Universal and cross-linguistic gender-based sound symbolism in Korean given names

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1 Introduction

Sound symbolism is the idea that meaning in spoken language can be encoded at a submorphemic level. This presents a challenge to the notion that morphemes are the smallest meaningful units in language, as well as the traditional view in linguistics that the association between form and meaning (at least at the phonological level) is always arbitrary (de Saussure, 1916; Hockett, 1960). While such a view does acknowledge the presence of some sound symbolic phenomena, such as onomatopoeia (Svantesson, 2017), these were considered minor and inconsequential. Recent research in the area of sound symbolism has argued that it is more pervasive than previously assumed (Monaghan, Shillcock, Christiansen, & Kirby, 2014; Sidhu & Pexman, 2015, 2018; Svantesson, 2017). For example, some research has shown that sound symbolic patterns show up in certain areas of vocabulary such as given names (Ananthathurai et al., 2019; Cassidy, Kelly, & Sharoni, 1999; Cutler, Mcqueen, & Robinson, 1990; MacAuley, Siddiqi, & Toivonen, 2018; Mohsin, Sullivan, & Kang, 2019; Mutsukawa, 2016; Sidhu & Pexman, 2015; Shinohara & Kawahara, 2013; Slater & Feinman, 1985; Starr, Yu, & Shih, 2018; Sullivan, 2018; Wong & Kang, 2019; Wright, Hay, & Bent, 2005), character names (Kawahara, Noto, & Kumagai, 2018; Shih et al., 2019; Starr et al., 2018; Sutton, 2016), animal names (Berlin, 1994) and brand names (Abel & Glinert, 2008; Klink & Wu, 2014; Shrum, Lowrey, Luna, Lerman, & Liu, 2012) while other work has focused on integrating sound symbolism with mainstream phonology in the form of proposals about how sound symbolism can be integrated into Optimality Theoretic frameworks (Alderete & Kochetov, 2017; Kawahara, Katsuda, & Kumagai, 2019).

Similarly, sign languages may display cross-linguistic iconicity at a phonological level (Östling, Börstell, & Courtaux, 2018; Perniss, Thompson, & Vigliocco, 2010). While sign languages display extensive iconicity at the level of the sign, they also display arbitrariness in that not all signs are iconic, and even when they are, the choice of sign is arbitrary in the sense that it is language specific. That is, one language may use one iconic representation of a meaning while another language uses a different one. Despite this, there is some evidence that, as with sound symbolic patterns, iconicity may be encoded in phonological elements of signs such as the number of articulators used and location of the signs (Östling et al., 2018).

Much of this sound symbolism research focuses on gradient patterns that have been proposed to be universal, such as size-symbolism (Newman, 1933; Ohala, 1984, 2004; Sapir, 1929; Tanz, 1971) and shape symbolism (Köhler, 1929; Maurer, Pathman, & Mondloch, 2006; Nielsen & Rendall, 2011; Westbury, 2005), or on examining whether or not patterns are universal (Lapolla, 1994; Shinohara & Kawahara, 2010; Shrum et al., 2012; Tzeng, Nygaard, & Namy, 2017). For example, in the vowel height and backness patterns (Newman, 1933; Sapir, 1929), high vowels (e.g. /i u/) and front vowels (e.g. /i e/) are associated with smallness, whereas low vowels (e.g. /æ ɑ/) and back vowels (e.g. /u o/) are associated with largeness, amongst other meanings. This has been proposed to be universal for acoustic reasons – higher and more front vowels result in a smaller oral cavity than lower and more back vowels (Ohala, 1984, 2004). This proposal is supported by experimental nonce word studies in multiple languages in which the target sound symbolic pattern is manipulated and participants are asked to associate the nonce words with the meanings associated with the target pattern (see, for example, Shinohara and Kawahara (2010), Sapir (1929) and Newman (1933)).

In addition to being found in experimental nonce word studies, sound symbolic patterns, such as the vowel height and backness patterns, have also been found in corpus (and experimental) studies of animal names, brand names, character names and given names. In the realm of animal names, Berlin (1994) has found that bird names in four unrelated south and central American languages (Huambisa, Wyampí, Apalái and Tzeltal) tend to have more high and/or front vowels than fish names, and furthermore, within bird and fish names, those of smaller birds and fish have more high and/or front vowels than larger birds and fish. In the realm of brand names, studies of real and nonce brand names (Abel & Glinert, 2008; Klink & Wu, 2014; Shrum et al., 2012) show that sound symbolism which matches or contradicts the desirable traits of a product influences consumers' perception of that product and may influence purchasing decisions. Findings in Pokémon names are more mixed (Shih et al., 2019), vowel quality is correlated with size in English, but not in Russian or Japanese. In Korean and Cantonese, vowel height-size patterns emerge, but they are not in the expected direction. (Shih et al., 2019) argue that this is because of an interaction of universal and language-specific factors.

In given names, at least in English, female names tend to contain more high and/or front vowels (Cutler et al., 1990; Sullivan, 2018; Wright et al., 2005). Given names present an interesting case study for sound symbolism as they necessarily encode binary gender information (setting aside gender neutral names and other issues, though see Cassidy et al. (1999) for an analysis of gender neutral names in English) and they differ across languages. In the first case, this could help with the identification of sound symbolic patterns that are either directly or indirectly related to gender. That is, patterns that directly encode gender, or those that encode some other meaning which itself has an association with gender (e.g. /i/ is smaller and smaller is more female, so female names have more /i/ than male names). In the second case, this allows for an exploration of how cross-linguistic these sound symbolic patterns are. Do the patterns show up across multiple languages in corpus studies? Do speakers of different languages use the same patterns when assigning gender to nonce names?

The current study seeks to address these questions by looking at sound symbolic patterns in Korean names and then assessing how speakers of English and Korean use those patterns in a "name-gendering" experiment. Korean is an ideal language for addressing these questions as it has language-specific sound symbolic patterns in its consonants (obstruent type) and vowels (dark/light vowels) (Sohn, 1999) that are not present in English. Amongst the meanings found in these sound symbolic patterns are those such as size, which may be associated with particular genders (i.e. smallness being associated with females and largeness with males). These patterns are described in more detail in Section 3. Whether or not these patterns are mirrored in gender-sound correspondences in real names will reveal if they are active in the Korean name lexicon and Korean speakers' minds. The experiment will also reveal how English speakers assign gender to Korean nonce names. Do they make use of the patterns tested, and in particular, what do they do when the Korean language-specific patterns are manipulated?

Section 2 provides an overview of the sound symbolic patterns found in a selection of previous studies covering Armenian, Cantonese, English, French, Japanese, Kutchi and Urdu given names. An overview of relevant Korean phonology and language-specific sound symbolic patterns can be found in section 3. Section 4 outlines the corpus analysis of Korean given names, including the target factors, methods, results and discussion. Section 5 outlines a second corpus analysis in which English and Korean given names are evaluated for two of the target factors for the experiment. The primary purpose of this analysis is to ensure that the patterns from the larger corpus studies hold for the manipulations being used in the experiment. It also provides a more direct comparison of the different obstruent types than was possible in the first corpus analysis. The name gendering experiment is outlined and discussed in Section 6. Finally, the paper concludes in Section 7 with a discussion of the implications of the findings and directions for future research.

2 Sound Symbolic Patterns in Given Names

Much of the work done on sound symbolic patterns in given names has been on English (Cassidy et al., 1999; Cutler et al., 1990; MacAuley et al., 2018; Sidhu & Pexman, 2015, 2019; Slater & Feinman, 1985; Sullivan, 2018; Sullivan & Kang, 2019; Wright et al., 2005), though more recent work has also looked at Armenian (Ananthathurai et al., 2019), Cantonese (Starr et al., 2018; Wong & Kang, 2019, 2020), French (Sidhu, Pexman, & Saint-Aubin, 2016; Sullivan, 2018), Japanese (Mutsukawa, 2016; Shinohara & Kawahara, 2013), Kutchi (Ananthathurai et al., 2019) and Urdu (Mohsin et al., 2019). The types of patterns investigated can be broadly categorized into suprasegmental patterns (length, weight, tone, stress), positional patterns, vowel patterns and consonant patterns. Below I summarize the findings of studies by Ananthathurai et al. (2019), Mohsin et al. (2019), Mutsukawa (2016), Sullivan (2018) and Wong and Kang (2019) and outline expectations based on previous English studies (Cassidy et al., 1999; Cutler et al., 1990; Sidhu & Pexman, 2015; Slater & Feinman, 1985; Wright et al., 2005), language-specific patterns (e.g. the distribution of French nasal vowels in adjectives based on grammatical gender) or sound symbolic patterns. A summary of the results can be found in Table 1.

