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The proximate unit in Korean speech production: Phoneme or syllable?

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Abstract

We investigated the "proximate unit" in Korean, that is, the initial phonological unit selected in speech production by Korean speakers. Previous studies have shown mixed evidence indicating either a phoneme-sized or a syllable-sized unit. We conducted two experiments in which participants named pictures while ignoring superimposed non-words. In English, for this task, when the picture (e.g., dog) and distractor phonology (e.g., dark) initially overlap, typically the picture target is named faster. We used a range of conditions (in Korean) varying from onset overlap to syllabic overlap, and the results indicated an important role for the syllable, but not the phoneme. We suggest that the basic unit used in phonological encoding in Korean is different from Germanic languages such as English and Dutch and also from Japanese and possibly also Chinese. Models dealing with the architecture of language production can use these results when providing a framework suitable for all languages in the world, including Korean.

Keywords

Korean speech production; phonological encoding; proximate unit; segment vs. syllable

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Phonological units in Korean speech production

In speaking, we transform our thoughts into sound waves which other speakers of the language perceive and understand. The act of speaking involves selection of the appropriate words from the mental lexicon (i.e., lexical selection) as well as assembling the sounds associated with these words for articulation. This article focuses on the latter process, called *phonological encoding*. Several theoretical models have been formulated describing in varying detail how the ability to speak might be organised in the mind (e.g., Caramazza, 1997; Dell, 1986; Levelt et al., 1999). Among these models, Levelt et al. (1999) is most explicit on how phonological encoding of words takes place. According to this model, two pieces of information are needed: (1) *the metrical frame*, specifying the number of syllables and the stress position, and (2) *the phonological units*, which are the *initially selected units* which will be used to fill the slots of the metrical frame. For example, uttering a word such as "panda" would involve a bi-syllabic metrical frame with stress on the first syllable (i.e., ω = 'σσ), and the phonological units would be /p/$_1$ /æ/$_2$ /n/$_3$ /d/$_4$ and /ə/$_5$. These two pieces of information are then combined to form the bi-syllabic phonological word ['pæn-də] with stress on the first syllable.

The Levelt et al. (1999) model was developed using experimental data from mainly Germanic languages such as Dutch, English, and German. However, it is becoming clear that the model details are not the same for all languages due to the numerous phonological, morphological, and orthographic differences between them. Indeed, a recent paper by Roelofs (2015) has already amended parts of the model to accommodate findings from other languages such as Mandarin Chinese and Japanese (e.g., *Chinese*: Chen et al., 2002; O'Séaghdha et al., 2010; *Japanese*: Kureta et al., 2006; Verdonschot et al., 2011).

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These findings have shown that the initially selected phonological unit during phonological encoding—the "proximate" unit (see O'Séaghdha et al., 2010)—is not the same in all languages. Specifically, it has been shown using different experimental paradigms such as implicit priming and masked priming; whereas the proximate unit is the phoneme (segment) in Dutch and English (and other European languages), it is the (atonal) syllable in Mandarin Chinese and the mora in Japanese[1] (for a comprehensive overview of these findings, see O'Séaghdha, 2015; Roelofs, 2015). The status for many other languages, however, is largely unexplored.

In this study, we focus on Korean. Korean is of special interest because of the numerous phonological, morphological, and orthographic differences between Korean and other languages, for example: Dutch and English, on the one hand, and Mandarin Chinese and Japanese, on the other. These differences suggest a role for either phonemes (segments) or syllables as the potential proximate unit in Korean, as we discuss below.

First, the Korean syllable is far less complex than that of English and Dutch, suggesting a putative role for the syllable as a proximate unit (although the Korean syllable is more complex than Mandarin). A Korean syllable is maximally CGVC (C = consonant, G = glide, V = vowel) where only a single consonant is allowable in onset and coda position. This contrasts with English and Dutch which allow as many as three consonants in syllable onsets (e.g., "sprain") and four consonants in syllable codas (e.g., "texts"). Hence, the number of possible syllables in Korean is 1,832 (derived from the subtraction of the unattested syllables from all possible combinations from 19 consonant onsets, 21 vowels, and 7 coda consonants; Won, 1987), which is considerably smaller than the 12,000 possible syllables in Dutch (Schiller, 1998), but also much larger than the approximately 400 syllables in Mandarin Chinese when ignoring tones (and 1,200 for tonal syllables; O'Séaghdha et al., 2010). Furthermore, in contrast to Mandarin where resyllabification is non-existent, Korean allows numerous phonological processes to occur across the syllable boundary. For example, when the second syllable of a disyllabic word begins with a vowel, the coda of the first syllable is resyllabified to the onset of the second syllable, for example, /hak.u/ "buddy" → [ha.ku]. Another example is nasal assimilation in which the coda of the first syllable is nasalised and assimilated with the nasal onset in the second syllable, for example, /hak.mun/ "learning" → [haŋ.mun].[2]

Second, the Korean orthographic system (Hangul) is different from all alphabetic scripts, where a letter corresponds to a phoneme, as in English and Dutch; Chinese "hanzi" (and Japanese kanji) characters represent (morpho-) syllables, and Japanese "kana" script represents moras. Hangul is an "alphabetic syllabary" in which both phonemes and syllables are explicitly represented in the writing system (e.g., Taylor, 1980; Taylor & Taylor, 2014). Hangul is a relatively transparent orthography where grapheme-to-phoneme correspondence is consistent, and thus, each phoneme is represented by a Hangul letter. These letters are, however, not linearly ordered as in the alphabetic writing system, but grouped into a square block, which corresponds to a syllable. The syllables are separated by a physical gap: For example, the printed word <한글> /han.kɨl/ is composed of two syllable blocks. The physical demarcation of syllable blocks renders the readers to clearly distinguish the syllable boundary (e.g., unlike English in which a word such as "music" is not written as mu-sic). Thus, Hangul maps graphemes onto phonemes just as English and Dutch do, but the composition of its graphemes is shaped into a square-like syllable-sized block, like a Chinese hanzi character.

The putative roles of segments and syllables as the proximate unit in Korean find empirical support in observations of natural language use, such as word games and speech errors. Some word games in Korean respect the syllable, whereas other word games respect the phoneme. For example, a Korean word-chain game played by children named *kketmaliski* requires players to utter a word which begins with the final part of the previously heard word. Here, the final part must be the syllable. For instance, when *han.kuk* "Korea" is presented, *kuk.su* "noodle" is valid, but *ki.lin* "giraffe" (onset overlap) or *ku.lɨm* "*cloud*" (onset plus a vowel overlap) is not a valid continuation. It is of interest to note that the syllable in question is the *underlying syllable* as represented in the Hangul orthography, for example: *kuk.min* "people" would also be a valid answer here, even though the coda of the first syllable is ultimately pronounced as a nasal as it is situated before a labial nasal (i.e., [kuŋ]), whereas a word with an underlying nasal in the coda of the first syllable (/kuŋ.li/ "deliberation") is not a valid answer. We will return to this point in the "General Discussion" section. On the contrary, Sohn (1987) describes another language game in which vowels of two consecutive syllables are switched around without affecting other parts of the syllable. For instance, the nonword *ha.pok* is derived from *ho.pak* "pumpkin" where only the two vowels in the first and the second syllables are switched without any change in the quality of the surrounding consonants, suggesting a role for the phoneme as a functional phonological unit.

