A Course in Phonetics.* New York; Harcourt Brace Jovanovich, Inc.

Lisker, L. 1957. "Closure duration and the intervocalic voiced-voiceless distinction in English." *Language, 33,* 42-49.

Lotz, J.; Abramson, A. S.; Gerstman, L. J.; Ingemann, F.; Nemser, W. J. 1960. "The perception of English stops by speakers of English, Spanish, Hungarian, and Thai: A tape-cutting experiment." *Language and Speech, 3,* 71-77.

O'Kane, D. 1978. "Manner of vowel termination as a perceptual cue to the voicing status of post-vocalic stop consonants." *Journal of Phonetics, 6,* 311-318.

Port, R. F. 1979. "The influence of tempo on stop closure duration as a cue for voicing and place." *Journal of Phonetics, 7,* 45-56.

Raphael, L. T. 1972. "Preceding vowel duration as a cue to the perception of voicing of word-final consonants in American English." *JASA, 51,* 1296-1303.

Reeds, J. A.: Wang, W. S-Y. 1961. "The perception of stops after 's'." *Phonetica, 6,* 78-81.
Sapir, E. 1921. *Language: An Introduction to the study of Speech.* New York: Harcourt Brace.

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