Suprasegmental patterns related to length (in syllables, segments or moras), syllable weight/closure, stress and tone. In terms of length, female names were predicted to be longer than male names. In English, French and Urdu, female names were longer than male names. In contrast, male names are longer than female names in Kutchi and Japanese. Length is not predictive of gender in Armenian and is not a factor in Wong and Kang (2019)'s Cantonese study (though Starr et al. (2018) found that monosyllabic names were more likely to be male than female, consistent with the pattern in the majority of the other languages). In terms of weight, male names are expected to have more heavy or closed syllables than female names. This factor was not assessed in Armenian and Kutchi, however, the presence of closed or heavy syllables was associated with maleness in all the other languages. In addition to length and weight, stress was investigated in English and tone height in Cantonese. In English, stress was, as expected, more likely to be initial, regardless of gender, but if it was non-initial, the name was more likely to be female. In Cantonese, contrary to the expectation that high tone would occur more often in female names, it was associated with maleness. This may be due to the fact that it was

Table 1: Summary of the results of previous corpus analyses of English (ENG), French (FRN), Armenian (ARM), Kutchi (KUT), Urdu (URD), Cantonese (CAN) and Japanese (JPN) by factor. (See Section 2 for references.) The final column indicates the percentage of languages tested which displayed the expected pattern, with the opposite pattern in brackets, for all factors that were tested in more than one language. Legend: ✓– trend in the expected direction; X – trend in the opposite direction, NA – not investigated to my knowledge

	ENG	**FRN**	**ARM**	**KUT**	**URD**	**CAN**	**JPN**	**%**
Length	✓	✓		X	✓	NA	X	50% (33%)
Syllable Weight	✓	✓	NA	NA	✓	✓	✓	100%
Initial Open Syllable	✓		✓		NA	✓		50%
Final Open Syllable	✓	✓	✓	✓	NA	✓		83%
Initial Vowel		✓	✓	X	NA	NA	✓	60% (20%)
Vowel Height	✓		✓	X	NA	✓	NA	60% (20%)
Vowel Backness	✓		✓			✓	NA	50%
Vowel Roundness	NA	NA	NA	NA	NA	X✓	NA	
Vowel Nazalization	NA	✓	NA	NA	NA	NA	NA	
Sonorancy		✓	✓		✓	✓	NA	67%
Coronal Place	NA	NA	NA	NA	NA	✓	NA	
Stress	✓	NA	NA	NA	NA	NA	NA	
Tone Height	NA	NA	NA	NA	NA	X	NA	

associated with falling tone.

Positional patterns are related to the syllable type of the initial or final syllable, as well as the initial segment's type (consonant or vowel). Female names were predicted to be more likely to begin or end with a vowel or open syllable. These factors were not investigated in Urdu. Onsetless (vowel-initial) initial syllables are more likely to be female in French and Japenese whereas those with an onset (consonant initial) are more likely to be female in Kutchi. This pattern was not a significant predictor in Armenian or English. An open initial syllable was more likely to be female in English, Armenian and Cantonese. This was not a significant predictor in French, Kutchi or Japanese. Final syllables were predictive of femaleness in all languages except Japanese where it was not a significant predictor.

Vowel patterns relate to vowel height, backness, roundness and nasalization. Female names are predicted to contain more likely to contain high and/or front vowels. Rounding patterns are less clear, though given that back vowels are round and rounding lowers F2, rounding may be associated with maleness, consistent with the frequency code hypothesis (Ohala, 1984, 2004). To my knowledge, these factors were not investigated in Japanese.

In terms of height, high vowels are predictive of femaleness in English, Armenian and Cantonese. In Kutchi, the pattern was opposite with high vowels predicting maleness. This factor was not investigated in Urdu and was not a significant predictor in French. In terms of backness, front vowels are predictive of femaleness in English, Armenian and Cantonese. It was not predictive in French, Kutchi or Urdu. Vowel rounding in Cantonese was predictive of femaleness on the first syllable, but maleness on the second syllable. The presence of nasal vowels in French was found to be predictive of maleness. Nasalization was tested in French only and expected to be associated with maleness, given that such a pattern exists in the French lexicon (e.g adjectives have male and female endings based on the gender of the noun they modify: when an adjective ends in an /n/, the female version contains an oral vowel and the nasal as in *bonne* /bɔn/ 'good (F)', whereas the male version contains a nasal vowel, as in *bon* /bɔ̃/ 'good (M)')

Consonant patterns primarily investigate sonorancy by contrasting sonorants with obstruents. Female names were expected to contain more sonorant consonants than male names. More sonorous consonants are associated with femaleness in French, Armenian, Urdu and Cantonese. Sonorancy was not predictive of gender in English in Sullivan (2018), but was found to be a factor in Sidhu and Pexman (2015). This factor was not predictive of gender in Kutchi and it is not clear if it was investigated in Japanese. Place was also investigated in Cantonese, with coronals being predictive of femaleness in all positions except the initial syllable onset were it was predictive of maleness.

Table 1 shows the percentage of languages tested for each pattern in which that pattern was present in the expected direction and, in parentheses, the percentage of those in which it was present in the opposite direction. The remaining percentage reflects the proportion of tested languages in which the pattern was not a factor. These percentages were only calculated for factors which were tested on at least two languages. Overall, these results indicated that the sound symbolic tendencies tend to be stochastic in nature. For all factors tested, no less than 50% of the languages tested show significant effects in the expected direction and always outnumber the languages with significant effects in the opposite direction.

The final syllable type factor is interesting because the only language it doesn't occur in is Japanese, where restrictions on the syllable coda mean that nasals, which also tend to be more female, are the only consonants which could appear in this position (Labrune, 2012). Thus, it appears that in this case, language specific factors may prevent this pattern from being realized, even if it is universal. Another language in which a language-specific pattern may override a potentially universal pattern is Korean where the dark-light sound symbolic pattern runs somewhat contrary to the proposed universal height pattern (K.-

O. Kim, 1977; Larsen & Heinz, 2012). Investigating Korean also adds another language to those whose given names have been analyzed for sound symbolic patterns.

3 Korean Phonology and Sound Symbolic Patterns

Korean presents a good opportunity to investigate sound symbolism in given names for a couple of reasons. First, Korean is a language isolate and is therefore unrelated to other languages, particularly English (Dryer & Haspelmath, 2020). Korean names, however, are not unrelated to Cantonese names as they are formed with Sino-Korean characters (ancient borrowings from Chinese) (Sohn, 2006), thus it is possible there may be similarities between the two languages based on their etymological relation. Second, Korean has a language-specific sound symbolic lexicon in which two phonological sound symbolic patterns – a dark/light vowel pattern and an obstruent type pattern – are present (Cho, 2006; K.-O. Kim, 1977; Sohn, 1999). In the vowel pattern, dark (higher) vowels /e y ə u/ are associated with largeness, amongst other meanings, and light (lower) vowels /ɛ ø a o/, with smallness. In the obstruent type pattern, fortis, lenis and aspirated obstruents are associated with different meanings. These patterns and their associated meanings are described in more detail in Section 3.2. It will be interesting to see if these language-specific patterns, in which the associated meanings may be related to gender, are found in real Korean given names. Furthermore, the dark-light pattern runs somewhat contrary to the proposed universal vowel height pattern (Larsen & Heinz, 2012), which presents an opportunity to explore the interaction of cross-linguistic and language-specific phenomena.

3.1 Sounds and Phonetic Processes in Korean

Korean has 10 monophthongs, 6 diphthongs with /j/ on-glides, 4 diphthongs with /w/ on-glides and one diphthong with a /j/ offglide (following certain consonants) as outlined in Table 2 (Sohn, 1999). The front round vowels /y/ and /ø/ are often realized as diphthongs (/wi/ and /we/) in most dialects. There is also a merger between /e/ and /ɛ/ for younger speakers and /je/ and /jɛ/ may be realized as monophthongs following certain consonants. The diphthong /ɨj/ is realized as /i/ by most speakers.

Korean has bilabial, alveolar and velar stops and nasals, alveolar and glottal fricatives, palatal affricates and an alveolar lateral approximant, as outlined in Table 3 (Sohn, 1999). Stops, fricatives and affricates may be lenis, fortis, or aspirated. The difference between the stops is characterized by a combination of voice onset time (VOT) and fun-

Table 2: South Korean Vowels - All monophthongs are possible. Glides in brackets represents on/off-glides for the possible diphthongs.