Speech error data can also be informative as to the nature of the phonological unit in speech production. In English, most phonological errors involve a single segment or clusters, and errors involving whole syllables are not as common (Bock, 1991; Dell, 1995). In contrast, both syllable and segment errors are observed in Mandarin (Chen, 1993), and errors mostly adhere to morae in Japanese (Kubozono, 1989). J. I. Han et al. (2019) examined the errors in a large-scale corpus of spontaneous speech (i.e., the Seoul Naturalistic Speech Corpus; Yun

et al., 2015) which contains audio-recorded interviews of 40 standard Korean speakers and found that Korean speakers produced segmental as well as syllabic errors. Korean has higher numbers of segmental than syllabic errors as in the Germanic languages. However, considering the proportions of segmental and syllabic errors, Korean showed similar proportions of errors involving segments (46.1%) and syllables (39.5%), while there are few, if any, pure syllable errors in Indo-European languages (especially not in Germanic languages; see (Bock, 1991; Dell, 1995).[3]

Experimental investigations regarding the role of the segment and the syllable in Korean speech production are scarce. We are aware of just four such studies, and the evidence regarding the onset segment is mixed. Three of these studies employed the masked-priming read-aloud paradigm. Kim and Davis (2002) were the first to report data on Korean, using masked priming in combination with reading aloud and lexical decision. The targets were all monosyllabic words. There were five prime conditions differing in the amount of (orthographic and phonological) overlap, namely, an identity prime (<결> - <결>, both /kjʌl/ "grain"); an onset prime (<개> - <결>, /kæ/ "dog", /kjʌl/); an "onset-plus" (CV) prime (<겨> - <결>, /kjʌ/ "bran", /kjʌl/); a rime prime, wherein the vowel and coda of the prime (i.e., the rime) overlapped with the target (<멸> - <결>, /mjʌl/ "a kind of pepper plant", /kjʌl/); and an unrelated prime serving as the control (e.g., <돈> /don/ "money"). In reading aloud, Kim and Davis (2002) did not obtain significant onset effects (7 ms; although this result approached significance, $p = .06$); however, they obtained a significant identity priming effect (17 ms) as well as a significant 19-ms "onset-plus" (i.e., CV) effect. The form-priming effect (i.e., facilitation due to an overlap in rime) was not significant (–4 ms; e.g., /mjʌl/ - /kjʌl/). The lexical decision task they administered showed—consistent with previous studies in European languages—only significant identity priming, suggesting that the beneficial effects of begin-related overlap in the read-aloud task originated during phonological encoding. In sum, theirs was the first to investigate the masked onset priming effect in Korean, and unlike the effect in European languages which is highly robust, the authors reported the absence of a statistically significant effect in reading aloud in Korean.

In contrast, Witzel et al. (2013) did find significant phoneme onset priming effects. They also employed a masked-priming read-aloud task but used bi-syllabic Korean *non-words* as targets instead. These non-words were all preceded by one of three disyllabic Hangul primes (also non-words), specifically: onset phoneme overlap (e.g., <페추> - <피토> /pʰɛ.cʰu/, /pʰi.tʰo/), CV overlap (e.g., <피추> - <피토> /pʰɪ.cʰu/, /pʰɪ.tʰo/), versus an unrelated prime (e.g., <카추> - <피토> /kʰa.cʰu/, /pʰɪ. tʰo/). The results by Witzel et al. (2013) showed significantly faster reaction times (RTs) when primes and target shared the onset phoneme (9 ms) and the CV syllable (16 ms), and priming was significantly larger for CV primes compared with phoneme primes. Note that the first syllable of all of their primes and targets were open syllables (i.e., CV syllables), and hence it is unclear whether the greater benefit observed with the CV overlap was due to the greater amount of segmental overlap or due to the overlap in the syllable.

J. I. Han and Choi (2016) used the form preparation (implicit priming) paradigm with picture targets (i.e., the picture served as the prompt for the picture name to be produced) with disyllabic names (e.g., /ki.lin/, "giraffe", /i.cʰa/, "train"). A significant form preparation effect was found for the syllable overlap (17 ms, $p < .001$) and a marginally significant effect for onset segment overlap (11 ms, $p = .06$). J. I. Han and Choi (2016) took the absence of reliable onset effect in the form preparation paradigm (which is in sharp contrast with the robust effect found with Dutch and English) to argue that the proximate unit in Korean speech production is the syllable, rather than the phoneme.

More recently, J. I. Han and Verdonschot (2019) used two different tasks to investigate the phonological unit of Korean word production. In their first experiment, they used a masked-priming read-aloud task, with two-character non-word target stimuli written in Hangul. They were especially interested in the role of the syllable, and their experimental design included various syllable conditions, which will be described in more detail later. For now, the relevant findings are a significant 19-ms priming effect for the onset segment ("Same onset," for example, <댄소> - <독가> /tæn.so/ - /tok.ka/ vs. Control, for example, <남무> - <독가> /nam.mu/ - /tok.ka/) and a 30-ms syllable overlap effect ("Same syllable," for example, <독쇠> - <독가> /tok.swɛ/ - /tok.ka/ vs. Control, for example, <남무> - <독가> /nam.mu/ - /tok.ka/). The syllable overlap effect was greater than the benefit due to the CV segment overlap. Their second experiment used the phonological Stroop task (see Coltheart et al., 1999; Verdonschot & Kinoshita, 2018) in which two-character Hangul non-words were presented in colour, and participants had to name the colour of the ink. The overlap between the colour name (e.g., /no.laŋ/ "yellow") and the distractor was manipulated either at the segment level (C-overlap, for example, <낙문> /nak.mun/ vs. control <각문> /kak.mun/) or at the CV level (CV overlap, for example, <녹니> /nok.ni/ vs. control <악니> /ak.ni/). In this experiment, both C-overlap and CV overlap facilitated colour-naming latencies relative to the control (14 and 22 ms, respectively), and the CV overlap produced greater facilitation than the C-overlap. In sum, J. I. Han and Verdonschot (2019) replicated the pattern of results reported by Witzel et al. (2013) with both the masked-priming read-aloud task (used by Witzel et al.) and the phonological Stroop task.

As for Witzel et al.'s (2013) findings, these results could be interpreted in terms of the benefit due to segmental overlap, and in line with this, J. I. Han and Verdonschot (2019) concluded that "the onset segment and not the syllable is the initial (or proximate) phonological unit used in the segment-to-frame encoding process during speech planning in Korean" (p. 901). Importantly, their conclusion also took into account the findings from the additional conditions in their masked-priming read-aloud experiment (Experiment 1) referred to earlier. Specifically, in addition to the "Same syllable" (e.g., <독쇠> - <독가> /tok.swɛ/ - /tok.ka/) condition, there were two additional conditions in which the first syllable of the prime was the same orthographic (underlying) syllable as the first syllable of the target, but it would have been realised as a phonetically different syllable, namely, the "Resyllabification" condition, in which the coda of the first syllable would be resyllabified to the onset of the second syllable when pronounced, for example, 독유 /tok.ju/ → /to.kju/, and the "Coda change" condition, in which the coda of the first syllable would undergo a phonological change (nasalisation) and is assimilated with the nasal onset of the second syllable, for example, 독머 /tok.mə/ → /toŋ.mə/, during production. The key result was that these two conditions behaved *exactly* like the "Same syllable" condition, indicating that there was no extra benefit when the whole syllable was shared between prime and the target words compared with the case where only part of the syllable was shared. This led Han and Verdonschot to conclude that the syllable is *not* used as the initial unit of phonological planning in Korean. There are two points to note, however. One is that the "Resyllabification" and "Coda change" conditions were tested only in Experiment 1. These conditions—which require the first syllable to be CVC—could not be included in their Experiment 2 using the phonological Stroop task due to the constraint that all of the to-be-named colour names contained an open syllable (CV) as the first syllable. Given that Experiment 1 used the masked-priming read-aloud task, J. I. Han and Verdonschot (2019) suggested that the result may have reflected the possibility that "participants may not have had sufficient time to process the primes up to the point that re-syllabification or nasalisation could have been carried out" (p.901). It is therefore essential to replicate these conditions using a different task. The second point to note is the ambiguity concerning the underlying syllable in the Resyllabification and Coda change conditions. Recall that unlike alphabetical scripts, Hangul characters explicitly represent the syllable by grouping the letters into a square block, and the first syllable in the "Same syllable," "Resyllabification," and "Coda change" conditions was orthographically identical. It could be argued, therefore, that the first syllable in the "Resyllabification" and "Coda change" distractors was *underlyingly the same* as the "Same syllable" distractor. The earlier mentioned fact is that in the Korean word-chain game *kketmaliski, kuk.min* is a valid continuation of *han.kuk* even though "kuk" in *kuk.min* is realised as [kuŋ] is consistent with this. Taking all the studies together then, it may be premature to accept the conclusion that the onset segment and not the syllable is the proximate unit in Korean speech production, as it rests on the absence of evidence for the syllable, and a stronger test is needed.

This study further investigates the role of onset segment and syllables in Korean speech production, using the picture–word interference (hereafter PWI) paradigm. To our knowledge, the PWI task has not (yet) been used to study the proximate unit in Korean, but we believe it is important to extend the range of paradigms beyond the two main tasks used to date, namely, form preparation and masked priming. O'Séaghdha and Frazer (2014) have pointed out limitations with these tasks. Specifically, he suggested that some form preparation effects may involve memory cuing which allows the shared component to more quickly retrieve the to-be-named target word, instead of (or in addition to) preparation of the shared component. Furthermore, the form preparation effect may be strategic, as attested by the observation that in J. I. Han and Choi's (2016) study, the effect (for either the onset segment or syllable) was absent in the first block of trials and appeared only from the second block onwards. The possibility that the emergence of the form preparation effect—despite the alternative term *implicit* priming effect—depends on participants explicitly noticing the shared component makes it a less ecologically valid paradigm to study natural speech production. Of the masked-priming read-aloud paradigm, O'Séaghdha (2015) has commented that "masked primes could influence many word-production processes" (p. 13), not just phonological encoding. Indeed, a major alternative account of masked onset priming effect attributes the facilitation in reading aloud due to the onset overlap between the prime and the target to the sub-lexical grapheme–phoneme mapping process (e.g., Forster & Davis, 1991), and both Kim and Davis (2002) and Witzel et al. (2013) interpreted their finding of masked onset priming effect with Korean words written in Hangul in terms of this process, rather than using phonological encoding. Given these issues, we heed O'Séaghdha's (2015) call for "more data using tasks that more fully engage speech production processes," and consequently, we use the PWI task here.

The PWI task has been a mainstay of speech production research. The advantages of this task over the masked-priming read-aloud paradigm are twofold: first, the target is not a written word and hence it is less prone to the influence of orthography (see the results of Kinoshita & Mills, 2020; Kinoshita & Verdonschot, 2020, which suggest that the benefit of onset segment overlap in the PWI task is purely phonological, with no added benefit from orthographic overlap); second, the distractor is available for a longer period than masked primes (i.e., until the participant's response), and hence there is a greater scope to

observe effects of different sized units.[4] In these respects, the PWI task is similar to the Stroop colour-naming task, the task used previously to investigate the proximate unit in Japanese (Verdonschot & Kinoshita, 2018) and Korean (J. I. Han & Verdonschot, 2019). One advantage of the PWI task over the Stroop colour-naming task is the greater range of available to-be-named targets, because they are not limited to colour names. It is relevant to note in this context that J. I. Han and Verdonschot (2019) were unable to fully replicate the design of their masked-priming read-aloud experiment (Experiment 1) in the Stroop task (Experiment 2), because the first syllable of the to-be-named colours (blue, white, yellow) in Korean had to be an open syllable (CV syllable), and therefore the "Resyllabification" and "Coda change" conditions could not be included.

In our current study, we used as targets (presented as a picture) disyllabic words with initial CVC syllable (e.g., /kuk.su/ "noodle") and disyllabic words with initial CV syllable (e.g., /ca.sʌk/ "magnet") with disyllabic non-word distractors superimposed on the picture. For the former type of targets, we included all of the conditions used in J. I. Han and Verdonschot's (2019) masked-priming read-aloud experiment, namely, the Same syllable (e.g., 국퐁 /kuk.p^{h}oŋ/), Same onset (i.e., 걸맴 /kʌl.mæm/), Resyllabification (i.e., 국억 /kuk.ʌk/ > [ku.kʌk]), and Coda change (e.g., 국눈 /kuk.nun/ > [kuŋ.nun]) conditions, and compared them with the unrelated Control (e.g., 산묩 /san.mop/). For the initial CV targets, the Resyllabification and Coda change conditions could not be included (for the reasons mentioned earlier), and hence, there were the Same syllable (e.g., 자홉 /ca.hop/), Same onset (e.g., 종팔 /coŋ.p^{h}al/), and the unrelated Control condition (e.g., 꼭찰 /k'ok.c^{h}al/). Importantly, in addition, for both types of targets, we included the Same CV condition to provide a further test of whether syllable overlap confers a greater benefit than CV overlap. The Same CV distractors differed from the to-be-named target in the syllable, such that for the initial CVC targets (e.g., /kuk.su/, "noodle") the Same CV distractor contained an initial CV syllable (e.g., 구툴 /ku.t^{h}ul/) and for the initial CV targets (e.g., /ca.sʌk/ "magnet") the Same CV distractor contained an initial CVC syllable (e.g., 잠진 /cam.cin/). Note that unlike the "Resyllabification" and "Coda change" distractors, the syllable of the Same CV distractors (that differed from the target) was explicitly represented orthographically. Furthermore, for the initial CV targets (but not for the initial CVC targets), the amount of segmental overlap with the target was equated for the Same syllable distractors and the Same CV distractors. Thus, for the CV targets, the advantage of the Same syllable condition relative to the Same CV condition would indicate a benefit due to the shared syllable and provides a strongest test of the role of syllable. Table 1 shows all distractor conditions and examples.