	Front		Central	Back
High	i	y	ɨ(j)	(j)u
Mid	(w/j)e	ø	(w/j)ə	(j)o
Low	(w/j)ɛ		(w/j)a	

damental frequency (F0). Historically, aspirated stops had high VOT and F0, lenis stops had medium VOT and low F0 and fortis stops had low VOT and medium-high F0 (Kim-Renaud, 1974; C.-W. Kim, 1965). More recently, lenis and aspirated stops have been merging in VOT in Seoul Korean, resulting in them being distinguished primarily by F0 rather than VOT (Silva, 2002).

Table 3: South Korean Consonants - Stops, fricatives and affricates may be lenis (single symbol), fortis (double symbol) or aspirated (symbol with superscript h)

	Bilabial	Alveolar	Palatal	Velar	Glottal
Stops	p pp p^h	t tt t^h		k kk k^h	
Nasals	m	n		ŋ	
Fricatives		s ss			h
Affricates			c cc c^h		
Approximates		l			

The phonetic processes relevant to the current study include /n, l/-shifting, nasalization, tensification, palatalization, /h/ aspiration, coda neutralization and resyllabification (Sohn, 1999). /n,l/-shifting occurs at a syllable boundary where the first syllable ends in a nasal or an obstruent and the second syllable begins with /l/. The obstruents either assimilates to the /l/ (e.g. /nonli/ 'logic' becomes [nolli], Sohn (1999, p. 169)) or the /l/ nasalizes (e.g. /caplok/ 'miscellany' becomes [camnok], Sohn (1999, p. 169)). Nasalization occurs when a consonant followed by a nasal becomes nasal (e.g. /hakmun/ 'learning' becomes [haŋmun] Sohn (1999, p. 173)). Tensification occurs when two obstruents are adjacent and the second obstruent becomes tense (e.g. /capci/ 'magazine' becomes [capcci], Sohn (1999, p. 173)). Palatalization occurs when an alveolar stop is followed by /i/ or /j/ and it palatalizes (e.g. /kat^hi/ 'together' becomes [kac^hi], Sohn (1999, p. 174). /h/ aspiration occurs when a lenis stop is followed by /h/ and they combine to form an aspirated stop (e.g. /pathita/ 'supply' becomes [pac^hida], Sohn (1999, p. 166)). Obstruents in coda position neutralize to the lenis stop at their place of articulation

(/h/ and the palatal affricates neutralize to /t/, e.g. /nath/ ‘piece, unit’ and /nac^{h}/ ’‘ace’ both become [nat], Sohn (1999, p. 165)).

3.2 Consonant and Vowel Patterns in the Korean Sound Symbolic Vocabulary

Korean has a sound symbolic vocabulary in which certain vowels and consonants convey specific meanings (Cho, 2006; K.-O. Kim, 1977; Sohn, 1999). These sound symbolic patterns don’t extend to the rest of the Korean lexicon, however there is a dark (/e y ə u/)–light (/ɛ ø a o/) verbal vowel harmony pattern which matches part of the sound symbolic pattern (/a/ and /o/, but not /ɛ/ and /ø/ are considered light vowels in verbal harmony (Larsen & Heinz, 2012; Sohn, 1999). For example, the plain imperative suffix is realized as /–ala/ when then preceding vowel is /a/ or /o/ (e.g. /cap-ala/ ‘catch (it)!’) and as /–əla/ elsewere (e.g. /ttwi-əla/ ‘Jump!’) (Sohn, 1999, p. 182). If these patterns extend to Korean names, and speakers use them to assign gender to names, it could suggest the patterns are more salient than previously assumed.

The different types of obstruents can convey different sound symbolic meanings (Sohn, 1999). Lenis obstruents /p t k s c h/ are associated with slowness, gentleness, heaviness and bigness. Fortis obstruents /pp tt kk ss cc/ are associated with compactness, hardness, tightness, smallness and extra swiftness. Aspirated obstruents /p^{h} t^{h} k^{h} c^{h}/ are associated with flexibility, elasticity, crispness and swiftness. The size related associations in this data suggest that lenis obstruents should be associated more with maleness and fortis with femaleness. However, if the acoustic properties are considered, aspirated and fortis obstruents are both more intense than lenis obstruents (K.-O. Kim, 1977; Sohn, 1999), suggesting they may be associated more with maleness. Furthermore, fortis and aspirated stops induces high F0 on the following vowel which would create a stable or falling tone in the accentual phrase, rather than a rising tone (Jun, 1993). Following Wong and Kang (2019), where they found that, in Cantonese, falling contours across syllables are more frequent in male names and rising contours across syllables are more frequent in female names so fortis and aspirated obstruents in Korean may be more associated with maleness than lenis obstruents, though if height, rather than contour, is a factor in Korean, the opposite might be true. Given these conflicting possibilities, it is not clear how the different stops may relate to each other in terms of gender, though the acoustic properties of the stops seem to suggest fortis and aspirated are more male than lenis ones.

The dark-light vowel pattern divides the vowels up into three categories (light, dark and neutral) based on their height, as shown in Table 4 (Larsen & Heinz, 2012). Korean vowels can be divided into four series based on rounding and backness. Each series is represented by a column in Table 4. The lowest vowel in each series is a light vowel /ɛ ø a o/, the next lowest in the dark vowel /e y ə u/ and the highest, in the three vowel series, is a neutral vowel /i ɨ/. The light vowels are associated with brightness, lightness, thinness, sharpness, smallness and quickness whereas the dark vowels are associated with darkness, dullness, deepness, heaviness, slowness and thickness (Sohn, 1999).[1] The fact that light vowels are associated with smallness and other related adjectives whereas dark vowels are associated with adjectives like heaviness, which are related to largeness, might suggest that names with dark vowels would be associated with maleness and light vowels with femaleness. This pattern runs opposite the proposed universal vowel height pattern (K.-O. Kim, 1977), because higher vowels are associated with smallness and lower vowels with largeness in the height pattern, but it is the lower vowels that are associated with smallness in the Korean pattern. How active the dark-light pattern is for Korean speakers beyond the sound symbolic vocabulary is not clear. Taylor and Taylor (1962) found that speakers rate nonce words with light vowels as smaller than those with dark vowels whereas Lee (2015); Shinohara and Kawahara (2010) found the opposite.[2] Thus, if the dark-light pattern is active beyond the sound symbolic vocabulary, it may be that the height pattern will not hold in the corpus analysis or be used by participants in the name gendering experiment.

Table 4: Dark-Light Sound Symbolism in Korean Vowels

	Front		Central	Back	
High	i	y	ɨ	u	**Neutral**
Mid	e	ø	ə	o	**Dark**
Low	ɛ		a		**Light**

4 Sound Symbolism in a Corpus of Korean Names

In order to assess the presence of gender-based sound symbolic patterns in Korean given names, I analyzed a corpus of male and female Korean given names for the language-

[1] It is not clear where these associations come from, though some have suggested that the verbal vowel harmony pattern results from a historical shift (C.-W. Kim, 1978).

[2] It should be noted that Lee (2015) focuses on the comparison between /i/ and /a/, which compares light vowels with neutral vowels, not dark vowels and Shinohara and Kawahara (2010) focuses on height, not dark/light patterns.

specific patterns (obstruent type and dark-light vowel type) and most of the factors evaluated in other languages (syllable weight, open and final syllable type, initial segment type, vowel height, backness and roundness and consonant sonorancy, but not length, nasal vowels or coronal consonants). In addition, the presence of diphthongs was evaluated, both in terms of comparing the number of monophthongs and diphthongs in a name and comparing the type of diphthong based on whether the glide portion was /w/ or /j/.

For the factors tested in other languages, Korean is hypothesized to have the same patterns as in those languages (Section 2), except, potentially, for vowel height. That is, compared to male names, female names should have more open syllables, front vowels, non-round vowels and sonorant consonants. They should also be more likely to have open initial and final syllables and to begin with a vowel. For diphthongs, if they are heavier than monophthongs, which is not clear in Korean (Sohn, 1999), they may occur more in male names. Within diphthongs, those with /w/-glides should be more likely to be male as /w/ is round and associated with back vowels whereas /j/ is front and associated with /i/, which is more common in female names in English (Cutler et al., 1990; Wright et al., 2005).

For the two Korean-specific factors, vowel type and obstruent type, the predicted patterns are based on the discussion in Section 3. For the dark-light pattern, dark vowels are expected to be more male. As these vowels are higher than light vowels, the height pattern is expected to be either non-existant or reversed if the language specific pattern overrules the more universal one. For the obstruent type factor, all obstruents are expected to be more male than sonorants, though aspirated and/or fortis obstruents may be more male than lenis ones. Each obstruent type is tested separately in this analysis, so no comparisons between obstruent types are made. However comparisons of obstruent types in select positions are made in the analysis in Section 5.