In addition to the inclusion of the "Same CV" condition, the design of this study differs from J. I. Han and Verdonschot's (2019) Experiment 1 in two respects. First, in that experiment, all of their targets contained an initial CVC syllable with the coda /k/ or /p/ (e.g., 독 /tok/, 숍 /sop/, etc.), which was a necessary constraint for creating their Resyllabification and Coda change conditions. However, this may have invoked an anticipatory bias towards producing a syllable with a (/k/ or /p/) coda. In the present experiment, the targets with the initial CVC syllable and initial CV syllable (e.g., 기 /ki/ in 기린 /ki.lin/ "giraffe") were mixed randomly to avoid such a bias. Second, although the primes and targets in J. I. Han and Verdonschot's (2019) Experiment 1 were all *non-words*, the first syllable was typically a freestanding morpheme: For example, while "독쇠" [tok.swɛ] is a non-word, the first syllable 독 [tok] is a free morpheme (meaning "poison"). This would be akin to an English non-word such as "*birdflisk*" *where* the first syllable contains the free morpheme "*bird" being* primed with a word such as "*bird-grop.*" The result that the Same syllable, Resyllabification, and Coda change conditions in J. I. Han and Verdonschot's (2019) Experiment 1 did not differ from each other may potentially have been due to this morphemic overlap. In speech production tasks, morphemic overlap is known to facilitate naming more than a phonological overlap: For example, Roelofs (1996) showed, using the implicit priming paradigm, that the form preparation effect was greater when the set of words were polymorphemic words sharing a morpheme (e.g., bijvak, bijrol, bijnier, "subsidiary subject," "supporting role," "adrenal," which are polymorphemic words sharing the morpheme "bij") than when the set comprised monomorphemic words sharing a phonologically identical syllable (e.g., bijbel, bijna, bijster, meaning "bible", "almost", "very"; see also Zwitserlood et al., 2000, using the PWI paradigm and Koester & Schiller, 2008, using the long-lag word–picture priming paradigm). To test this possibility, in this article, we report two PWI experiments, with Experiment 1 using picture targets with polymorphemic names with non-word distractors in which the first syllable is a free morpheme, and Experiment 2 using picture targets with monomorphemic names in which the first syllable is a non-morphemic syllable (this may be likened to picture names like "rabbit" in English where the first syllable is not a free morpheme). If the absence of difference between the Same syllable, Resyllabification, and Coda change conditions is replicated in Experiment 1 but not in Experiment 2, this would suggest a morphemic origin. In addition, as the two experiments contained the same distractor conditions, they provide a further opportunity for replication of other comparisons.

Experiment 1—free morpheme initial syllable targets

The first experiment investigated the role of onset segments and syllables in Korean speech production. Picture naming was used to optimally involve production

Table 1. Mean naming latencies (in ms) in Experiment 1 (note: the initial syllable is a free morpheme).

CVC target			CV target	
Condition	Example	Mean RT (*SD*)	Example	Mean RT (*SD*)
Target picture	/kuk.su/ (noodle)		/ca.sʌk/ (magnet)	
Same syllable	국풍 /kuk.pʰoŋ/	553 (55)	자흡 /ca.hop/	548 (47)
Same CV	구툴 /ku.tʰul/	601 (54)	잠진 /cam.cin/	578 (54)
Resyllabification	국억 /kuk.ʌk/ [ku.kʌk]	550 (53)		
Coda change	국눈 /kuk.nun/ [kuŋ.nun]	550 (54)		
Same onset	걸맴 /kʌl.mæm/	629 (69)	종팔 /coŋ.pʰal/	580 (54)
Control	산몹 /san.mop/	620 (58)	꼭찰 /k'ok.cʰal/	595 (56)
Onset overlap benefit (Control—Same onset)	−9		15	
Syllable overlap benefit (Control—Same syllable)	67		47	
Whole syllable effect[a] (Same CV—Same syllable)	48		30	

RT: reaction time; CVC: consonant-vowel-consonant; CV: consonant-vowel.
[a]For the CVC targets, the Whole syllable effect is confounded with the number of segments shared with the target as the Same syllable distractor but not the Same CV distractor shared the coda segment of the initial syllable with the target. For the CV targets, the Whole syllable effect represents a pure benefit of sharing the whole syllable, as the Same syllable distractor and the Same CV distractor contained the same initial CV segments.

processes, and superimposed non-words were used as distractors.

Method

Participants. Thirty students (11 males, age = 21 ± 2 years) from Konkuk University, Republic of Korea, all native Korean speakers, participated in the experiment and received monetary compensation.

Design. The experiment used the picture–word interference task, which had the distractor type (i.e., Same syllable, Resyllabification, Coda change, Same CV, Same onset, and Control) manipulated within participants. The dependent variable was the picture-naming response latency.

Materials. Stimuli consisted of eight pictures (black-and-white drawings) and 240 disyllabic Korean non-words. All pictures had disyllabic names, four pictures had names starting with a CVC syllable (e.g., /kuk/), and four had names starting with a CV syllable (e.g., /ca/), hereafter referred to as CVC targets and CV targets, respectively. In Experiment 1, all the targets contained an initial syllable which was a free morpheme, that is, in the target /kuk.su/ meaning "noodle," the syllable /kuk/ means "soup." Note that the initial syllable morpheme was not always semantically related to the whole word: for example, the target /pak.cwi/ meaning "bat" (animal) contains the initial syllable /pak/ which means "gourd."

For the CVC targets, there were six distractor conditions: (1) Same syllable, (2) Resyllabification, (3) Coda change, (4) Same CV, (5) Same onset, and (6) Control; for the CV targets, there were four (instead of six) distractor conditions as CV targets do not have a coda: (1) Same syllable, (2) Same CV, (3) Same onset, and (4) Control. For each distractor condition, six disyllabic distractor words were devised (one for each block) totalling 4 CVC targets × 6 conditions × 6 blocks + 4 CV targets × 4 conditions × 6 blocks = 240 stimuli. All stimuli used in Experiment 1 can be found in Supplementary Material A.

Apparatus and procedure. Participants were tested individually, seated approximately 60 cm in front of a Samsung S24E450F monitor, upon which the stimuli were presented. Each participant completed 240 test trials, in six blocks. Each picture was named as many times as it had conditions in each block (i.e., 4 CVC targets × 6 conditions, and 4 CV targets × 4 conditions, i.e., 40 items per block). There were self-paced breaks between the blocks, and for each block two pseudorandomised lists were created (using the "mix" software; van Casteren & Davis, 2006) for which each list had the restriction that picture name, picture category, first character, and condition could not directly follow each other. Half of the participants were assigned to one version and the other half to the other version. Six block orders were generated according to a Latin square design to avoid any block order effects. A practice block of eight trials using stimuli (which were not the test stimuli) with the target presented in the same format as the test block preceded the experiment proper. The task was a picture-naming task. Participants were instructed at the outset of the experiment that on each trial they would be presented with a black-and-white line drawing, and their task was to name the picture, as fast and accurately as possible. Stimulus presentation and data collection were achieved through the use of E-prime 2.0 software (e.g., Spapé et al., 2019). Stimulus display was synchronised to the screen refresh rate (16.7 ms). Each trial started with the presentation of a fixation mark (+) for 750 ms at the centre of the screen. This was followed then by the target picture which also contained a superimposed distractor word.

Targets were presented for a maximum of 3,000 ms or until the participant's response. The experimenter then judged the accuracy of a trial by pressing 1 (correct), 2 (voicekey problem), or 3 (error) on a keyboard. After this, an empty screen of 250 ms was shown, which was again replaced by the fixation.

Results

Naming latencies were analysed using linear mixed-effects (LME) modelling with subjects and items as crossed random factors (Baayen, 2008), using the packages lme4 (version 1.1-17; Bates et al., 2015), and lmerTest (version 3.0-1; Kuznetsova et al., 2018) implemented in R (version 3.5.1; 2018-07-02; R Core Team, 2018). CVC targets and CV targets were analysed separately. In the analysis of naming latencies, error trials were excluded, and the latencies were log-transformed to meet the distributional assumptions of LME. We initially tested LME models that included the subject random slope on the distractor type factor; however, as the models did not converge, all the models we report here included subject and item random intercepts.

RT. The mean correct naming latencies are shown in Table 1. Error rates were not analysed, as there were too few errors (78 out of 7,200 trials, or 1%).

CVC targets. The data shown in Table 1 indicates the pattern: (Same syllable = Resyllabification = Coda change) < Same CV < Same onset = Control. This pattern was confirmed by the statistical model with Distractor type as the fixed factor (referenced to the various Distractor conditions) and words (144) and subjects (30) as crossed random effect factors: logRT ~ Distractortype + (1| word) + (1| subj). Relative to the Control condition, all conditions were significantly faster (all $|t| > 2.815$, all $p < .001$) except the Same onset condition, $t = 0.488$, $B = 0.0006257$, $SE = 0.001282$, $p = .62$, that is, there was no onset effect, but a significant syllable effect. Relative to the Same syllable condition, Resyllabification and Coda change condition did not differ significantly from this condition (both $|t| < 1$, $p > .649$), but the Same CV condition was significantly slower, $t = 5.976$, $B = 0.007649$, $SE = 0.00128$, $p < .001$.

CV targets. For these targets, the data shown in Table 1 indicate the pattern: Same syllable < Same CV = Same onset = Control. As for the CVC targets, this pattern was confirmed by the statistical model with Distractor type as the fixed factor (referenced to the various Distractor conditions) and words (96) and subjects (30) as crossed random effect factors: logRT ~ Distractortype + (1| word) + (1| subj). Relative to the Control condition, all conditions (except the Same onset condition) were significantly faster (all $|t| > 2.132$, all $p < .05$). The Same onset condition was *marginally* faster than the Control condition, $t = -1.96$, $B = -0.02736$, $SE = 0.01396$, $p = .053$. Relative to the Same onset condition, the Same syllable condition was significantly faster, $t = -3.785$, $B = -0.052797$, $SE = 0.014948$, $p < .001$, but the Same CV condition was not, $t = -0.173$, $B = -0.002411$, $SE = 0.013959$, $p = .863$. This last pattern indicates that the benefit due to the syllable overlap beyond the onset overlap was not a segmental overlap effect, as both the Same syllable and Same CV distractors shared the first two segments with the target picture name.

Experiment 2—non-morphemic initial syllable targets

The design of Experiment 2 was identical to Experiment 1, except that the first syllable of picture targets was *not* a morpheme here. This is akin to disyllabic words in English such as "rabbit" or "campus" (where "rab" and "cam" are not morphemes). All stimuli used in Experiment 2 can be found in Supplementary Material B. A different group of participants compared with Experiment 1, all students of Konkuk University took part in this experiment for a monetary reward ($N = 30$, 20 males, age = 21 ± 2 years).

RT

The mean correct naming latencies are shown in Table 2. Error rates were not analysed, as there were too few errors (77 out of 7,200 trials, ~1%).

CVC targets

The data shown in Table 2 are similar to those of Experiment 1 and indicate the pattern: (Same syllable = Resyllabification = Coda change) < Same CV < Same onset = Control. This pattern was confirmed by the statistical model with Distractor type as the fixed factor (referenced to the various Distractor conditions) and words (144) and subjects (30) as crossed random effect factors: logRT ~ Distractortype + (1| word) + (1| subj). Relative to the Control condition, all conditions were significantly faster (all $|t| > 4.72$, all $p < .001$) except the Same onset condition, $t = -1.585$, $B = -0.02354$, $SE = 0.01485$, $p = .115$, that is, there was no onset effect, but a significant syllable effect was found. Relative to the Same syllable condition, Resyllabification and Coda change condition did not differ significantly from this condition (both $|t| < 1$, $p > .73$), but the Same CV condition was significantly slower, $t = 2.93$, $B = 0.043382$, $SE = 0.014804$, $p < .01$. Finally, referenced to the Same onset condition, the Same CV condition was significantly faster, $t = -3.128$, $B = -0.04642$, $SE = 0.01484$, $p < .001$.

Table 2. Mean naming latencies (in ms) in Experiment 2 (note: the initial syllable is not a morpheme).

CVC target			CV target	
Condition	Example	Mean RT (*SD*)	Example	Mean RT (*SD*)
Target picture	/kʌk.swɛ/ "clamp"		/kʌ.p^{h}um/ "bubble"	
Same syllable	꺾담 /k'ʌk'.tam/	583 (77)	거흥 /kʌ.hoŋ/	578 (72)
Same CV	꺼항 /k'ʌ.haŋ/	611 (86)	검통 /kʌm.t^{h}oŋ/	614 (75)
Resyllabification	꺾윤 /k'ʌk'.jun/ [k'ʌ.k'jun]	578 (62)		
Coda change	꺾낭 /k'ʌk'.naŋ/ [k'ʌŋ.naŋ]	583 (70)		
Same onset	꼴구 /k'ol.ku/	643 (89)	균출 /kjun.c^{h}ul/	626 (70)
Control	물추 /mul.c^{h}u/	657 (82)	능녕 /niŋ.njʌŋ/	624 (71)
Onset overlap benefit (Control—Same onset)		14		-2
Syllable overlap benefit (Control—Same syllable)		74		46
Whole syllable effect[a] (Same CV—Same syllable)		28		36

RT: reaction time; CVC: consonant-vowel-consonant; CV: consonant-vowel

[a]For the CVC targets, the Whole syllable effect is confounded with the number of segments shared with the target as the Same syllable distractor but not the Same CV distractor shared the coda segment of the initial syllable with the target. For the CV targets, the Whole syllable effect represents a pure benefit of sharing the whole syllable, as the Same syllable distractor and the Same CV distractor contained the same initial CV segments.

CV targets

For the CV targets, the data shown in Table 2 are similar to the pattern observed in Experiment 1: Same syllable < Same CV = Same onset = Control. This pattern was confirmed by the statistical model with Distractor type as the fixed factor (referenced to the various Distractor conditions) and words (96) and subjects (30) as crossed random effect factors: logRT ~ Distractortype + (1| word) + (1| subj). Relative to the Control condition, the Same onset condition did not differ significantly, $t = -0.223$, $B = -0.00238$, $SE = 0.01067$, $p = .824$. Relative to the Same onset condition, the Same syllable condition was significantly faster, $t = -7.086$, $B = -.0.07562$, $SE = 0.01067$, $p < .001$, but the same CV condition was not, $t = -1.356$, $B = -0.01447$, $SE = 0.01067$, $p = .178$. As in Experiment 1, this last pattern indicates that the benefit due to the syllable overlap beyond the onset overlap was not a segmental overlap effect, because both the Same syllable and Same CV distractors shared the first two segments with the target picture name.

Bayes factor analysis

Given the undefined empirical status of the onset effect in the Korean speech production literature, we calculated the Bayes factor for the effect in our Experiments 1 and 2 to quantify the strength of evidence for the effect. A Bayes factor is an odds ratio, with 1 indicating equal evidence for the two mutually exclusive hypotheses, generally odds of 3 or greater indicating "some evidence," greater than 10 indicating "strong evidence," and odds greater than 30 indicating "very strong evidence" (Dienes, 2014; Jeffreys, 1961) for one hypothesis over the other. For each experiment, the data for the CVC targets and CV targets were combined, and the Bayes factor against the Onset effect (Same onset vs. the Control) was calculated using the BayesFactor package (version 0.9.12-4.1; Morey & Rouder, 2018) with the model that contained only the subject and distractor as crossed random intercept (i.e., the null model) as the numerator. For both Experiments 1 and 2, the Bayes factor was 7 in favour of the null model, indicating moderately strong evidence against the presence of onset effect.