The results and discussion in this section will focus primarily on the syllable type, vowel type (dark-light), vowel height, obstruent type and vowel rounding factors. These factors were chosen as they represent the factor found most commonly across languages (syllable structure), the factors that are specific to Korean and thus are new in this study (vowel and obstruent type) and the factor which was only analysed in Cantonese (rounding). Some other factors will be discussed in less detail. These factors allow the following questions to be addressed: Do Korean names conform to patterns observed in other languages? Do they conform to language-specific patterns, and, if so, how do these patterns interact with universal patterns? Are there similarities between Korean and Cantonese since most Korean names have ancient Chinese origins?

4.1 Data Collection

A corpus of 1944 Korean names was constructed based on the most popular baby names in Korea between 2008 and February 2020 as listed at koreanname.me (Kimkkikki, 2020). Names ranked in the top 1000 for each gender were extracted from the database and names longer than two syllables (4) and one syllable names (54) were removed, leaving 974 female names and 970 male names. The majority of these names were Sino-Korean, though some were pure Korean names (e.g. the one female name with a fortis obstruent) and others were loans from other languages (Yoonjung Kang, p.c.). As it was not always clear if the names were loans or not, all names were included in the analysis. A link to the full list of names can be found in Appendix A.

4.2 Data Coding

The names in the corpus were transcribed in R (R Core Team, 2019) both phonologically using a script based on one developed by Hyong Seok Kwon that converted Hangul orthography to IPA and modified IPA, and phonetically by applying relevant phonological rules to the phonological transcriptions. The IPA was modified for ease of analysis by symbolizing aspirated sounds with capital variants of lenis sounds (i.e. t^h became T) and fortis sounds as their voiced counterpart (or another unused symbol) (i.e. tt became d). All names were coded as being either male or female based on their classification at koreanname.me. Separate analyses were conducted for the full word and each syllable, as well as for the phonetic and phonological analyses, leading to six separate coded datasets. The phonetic versions of names were constructed by applying the processes in Section 3 to the phonological forms. Most of these processes affect the coda of the initial syllable and the onset of the final one.

The full words for both the phonetic and phonological analyses were coded for open syllable count, dark vowel count, light vowel count, front vowel count, back vowel count, high vowel count, low vowel count, round vowel count, diphthong count, /w/-diphthong count, /j/-diphthong count, stop count, sonorant count, lenis obstruent count, fortis obstruent count, and aspirated obstruent count. Details of how these were coded, alongside an example can be found in Table 5.

The initial and final syllables for both the phonetic and phonological analyses were coded for syllable type, initial segment type, vowel type (dark/light/neutral), vowel backness, vowel height, vowel roundness, vowel length/diphthong type, stop count, sonorant count, lenis obstruent count, fortis obstruent count, and aspirated obstruent count. Details of how these were coded, alongside an example can be found in Table 6.

Table 5: Coding criteria for full names

Factor	**Criteria**	**Levels**	**/sa.mi/**
Open Syllable Count	Number of open syllables	0, 1, 2	2
Dark Vowel Count	Number of dark vowels /e y ə u/	0, 1, 2	0
Light Vowel Count	Number of light vowels /ɛ ø a o/	0, 1, 2	1
Front Vowel Count	Number of front vowels /i e ɛ y ø/	0, 1, 2	1
Back Vowel Count	Number of back vowels /u o/	0, 1, 2	0
High Vowel Count	Number of high vowels /i y ɨ u/	0, 1, 2	1
Low Vowel Count	Number of low vowels /ɛ a/	0, 1, 2	1
Round Vowel Count	Number of round vowels /y ø u o/	0, 1, 2	0
Diphthong Count	Number of diphthongs /jV wV ɨj/	0, 1, 2	0
/w/-diphthong Count	Number of diphthongs with /w/ on-glides /wi we wɛ wə wa/	0, 1, 2	0
/j/-diphthong Count	Number of diphthongs with /w/ on-glides /je jɛ jə ja ju jo/ or off-glides /ɨj/	0, 1, 2	0
Stop Count	Number of stops /p ph pp t th tt k kh kk/	0, 1, 2, 3, 4	0
Sonorant Count	Number of sonorants /l m n ŋ/	0, 1, 2, 3, 4	1
Lenis Obstruent Count	Number of lenis obstruents /p t k s c h/	0, 1, 2, 3, 4	1
Fortis Obstruent Count	Number of fortis obstruents /pp tt kk ss cc/	0, 1, 2, 3, 4	0
Aspirated Obstruent Count	Number of aspirated obstruents /ph th kh ch/	0, 1, 2, 3, 4	0

Table 6: Coding criteria for individual syllables

Factor	Criteria	Levels	/sa/
Syllable Type	Syllable is open or closed	Open, Closed	Open
Initial Segment Type	Consonant (C) or Vowel (V)	C, V	C
Vowel Type	Is the vowel dark /e y ə u/, light /ɛ ø a o/ or neutral /i ɨ/?	Neutral, Dark, Light	Light
Vowel Backness	Is the vowel front /i e ɛ y ø/, central /ɨ ə a/ or back/u o/?	Front, Central, Back	Central
Vowel Height	Is the vowel high /i y ɨ u/, mid /e ø ə o/ or low /ɛ a/?	High, Mid, Low	Low
Vowel Roundness	Is the vowel round /y ø u o/ or unround /i e ɛ ɨ ə a/?	Round, Unround	Unround
Vowel Length	Is the vowel a monophthong or a diphthong? If a diphthong, is the glide /j/ or /w/?	Mono, j, w	Mono
Stop Count	Number of stops /p ph pp t th tt k kh kk/	0, 1, 2	0
Sonorant Count	Number of sonorants /l m n ŋ/	0, 1, 2	0
Lenis Obstruent Count	Number of lenis obstruents /p t k s c h/	0, 1, 2	1
Fortis Obstruent Count	Number of fortis obstruents /pp tt kk ss cc/	0, 1, 2	0
Aspirated Obstruent Count	Number of aspirated obstruents /ph th kh ch/	0, 1, 2	0

4.3 Analysis

Separate analyses were conducted for the full name, initial syllable and final syllable for both the phonetic and phonological transcriptions, leading to six separate analyses. For each analysis, three models were constructed: a classification tree (CART analysis), univariate mixed effects logistic regression models for each factor and a multivariate mixed effects logistic regression model. Details of how the models were constructed, as well as variable coding, are described below. All models were constructed in R.

4.3.1 Variable Coding

The variables used in the analyses were gender and the phonological factors in Tables 5 and 6. All variables were coded as factors. Note that the tables represent all possible levels. Coding was based on the actual levels present in a particular analysis. For example, there was only ever at most one fortis consonant in a name and it was always in the final syllable, so this factor was not present in any models for the initial syllable and only had two levels in full word and final syllable analyses, despite having five possible levels.

The variables were centred for the regression analyses. For variables with only two levels (e.g. gender, syllable type), contrast coding was applied such that the lowest number or alphabetically first level was coded as -0.5 and the other as 0.5 (e.g. for syllable type, closed was -0.5 and open was 0.5). For variables with 3 or more levels, Helmert coding was used. For factors with numerical values (e.g. number of sonorants), the first comparison was between 0 and other values (no sonorants, vs any sonorants), and subsequent comparisons were between the lowest number and all higher values (1 vs 2/3, and 2 vs 3, at most). For the vowel factor in the single syllable analyses, three non-numeric levels are used. These are coded for the following comparisons – Vowel Type: Neutral vs. Light/Dark, Light vs. Dark; Vowel Backness: Front vs Back/Central, Back vs Central; Vowel Height: High vs Low/Mid, Low vs Mid; Vowel Length: Monophthong vs Diphthongs, j vs w.

4.3.2 Classification Trees

Classification tree (CART) analyses were conducted to determine which factors were most predictive of name gender. CART analysis generates a decision tree which predicts the response variable based on the predictor variables (Baayen, 2008). Starting with the root node of the tree, the best prediction criterion is determined and used to segment the data present at that node into two sets. This process continues until further splits will not refine the data anymore or there are too few items at the node to make further splits. CART analysis was included because of the large number of variables and the collinearities between them. By dealing with one predictor variable at a time, CART analysis is able to determine if a factor is predictive only at certain levels of another variable (Baayen, 2008).