General discussion

The present experiments used a picture–word interference task to investigate which phonological unit—segment (phoneme) or syllable—is initially used in Korean speech production. The pictures had disyllabic names (e.g., /kuk.su/, "noodle," /ca.sʌk/ "magnet"), and the distractors were disyllabic non-words. The data patterns were consistent across two experiments and showed that relative to the unrelated control condition, (1) syllable overlap produced a large (about 50 ms or greater) naming benefit; (2) the benefit for onset overlap was small (generally less than 10 ms) and not statistically significant, with the Bayes factor indicating moderately strong evidence for the null effect; (3) for the initial CVC syllable targets (e.g., /kuk.su/), the Resyllabification and Coda change distractors which share the underlying syllable with the Same syllable distractor produced a naming benefit that was indistinguishable from the Same syllable distractor, and the benefits were significantly greater than those produced by the Same CV distractor; and (4) for the initial CV syllable targets, (e.g., /kʌ.p^{h}um/), the same syllable distractor (e.g., /kʌ.hoŋ) produced a significantly greater benefit compared with the same CV distractor which shared the same number of segments (e.g., /kʌm.t^{h}oŋ/). These findings provide compelling evidence for the role of the syllable in Korean speech production. In particular, this is the first study that directly compared the benefits conferred by syllable overlap (i.e., the same syllable condition) and segmental

overlap (i.e., the same CV condition) in Korean. Syllable overlap consistently produced a sizable advantage (i.e., 30 ms or more), and this was the case when the segmental overlap between the to-be-named target and the distractor was held constant (i.e., the fourth result mentioned above).

It is relevant to mention in this context that clear evidence for the role of the syllable, distinct from segmental overlap, is absent in speech production studies of European languages. Previous experiments used the masked-priming read-aloud or picture-naming task, and the results have been mixed. Ferrand et al. (1996) reported the initial evidence of syllable priming in French, that is, target words were read aloud faster when preceded by a prime that shared the syllable with the target, that is, *BALCON* ("balcony," where the syllables are BAL and CON) was named faster when preceded the prime *bal* than *ba*, and *BALADE* ("ballad," where the syllables are BA and LADE) was named faster when preceded by *ba* than *bal*. However, later studies (e.g., Schiller, 1998, 1999, with Dutch and English, respectively; Brand et al., 2003 with French, using the exact same stimuli used by Ferrand et al., 1996)[5] failed to replicate this pattern, finding only evidence for segmental overlap (the prime *bal* facilitated the naming of BAL.CON and BA.LADE more so than the prime *ba*). The fact that we found a clear role for the syllable here, independent of segmental overlap, may be due to task differences (e.g., previous studies used masked priming or PWI) or possibly the nature of Korean orthography (i.e., Hangul). Recall that Hangul explicitly represents the syllable by grouping the constituent letters into a square block; this contrasts with multisyllabic words written in the Roman alphabet in which the syllable boundary is not physically marked (i.e., music is not written as mu-sic). For example, consistent with an important role of the syllabic spatial organisation of Hangul characters, C. H. Lee and Taft (2009) have reported that the cross-language difference in the transposed letter similarity effect (i.e., the high level of confusion with the original base word which is generated by non-words in which adjacent letters are transposed, e.g., NAKPIN) in English and Korean was eliminated when English stimuli were presented in a "hangul-like format" (i.e., in which syllables of disyllabic English stimuli and their constituents were presented in separate vertical columns, resembling Hangul). In any event, it would be of interest to examine in future endeavours whether the current findings of clear syllable effects in the PWI task can be replicated in French, with the distractors written in the Roman alphabet.

In the present PWI task, the Same syllable, Resyllabification and Coda change conditions were indistinguishable. This replicated the pattern observed in J. I. Han and Verdonschot's (2019) masked-priming read-aloud experiment; thus, the absence of difference observed in their experiment was not because "participants may not have had sufficient time (due to the limited time the masked prime is available) to process the primes up to the point that re-syllabification or nasalisation could have been carried out" (J. I. Han & Verdonschot, 2019, p. 901). It is also important to note that the pattern of results was found regardless of whether the initial syllable of the picture targets was a free morpheme (Experiment 1) or a non-morphemic syllable (Experiment 2). This means that the result cannot be explained in terms of morphemic overlap.

One potential explanation may be the nature of Korean orthography (i.e., Hangul). As noted earlier, Hangul explicitly represents the syllable by grouping the constituent letters into a square block, and this makes the (underlying) syllable salient. In addition, it may be that written distractors themselves do not undergo phonological encoding, as the distractor itself would not have to be uttered, and hence it would not have been processed down to the level of phonetic planning. This means that for a distractor such as 국눈 /kuk.nun/ [kuŋ.nun], the first syllable 국 might have been converted through grapheme-to-phoneme conversion to /kuk/, and resyllabifications or coda changes such as /kuŋ/ are never realised. Therefore, that our Same syllable, Resyllabification, and Coda change conditions elicited equal effects might have occurred as in all these cases the segments /kuk/ first became available. We should point out that our written distractors were all non-words, and it is currently unclear whether real words, such as 국민 /kuk.min/ [kuŋ.min] "people," would have their coda change stored or not. Although we believe this to be unlikely (as resyllabification and coda change are phonological rules in Korean that apply to non-words as well as words), it is possible that with the use of real-word distractors the resyllabification and coda change conditions may show different effects compared with the Same syllable distractor. This needs to be investigated in future studies.

Incidentally, for CVC targets, half of all distractors shared the first grapheme with the target (e.g., 국 appears in three out of six distractor conditions as the first character for the target 국수 /kuk.su/ "noodle"). Therefore, one might consider whether effects for CVC targets (note: not for CV targets as only in 25% this was the case) are due to participants *strategically using this relationship*. However, a widely held notion is that effects in the Stroop/PWI task are *unintentional and uncontrollable* (i.e., effects appear even when they are detrimental to performance, e.g., Moors & De Houwer, 2006). In addition, J. I. Han and Verdonschot (2019) obtained the same result (i.e., same syllable = resyllabification = coda change) using masked priming in which participants did not consciously see the primes (and would not have been able to use a strategy), so we believe that a strategic effect is unlikely to be at play.

The absence of a statistically significant onset effect in the present picture–word interference task contrasts with the finding of a statistically significant onset effect by J. I. Han and Verdonschot (2019) using the phonological Stroop task. As the analysis method was slightly different in the two studies (Han and Verdonschot analysed the raw