CART analyses were run with name gender as the response variable and all the variables (as factors) in either Table 5, for the full name, or 6, for the individual syllables, as the predictor variables. The full model was constructed using the *rpart()* function from the rpart package (Therneau & Atkinson, 2018). Each model was trimmed using 10-fold cross-validation (Baayen, 2008) with the *plotcp()* function from the rpart package. The *plotcp()* function plots the size of the tree against its cross-validation error and a dotted line representing one standard error above the mean of the largest possible tree (i.e. the full model). The cost-complexity parameter (cp) of the leftmost point below the dotted line is used to trim the tree using the *prune()* function from the rpart package. This generates the best fit model and the predictor variables included in this model are considered statistically significant.

4.3.3 Univariate Mixed-Effects Logistic Regression Models

Mixed effects univariate logistic regression models were constructed with gender as the response variable and each factor in Table 5, for the full names, and Table 6, for the individual syllables, as the predictor variable. Fortis wasn't included in the analysis of the first syllable as no fortis consonants appeared in this syllable. The models included random intercepts for the first and second syllables to prevent popular syllables from dominating the analysis. In Sino-Korean names, which make up the majority of the corpus, each syllable represents a Chinese character which can carry its own meaning and can occur in multiple names (Sohn, 2006). The first syllable was included for the full name and first syllable models and the second syllable, for the full name and second syllable models. The models were constructed using the *glmer()* function from the lme4 package (Bates, Mächler, Bolker, & Walker, 2015). Significance was determined using the lmerTest package (Kuznetsova, Brockhoff, & Christensen, 2017). Factors were coded as described above.

4.3.4 Multivariate Mixed-Effects Logistic Regression Models

Mixed effects multivariate logistic regression models were constructed with the same structure as the univariate models, except that all the relevant factors were included as predictor variables. As the full models failed to converge, trimmed models were established by AIC (Akaike information criterion) values using a step-up process starting with the model with no predictor variables. Each main effect was added to the model and the model with the lowest AIC value was chosen for the next step, which began with that model and repeated the process (i.e. if the model with syllable type had the lowest AIC value, the model which included that factor as a predictor value was the starting model for the next step and the other factors would be added to that model and the AIC values compared). This process continued until the starting model for the current step yielded the lowest AIC value. In other words, once adding another factor failed to improve the fit of the model based on AIC values. This model was considered the best fit model and used to determine the significance of the predictor variables for this analysis.

4.4 Results

This section presents the results of the phonetic CART and multivariate regression analyses, as well as the univariate analyses for vowel type, vowel height, obstruent type, syllable closure factors and vowel rounding. Summaries of the results of both the phonetic and phonological analyses, as well as links to the complete results, can be found in Appendix A. The only major difference between the phonetic and phonological analyses was the degree to which the presence of aspirated consonants predicted name gender. This effect became prominent in the phonetic analyses and can be explained by the fact that the phonetic rules created more aspirated obstruents and changed many other obstruents to sonorants. The classification trees were generated using the *plot()* and *text()* functions. All other plots were generated using ggplot 2 (Wickham, 2016).

4.4.1 CART Analysis

The CART analysis for the full names (Figure 1) shows that the number of open syllables, the number of round vowels, the number of plain obstruents and the number of aspirated obstruents are significant predictors of Korean name gender. At each point where the tree branches, the factor and levels which determine that branching are shown, with names that meet those criteria being sorted into the left branch and those that do not being sorted into the right one. Each terminal node shows the predicted gender for that node and the number of female/male names sorted to the node. For example, at the first node, the function determines that the best factor for sorting all the data is the number of open syllables. If a names has one or two open syllables, it is more likely to be female and if it has no open syllables, it is more likely to be male. Thus, the names with no open syllables (95 female and 271 male) are sorted to the right branch and the rest are sorted to the left. In the right branch, we get a terminal node as no further sorting of the names at this node will improve the fit of the model. In the left branch, on the other hand, further sorting is necessary, so we get a branching node, this time sorting the names at this node in terms of the number of round vowels.

In all names, those with no open syllables are more likely to be male (e.g. 민준 [min-cun]) while those with at least one are more likely to be female (e.g. 서연 [səjən], 지우 [ciu]). Within names that have at least one open syllable, names with no round vowels are more likely to be female (e.g. 서현 [səhjən]) and those with at least one are more likely to be male (e.g. 서준 [səcun], 도윤 [tojun]). Within names with at least one open syllable and at least one round vowel, names with more than one plain obstruent are more likely to be male (e.g. 하준 [hacun]) while those with one or no plain obstruents are more likely to be female (e.g. 서윤 [səjun], 윤아 [juna]). Within the names with at least one open syllable, at least one round vowel and less than two plain obstruents, names with no aspirated consonants are more likely to be female (e.g. 윤서 [junsə]) while those with at least one are more likely to be male (e.g. 유찬 [juc^{h}an]). The size of these effects is indicated by the length of the vertical lines in the graph. Longer lines correlate with a larger effect. Thus, the number of open syllables and round vowels had the largest effect sizes.

Figure 1: Trimmed CART tree (cp = 0.015) for the full Korean names. The numbers below each terminal node represent the number of female (left) and male (right) names sorted to that node.

The CART analysis for the initial syllable (Figure 2) shows that syllable type, vowel backness and the presence of a stop are significant predictors of Korean name gender. In all names, those with an open initial syllable were more female (e.g. 하은 [haɨn]) while those with a closed initial syllable were more male (e.g. 준서 [cunsə]). Within names with an initial open syllable, those with a central vowel in the initial syllable were more likely to be female (e.g. 하윤 [hajun]) and those with a front or back vowel were more likely to be male (e.g. 시우 [siu], 주원 [cuwən]). Within names with an initial open syllable and a front or back vowel in that syllable, names without a stop in the onset of the initial syllable were more female (e.g. 예은 [eɨn]) and those with a stop in the onset of that syllable were more male (e.g. 태준 [tʰɛcun]. (Since these names have initial open syllables, the only location for a consonant was in the onset, and there would only be one there.) Syllable type and the presence of a stop had the largest effect sizes.

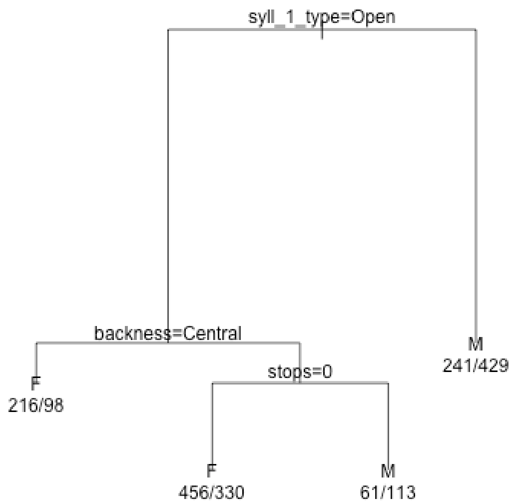

Figure 2: Trimmed CART tree (cp = 0.016) for the the initial syllable of Korean names. The numbers below each terminal node represent the number of female (left) and male (right) names sorted to that node.

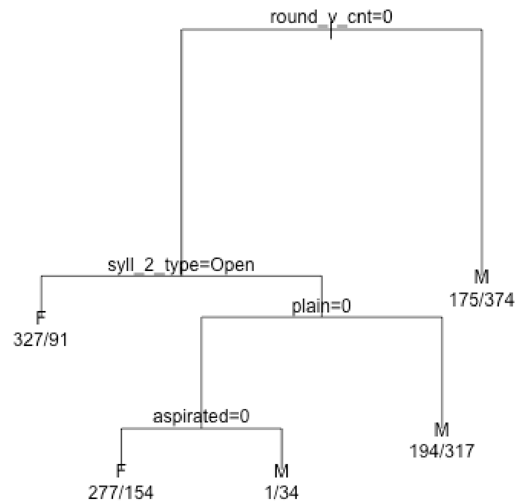

Figure 3: Trimmed CART tree (cp = 0.02) for the final syllable of Korean names. The numbers below each terminal node represent the number of female (left) and male (right) names sorted to that node.

The CART analysis for the final syllable (Figure 3) shows that vowel roundness, syllable type and obstruent type (plain and aspirated) were significant predictors of Korean name gender. Within all names, those with a round vowel in the final syllable were more likely to be male (e.g. 지후 [cihu]) and those without, more female (e.g. 민서 [minsə]). Within names without a round vowel in the final syllable, those with an open final syllable were more likely to be female (e.g. 지민 [cimin]) and those with a closed final syllable were more likely to be male (e.g. 서진 [səcin]). Within names with a closed final syllable containing a non-round vowel, those without a plain obstruent in the final syllable were more likely to be female (e.g. 지안 [cian]) and those with at least one were more likely to be male (e.g. 민성 [minsəŋ], 준석 [cunsək]). Within names with a closed final syllable containing a non-round vowel and no plain obstruents, those without an aspirated consonant in the final syllable were more likely to be female (e.g. 하린 [halin])and those with one were more likely to be male (e.g. 유찬 [jucʰan]). Vowel roundness and the presence of plain obstruents had the largest effect sizes.

4.4.2 Univariate Regression Analysis

The results in this section focus on the syllable structure, vowel backness, vowel type (dark/light), vowel height and obstruent type (fortis, lenis, aspirated) for the reasons discussed in the introduction of this section. A summary of the complete results of the univariate analysis can be found in Table 10. Full results can be found in Appendix A.

The first panel (FN) in Figure 4 shows the proportion of names with zero, one and two dark vowels which were male (blue) and female (purple). The proportion of male names increases as the number of dark vowels increases. The difference between no dark vowels and one or two dark vowels was significant in the univariate analysis (β = -1.2406, SE = 0.4795, z = -2.587, p = 0.00967), as was the difference between one and two dark vowels (β = -0.7949, SE= 0.3588, z = -2.215, p = 0.02673). In both cases, the higher number of dark vowels indicated that the name was more likely to be male. There was no significant effect of the number of light vowels in a name on gender.

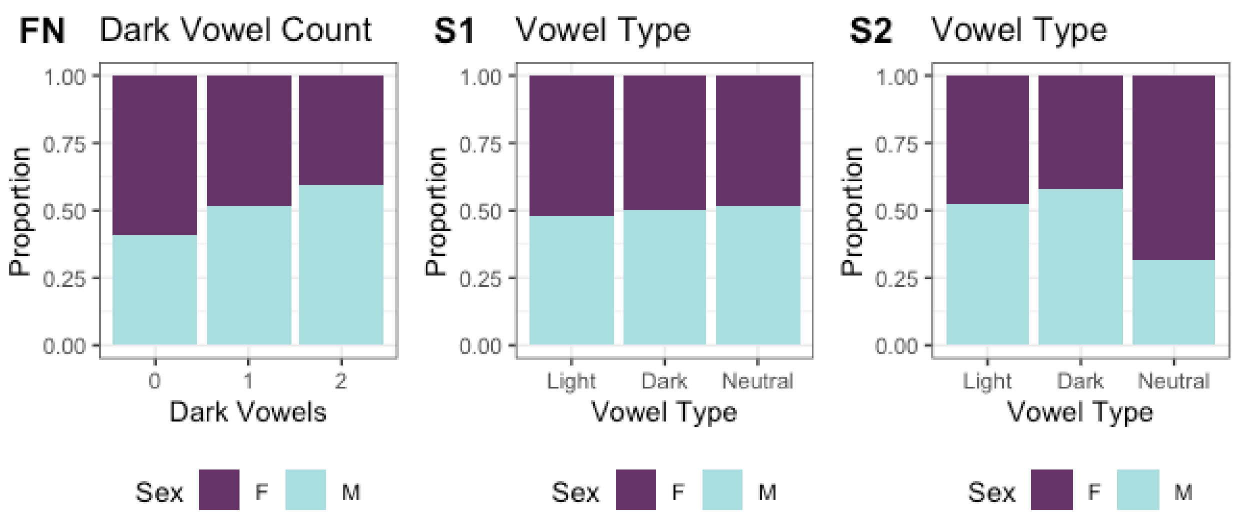

Figure 4: Bar charts showing the proportion of male and female names for each number of dark vowels in full names (FN) and vowel type (light, dark or neutral) in the initial (S1) and final (S2) syllables

The second (S1) and third (S2) panels if Figure 4 show the proportion of names with light, dark or neutral values in the initial and final syllables, respectively, which were male and female. In both syllables, there is a sightly higher proportion of male names when the vowel is dark than when it is light, however these results were not significant. Names with a neutral vowel in the final syllable were significantly more likely to be female than those names with either a light or dark vowel in the final syllable (β = -1.13834, SE = 0.13058, z = -8.718, $p < 0.001$). There was no effect of vowel type in the initial syllable.

In contrast to the results of vowel type, there were no significant effects of vowel height (high, mid, low) in the full names or in either of the two individual syllables.

Figure 5 shows the proportion of male vs female names by the number of lenis obstruents in the full name (FN), initial syllable (S1) and final syllable (S2). In each case, the proportion of male names increases as the number of lenis obstruents increases. The results of the univariate analysis indicate that these patterns are significant for the comparisons between no lenis obstruents and one or more lenis obstruents (β = -1.9483, SE = 0.6561, z = -2.969, p = 0.00298) and between one lenis obstruent and two or more lenis obstruents (β = -1.4007, SE = 0.6879, z = -2.036, p = 0.04174), but not between two and three lenis obstruents in the full name. There were also significant effects for the comparisons between no lenis obstruents and one or more lenis obstruents (β = -3.0492, SE = 0.8297, z = -3.675, p = 0.000238) and between one and two lenis obstruents (β = -4.0477, SE = 1.4962, z = -2.705, p = 0.006823) in the final syllable. There were no significant effects on the initial syllable.

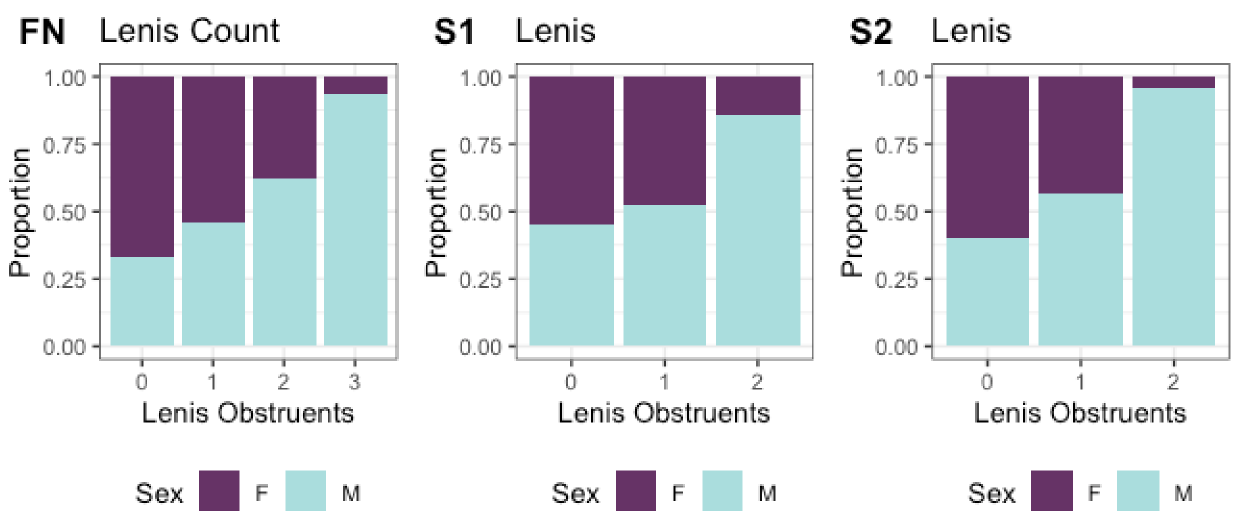

Figure 5: Bar charts showing the proportion of male and female names for each number of lenis obstruents in full names (FN) and in the initial (S1) and final (S2) syllables

Figure 6 shows the proportion of male vs female names by the number of fortis obstruents in the final syllable. There were no fortis obstruents in the initial syllable, so this also represents the proportions of fortis obstruents in the full name. A higher proportion of the names with a fortis obstruent are male. This effect is significant at the 0.10 level for the final syllable (β = 3.0192, SE = 1.8187, z = 1.660, p = 0.0969), but not the full name. It should be noted that all fortis consonants are the result of a phonetic post-obstruent tensing process (Kim-Renaud, 1974; Sohn, 1999), except for one in a pure Korean female name where it is underlying.