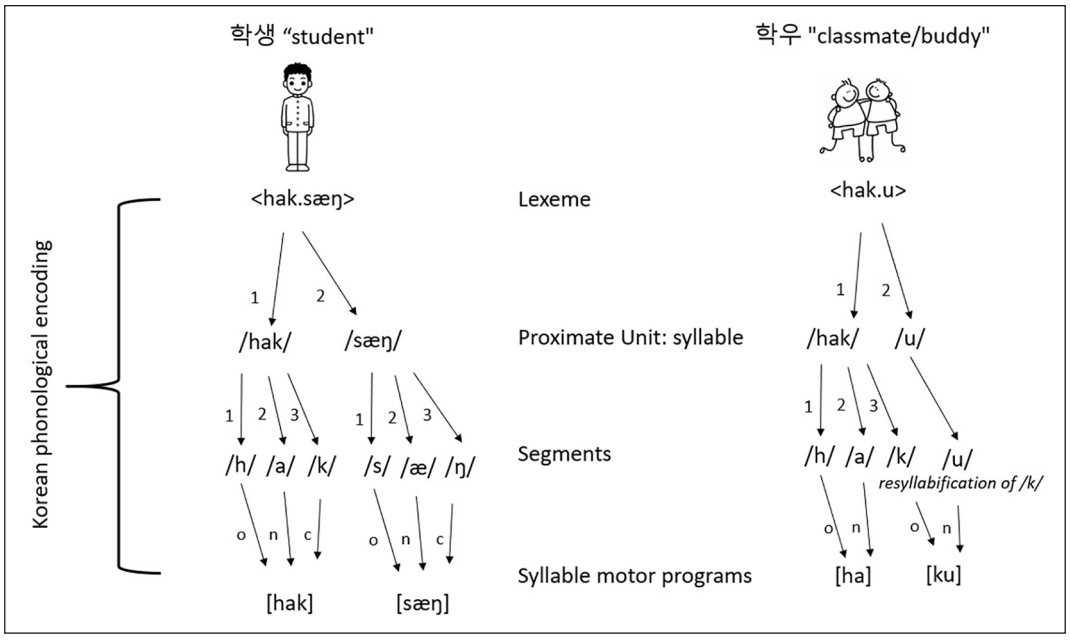

Figure 1. Proposed form encoding network for Korean.

RTs and trimmed RTs slower than 700 ms), we reanalyzed their data using the present analysis method using log-transformed RT as the dependent variable. This did not change the outcome and again yielded a significant onset effect ($t = -4.479, B = -0.033420, SE = 0.007461, p < .001$). Moreover, the Bayes factor for Han and Verdonschot's onset effect was 23, indicating strong support for the presence of the onset effect in their study. Thus, there is a true discrepancy between J. I. Han and Verdonschot's (2019) Experiment 2 and the present experiments. This is all the more surprising, given that the two studies used similar tasks—the phonological Stroop task and the PWI task, both of which involve to-be-named targets (i.e., colours and pictures) whose name must be retrieved conceptually—with both studies involving two-character Hangul non-word distractors.

A possible interpretation of the "discrepancy," however, is that it is not genuine; in fact, there does not seem to be even a quantitative difference between the two studies. The onset effect observed here ranged from −9 to 15 ms (−9 ms for the CVC targets and 15 ms for the CV targets in Experiment 1; 14 ms for the CVC targets and −2 ms for the CV targets in Experiment 2), while the onset effect found in J. I. Han and Verdonschot's (2019) phonological Stroop task using CV targets was 14 ms. Also across the studies we reviewed in the "Introduction" section, the onset effect was variable, that is, of the studies using the masked-priming read-aloud task, Kim and Davis (2002) found a non-significant 7 ms effect; Witzel et al. (2013) found a statistically significant 9 ms effect; and J. I. Han and Verdonschot (2019, Experiment 1) found a statistically significant 19 ms effect. J. I. Han and Choi (2016) used the implicit priming task and found a statistically non-significant 11 ms onset overlap effect, and they noted that the effect varied across blocks of trials. A reasonable summary of all the studies taken together would be that the onset effect in Korean speech production seems to be small and not robust.

One last, and important, avenue we would like to pursue is to theorise on how phonological encoding takes place in Korean.[6] Currently, comprehensive form encoding networks have been laid out for English/Dutch, Chinese, and Japanese (see Roelofs, 2015) but do not exist for Korean yet. In all these languages, the phonological encoding process consists of two parts (i.e., the "frame" and the "units"). Both the frame and units differ in the various languages, with the frame containing stress (English/Dutch), tonal (Chinese), or pitch accent (Japanese) information with the proximate unit being the phoneme (English/Dutch), syllable (Chinese) or mora (Japanese).

However, contrary to other languages, we would like to suggest that the Korean form network likely does not require any "frames" to be activated as Korean does not have stress, tone, or pitch accent. Therefore, no such information needs to be reconciled with any phonological unit as a first step. Note that the absence/presence of frames in Korean phonological encoding has not been explicitly investigated yet (as far as we know) and is subject to additional experimentation needed to verify this claim. Second, given our current findings, we propose the activation of proximate syllables followed by phonemic segments which, *unlike Chinese*, do not have their final positions assigned yet due to the presence of phonological processes such as resyllabification. Finally, syllabified motor programmes are created, which adhere to Korean phonological rules. Figure 1 illustrates the

prospective form network for a non-resyllabified word such as 학생 /hak.sæŋ/ [hak.s'æŋ] "student" and a resyllabified word such as 학우 /hak.u/ [ha.ku] "classmate/buddy." Note that /hak.u/ (a Sino-Korean word) does not initially activate the syllables /ha/ (and /ku/) as a proximate unit as /hak/ is a separately stored morpheme meaning "learning." Given the available experimental evidence up to this point, we conclude that the initial stage of Korean phonological encoding reserves an important role for the syllable. It seems that the initial unit used in phonological encoding in Korean is different from Germanic languages such as English and Dutch, but also from Japanese, and potential similarities and differences to Chinese need to be investigated in future research.

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Supplementary material

The supplementary material is available at: qjep.sagepub.com

Notes

1. This does not mean that phonemes are not engaged during Chinese and Japanese phonological encoding; the proximate unit only refers to the *initially* selected unit in this process (see Chen et al., 2016; O'Séaghdha, 2015; Roelofs, 2015).
2. Note that word-internal resyllabifications, like cross-lexical item resyllabifications, are also assumed to occur during prosodification (see Levelt et al., 1999).
3. We thank an anonymous reviewer for pointing this out to us.
4. We note in this regard that in Kinoshita's (2000) masked-priming read-aloud experiment, the benefit due to the overlap of an onset segment (e.g., suf-SIB) did not differ statistically from the benefit due to the overlap of the initial consonant-vowel (CV) (sif-SIB).
5. It should be noted that French is a syllable-timed language and Dutch and English are a stress-timed language, and the absence of syllable priming effect in these languages was initially attributed to this cross-language difference in speech rhythm. Korean is considered to lie between stress-timed and syllable-timed languages (Mok & Lee, 2008).
6. The authors would like to thank Ardi Roelofs for his insightful discussion on this issue.

References

Baayen, R. H. (2008). *Analyzing linguistic data: A practical introduction to statistics using R*. Cambridge University Press.

Bates, D. M., Maechler, M., Bolker, B., & Walker, (2015). Fitting Linear Mixed-Effects Models Using lme4. *Journal of Statistical Software*, *67*(1), 1–48.

Bock, K. (1991). A sketchbook of production problems. *Journal of Psycholinguistic Research*, *20*(3), 141–160.

Brand, M., Rey, A., & Peereman, R. (2003). Where is the syllable priming effect in visual word recognition? *Journal of Memory and Language*, *48*, 435–443.

Caramazza, A. (1997). How many levels of processing are there in lexical access? *Cognitive Neuropsychology*, *14*(1), 177–208.

Chen, J. Y. (1993). A small corpus of speech errors in Mandarin Chinese and their classification. *World of Chinese Language*, *69*, 26–41.

Chen, J. Y., Chen, T.-M., & Dell, G. S. (2002). Word-form encoding in Mandarin Chinese as assessed by the implicit priming task. *Journal of Memory and Language*, *46*, 751–781.

Chen, J. Y., O'Séaghdha, P. G., & Chen, T. M. (2016). The primacy of abstract syllables in Chinese word production. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *42*(5), 825.