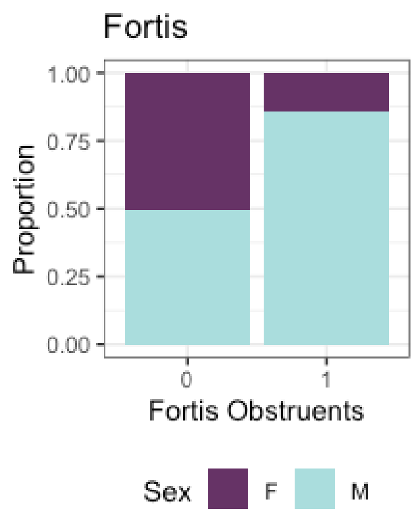

Figure 6: Bar chart showing the proportion of male and female names for each number of fortis obstruents. All fortis obstruents occur in the second syllable

Figure 7 shows the proportion of male vs female names by the number of aspirated obstruents in the full name (FN), initial syllable (S1) and final syllable (S2). In each case, the proportion of male names is higher when there is an aspirated consonant than when there is not. (No name has more than one aspirated consonant). This effect is significant in the full name (β = 1.6966, SE = 0.7135, z = 2.378, p = 0.01742) and at the 0.10 level in the final syllable (β = 2.3468, SE = 1.2907, z = 1.818, p = 0.06900), but not the initial syllable.

Figure 8 shows the proportion of male vs female names by the number of open syllables in full names (FN) and syllable type (open or closed) in the initial (S1) and final (S2) syllables. In each case, the proportion of female names increases as the number (or presence) of open syllables increases. This finding is significant in the full name for both the comparison between no open syllables and one or more open syllables (β = 2.2746, SE = 0.4987, z = 4.561, $p<0.001$) and that between one and two open syllables (β =1.6282, SE = 0.3839, z = 4.241, $p<0.001$). It was also significant in the initial syllable (β = -1.1673, SE = 0.3242, z = -3.601, p = 0.000317) and the final syllable (β = -1.46275, SE = 0.49875, z = -2.933, p = 0.00336).

Figure 9 shows the proportion of male vs female names by the number of round vowels in full names (FN) and in the initial (S1) and final (S2) syllables. The more round vowels

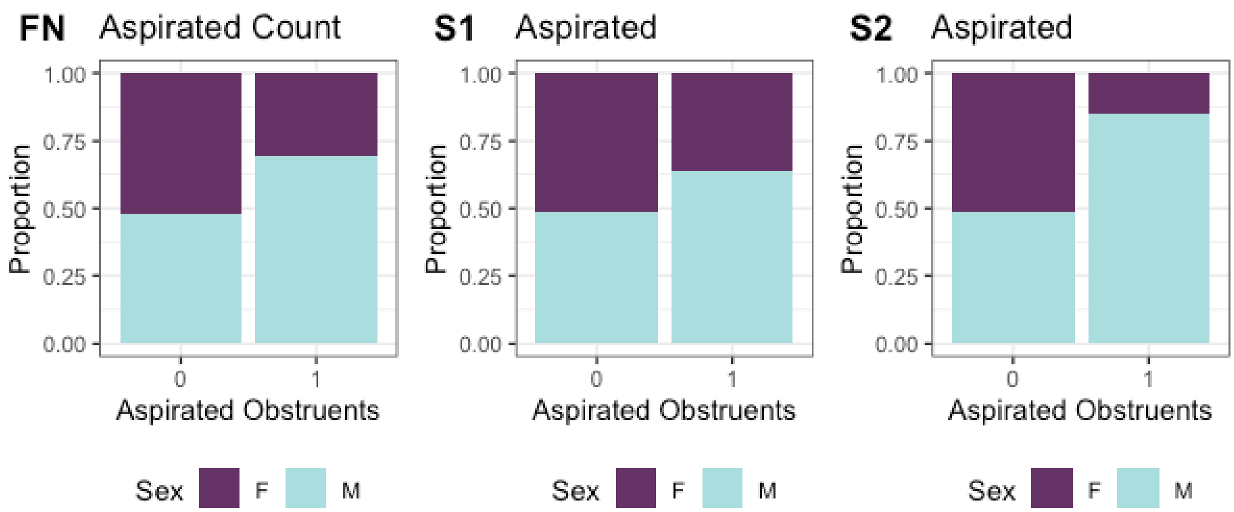

Figure 7: Bar charts showing the proportion of male and female names for each number of aspirated obstruents in full names (FN) and in the initial (S1) and final (S2) syllables

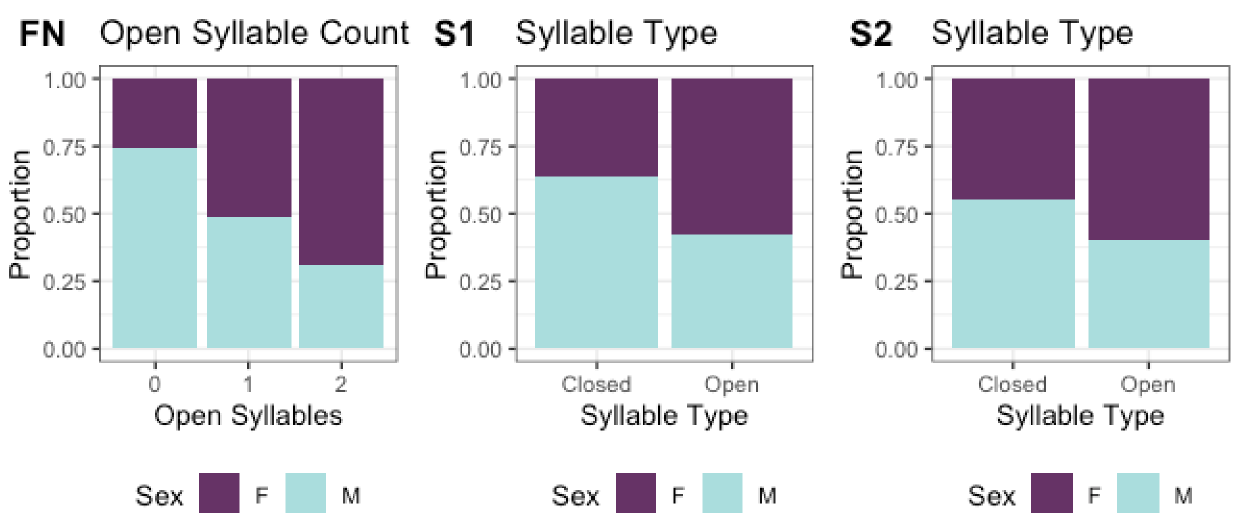

Figure 8: Bar charts showing the proportion of male and female names for each number of open syllables in full names (FN) and syllable type (open or closed) in the initial (S1) and final (S2) syllables

a full name has, the more likely it is to be male, though this effect is only significant when comparing names with no round vowels to those with at least one round vowel (β = -1.4569, SE = 0.5288, z = -2.755, p = 0.00587). The presence of a round vowel in the final syllable also results in a name being more likely to be male (β = 1.5669, SE = 0.4826, z = 3.247, p = 0.00117); however, the presence of a round vowel is not predictive of gender in the initial syllable.

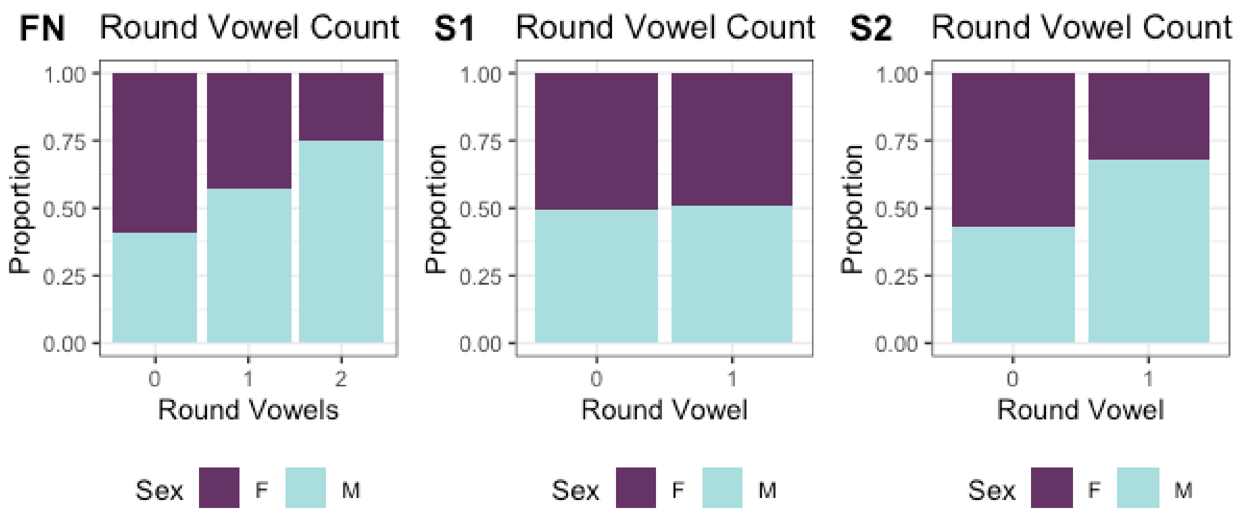

Figure 9: Bar charts showing the proportion of male and female names for each number of round vowels in full names (FN) and in the initial (S1) and final (S2) syllables

For all the other factors, there were either no significant effects, or the patterns were significant in the expected direction. For the full name analyses, most of the patterns were significant predictors on their own, and aside from the factors discussed above, only the number of diphthongs and the number of /w/-diphthongs did not display significant trends. For the initial syllable, most factors were not significant predictors and, aside from the factors discussed above, only the number of stops and vowel length (monophthongs vs diphthongs) were significant predictors of gender. For the final syllable, all factors not discussed above were significant predictors except initial sound type and stop count. A full summary of the results of the univariate analysis can be found in Table 10 and Appendix A.