Coltheart, M., Woollams, A., Kinoshita, S., & Perry, C. (1999). A position-sensitive Stroop effect: Further evidence for a left-to-right component in print-to-speech conversion. *Psychonomic Bulletin & Review*, *6*, 456–463.

Dell, G. S. (1986). A spreading-activation theory of retrieval in sentence production. *Psychological Review*, *93*(3), 283.

Dell, G. S. (1995). Speaking and misspeaking. *An Invitation to Cognitive Science*, *1*, 183–208.

Dienes, Z. (2014). Using Bayes to get the most out of non-significant results. *Frontiers in Psychology*, *5*, 781.

Ferrand, L., Segui, J., & Grainger, J. (1996). Masked priming of word and picture naming: The role of syllabic units. *Journal of Memory and Language*, *35*, 708–723.

Forster, K. I., & Davis, C. (1991). The density constraint on form- priming in the naming task: Interference effects from a masked prime. *Journal of Memory & Language*, *30*, 1–25.

Han, J. I., & Choi, T. H. (2016). The proximate unit in the production of Korean words. *Studies in Phonetics, Phonology and Morphology*, *22*, 383–398.

Han, J. I., Oh, J., & Kim, J.-Y. (2019). Slips of the tongue in the Seoul Korean corpus of spontaneous speech. *Lingua*, *220*, 31–42.

Han, J. I., & Verdonschot, R. G. (2019). Spoken-word production in Korean: A non-word masked priming and phonological Stroop task investigation. *Quarterly Journal of Experimental Psychology*, *72*, 901–912.

Jeffreys, H. (1961). *Theory of probability* (3rd ed.). Oxford University Press; Clarendon Press.

Kim, J., & Davis, C. (2002). Using Korean to investigate phonological priming effects without the influence of orthography. *Language and Cognitive Processes*, *17*, 569–591.

Kinoshita, S. (2000). The left-to-right nature of the masked onset priming effect in naming. *Psychonomic Bulletin & Review*, *7*(1), 133–141.

Kinoshita, S., & Mills, L. (2020). Phonological encoding in the oral but not manual Stroop task: Evidence for the role of a speech production process. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *46*(8), 1494–1504.

Kinoshita, S., & Verdonschot, R. G. (2020). Phonological encoding is free from orthographic influence: Evidence from a picture variant of the phonological Stroop task. *Psychological Research*. Advance online publication. doi: 10.1007/s00426-020-01315-2

Koester, D., & Schiller, N. O. (2008). Morphological priming in overt language production: Electrophysiological evidence from Dutch. *NeuroImage*, *42*, 1622–1630.

Kubozono, H. (1989). The mora and syllable structure in Japanese: Evidence from speech errors. *Language and Speech*, *32*(3), 249–278.

Kureta, Y., Fushimi, T., & Tatsumi, I. F. (2006). The functional unit of phonological encoding: Evidence for moraic representation in native Japanese speakers. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *32*, 1102–1119.

Kuznetsova, A., Brockhoff, P. B., & Christensen, R. H. B. (2018). *lmerTest: Tests in linear mixed effects models* (Version, 3.0–1). http://CRAN.R–project.org/package=lmerTest

Lee, C. H., & Taft, M. (2009). Are onsets and codas important in processing letter position? A comparison of TL effects in English and Korean. *Journal of Memory and Language*, *60*(4), 530–542.

Levelt, W. J., Roelofs, A., & Meyer, A. S. (1999). A theory of lexical access in speech production. *Behavioral and Brain Sciences*, *22*(1), 1–38.

Mok, P. P. K., & Lee, S. I. (2008). *Korean speech rhythm using rhythmic measures*. Paper presented at the 18th International Congress of Linguists (CIL18). Seoul, South Korea. http://ling.cuhk.edu.hk/people/peggy/Mok&Lee_CIL18.pdf

Moors, A., & De Houwer, J. (2006). Automaticity: A theoretical and conceptual analysis. *Psychological Bulletin*, *132*(2), 297.

Morey, R. D., & Rouder, J. N. (2018). *BayesFactor: Computation of Bayes factors for common designs* (R package version 0.9.12-4.1). https://rdrr.io/rforge/BayesFactor/

O'Séaghdha, P. G. (2015). Across the great divide: Proximate units at the lexical-phonological interface. *Japanese Psychological Research*, *57*(1), 4–21.

O'Séaghdha, P. G., Chen, J. Y., & Chen, T. M. (2010). Proximate units in word production: Phonological encoding begins with syllables in Mandarin Chinese but with segments in English. *Cognition*, *115*(2), 282–302.

O'Séaghdha, P. G., & Frazer, A. K. (2014). The exception does not rule: Attention constrains form preparation in word production. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *40*(3), 797–810.

R Core Team. (2018). *R: A language and environment for statistical computing*. http://www.R-project.org/

Roelofs, A. (1996.). Serial order in planning the production of successive morphemes of a word. *Journal of Memory and Language*, *35*, 854–876.

Roelofs, A. (2015). Modeling of phonological encoding in spoken word production: From Germanic languages to Mandarin Chinese and Japanese. *Japanese Psychological Research*, *57*, 22–37.

Schiller, N. O. (1998). The effect of visually masked syllable primes on the naming latencies of words and pictures. *Journal of Memory and Language*, *39*, 484–507.

Schiller, N. O. (1999). Masked syllable priming of English nouns. *Brain and Language*, *68*, 300–305.

Sohn, H. S. (1987). *Underspecification in Korean phonology* [Doctoral dissertation]. University of Illinois, Urbana-Champaign.

Spapé, M. M., Verdonschot, R. G., & van Steenbergen, H. (2019). *The E-Primer: An introduction to creating psychological experiments in E-Prime* (2nd ed., Updated for E-prime 3). Leiden University Press. http://www.e-primer.com

Taylor, I. (1980). The Korean writing system: An alphabet? A syllabary? A logography?. In P. A. Kolers, M. E. Wrolstad, H. Bouma (Eds.), *Processing of visible language* (pp. 67–82). Springer.

Taylor, I., & Taylor, M. M. (2014). *Writing and literacy in Chinese, Korean and Japanese: Revised edition* (Vol. 14). John Benjamins Publishing Company.

van Casteren, M., & Davis, M. H. (2006). Mix, a program for pseudorandomization. *Behavior Research Methods*, *38*(4), 584–589.

Verdonschot, R. G., & Kinoshita, S. (2018). Mora or more? The phonological unit of Japanese word production in the Stroop color naming task. *Memory & Cognition*, *46*, 410–425.

Verdonschot, R. G., Kiyama, S., Tamaoka, K., Kinoshita, S., La Heij, W., & Schiller, N. O. (2011). The functional unit of Japanese word naming: Evidence from masked priming. *Journal of Experimental Psychology: Learning, Memory and Cognition*, *37*, 1458–1473.

Witzel, N., Witzel, J., & Choi, Y. (2013). The locus of the masked onset priming effect: Evidence from Korean. *The Mental Lexicon*, *8*, 339–352.

Won, K. H. (1987). *Igosi Hangul ida [This is Hangul]*. Samchungdang.

Yun, W., Yoon, K., Park, S., Lee, J., Cho, S., Kang, D., . . . Kim, J. (2015). The Korean corpus of spontaneous speech. *Journal of the Korean Society of Speech Sciences*, *7*(2), 103–109.

Zwitserlood, P., Bölte, J., & Dohmes, P. (2000). Morphological effects on speech production: Evidence from picture naming. *Language and Cognitive Processes*, *15*, 563–591.