4.4.3 Multivariate Regression Analysis

The results of the best fit multivariate regression model for the full names are displayed in Table 7. The model includes the number of open syllables, number of stops, number of round vowels, number of /w/-based diphthongs and number of aspirated stops. All the factors were significant in the expected direction, though the comparison between one and two stops was only significant at the 0.10 level. The more open syllables a name had, the more likely it was to be female. The more stops and round vowels a name had, the more likely it was to be male. Names with a diphthong with a /w/-onglide and those with an aspirated stop were also more likely to be male than female.

Table 7: Best fit mixed effects logistic regression model for full names with gender (M or F) as the response variable, number of open syllables (Open $), number of stops (Stops), number of round vowels (Round V), number of diphthongs with /w/ on-glides (/w/ Diphthongs) and number of aspirated stops (Aspirated) as predictor variables, and random intercepts for the initial and final syllables. The second value in each comparison is the reference category (negative value).

	Estimate	***SE***	**z-value**	**p**	
(Intercept)	3.3817	0.6168	5.482	<0.001	***
Open $: 0 vs 1/2	2.3735	0.4747	5.000	<0.001	***
Open $: 1 vs 2	1.6549	0.3670	4.509	<0.001	***
Stops: 0 vs 1/2	-2.1418	0.5255	-4.076	<0.001	***
Stops: 1 vs 2	-1.0479	0.5593	-1.874	0.06099	.
Round V: 0 vs 1/2	-2.0938	0.5209	-4.020	<0.001	***
Round V: 1 vs 2	-1.1612	0.5119	-2.268	0.02331	*
/w/ Diphthongs: 1 vs 0	2.3789	0.7810	3.046	0.00232	**
Aspirated: 1 vs 0	1.8403	0.6450	2.853	0.00433	**

The results of the best fit multivariate regression model for the initial syllable are displayed in Table 8. The model includes syllable type, number of stops, number of aspirated consonants, vowel length/diphthong type and height. All the factors were significant, and most were in the expected direction, though the comparisons between monophthongs and diphthongs and between high vowels and mid/low vowels were only significant at the 0.10 level and that between mid and low vowels was not significant. Names with an initial open syllable were more likely to be female than male. Those with a stop, aspirated obstruent, diphthong, or diphthong with a /w/ on-glide in the initial syllable were more likely to be male than female. Running against the expected patterns for vowel height, names with a high vowel in the initial syllable were more likely to be male at the 0.10 significance level.

The results of the best fit multivariate regression model for the final syllable are displayed in Table 9. The model includes number of stops, vowel backness, vowel length, number of lenis obstruents, syllable type and number of aspirated obstruents. All the factors other than the number of stops and number of lenis obstruents were significant in the expected direction. Names with front vowels in the final syllable were more likely to be female and those with back vowels are more likely to be male. Names with monophthongs in the final syllable are more likely to be female while those with diphthongs, particularly those with /w/ on-glides are more likely to be male. Names with open fi-

Table 8: Best fit mixed effects logistic regression model for the initial syllable with gender (M or F) as the response variable, syllable type (Syllable), number of stops (Stops), number of aspirated stops (Aspirated), vowel length (Length) and vowel height (Height) as predictor variables, and a random intercept for the initial syllable. The second value in each comparison is the reference category (negative value).

	Estimate	***SE***	**z-value**	**p**	
(Intercept)	1.4481	0.4383	3.304	0.000954	***
Syllable: Open vs Closed	-1.1376	0.3081	-3.693	0.000222	***
Stops: 1 vs 0	0.8874	0.3600	2.465	0.013701	*
Aspirated: 1 vs 0	1.3896	0.6390	2.175	0.029648	*
Length: Monophthong vs Diphthong	-0.8638	0.4872	-1.773	0.076222	.
Length: /j/ vs /w/ On-Glide Diphthong	-1.9670	0.9052	-2.173	0.029785	*
Height: High vs Low/Mid	0.5458	0.3272	1.668	0.095257	.
Height: Low vs Mid	-0.5743	0.4112	-1.397	0.162525	

nal syllables are more likely to be female. Those with aspirated consonants in the final syllable are more likely to be male.

Table 9: Best fit mixed effects logistic regression model for the final syllable with gender (M or F) as the response variable, number of stops (Stops), vowel backnesss (Backness), vowel length (Length), number of lenis obstruents (Lenis), syllable type (Syllable) and number of aspirated stops (Aspirated) as predictor variables, and a random intercept for the final syllable. The second value in each comparison is the reference category (negative value).

	Estimate	***SE***	**z-value**	**p**	
(Intercept)	2.5165	0.9779	2.573	0.01007	*
Stops: 0 vs 1/2	7.7263	13.2529	0.583	0.55990	
Stops: 1 vs 2	18.1481	26.5103	0.685	0.49362	
Backness: Front vs Back/Central	-1.4482	0.5261	-2.753	0.00591	**
Backness: Back vs Central	2.0185	0.5069	3.982	<0.001	***
Length: Monophthong vs Diphthong	-1.5956	0.6148	-2.595	0.00945	**
Length: /j/ vs /w/ On-Glide Diphthong	-3.1816	1.1127	-2.859	0.00425	**
Lenis: 0 vs 1/2	-9.5075	13.2346	-0.718	0.47252	
Lenis: 1 vs 2	-17.3870	26.4673	-0.657	0.51123	
Syllable: Open vs Closed	-1.1714	0.4733	-2.475	0.01332	*
Aspirated: 1 vs 0	2.7568	1.1840	2.328	0.01989	*

4.4.4 Summary

A summary of the results of the three models (CART, univariate regression and multivariate regression) for all the factors can be found Table 10. This table collapses the vowel type, height and backness factors from the full name analysis into one factor which corresponds to the factor used in the single syllable analyses. For vowel type, the results for the dark vowel count factor are reported. For height and backness, both original factors display similar results, so the result displayed in the table corresponds with both. The vowel length factor in the individual syllable analyses was divided into two factors: vowel length (monophthong or diphthong) and diphthong type (/j/ or /w/ glide), which roughly correspond to the diphthong count and combined /j/ and /w/ diphthong counts from the full name analysis, respectively. For all other factors with more than one comparison, the result of the factor with the highest significance is reported.

Table 10: Summary of the results of the three models (CART, UV - univariate regression, MV - multivariate regression) for the full name, initial syllable and final syllable analyses. ✓ = significant at the 0.05 level or above, ? = significant at the 0.10 level, X = significant in the opposite direction at the 0.10 level, •= included in the trimmed MV model, but not significant, NA = not evaluated in this model

	Full Name			**Initial Syllable**			**Final Syllable**		
	CART	UV	MV	CART	UV	MV	CART	UV	MV
Open Syllables	✓	✓	✓	✓	✓	✓	✓	✓	✓
Initial Sound	NA	NA	NA						
Vowel Type		✓							
Vowel Height						X			
Vowel Backness		✓		✓				✓	✓
Vowel Roundness	✓	✓	✓				✓	✓	
Vowel Length					?	?	•	✓	✓
Diphthong Type		✓	✓			✓	•		✓
Stops		✓	✓	✓	✓	✓			•
Sonorants		?						✓	
Lenis Obstruent	✓	✓					✓	✓	•
Fortis Obstruent				NA	NA	NA		?	
Aspirated Obstruent	✓	✓	✓			✓	✓	?	✓

In terms of the target factors, the number of open syllables was a significant predictor of gender across the board (i.e. in all three models for all three analyses), with open syllables being predictive of femaleness. The vowel roundness factor was significant for the full name and the final syllable, with a round vowel being indicative of maleness.

This factor had no effect on the initial syllable.

For vowel type, despite the fact that more names with dark vowels were male, compared to those with light vowels, the sound symbolic dark/light pattern was only significant in the full name for the number of dark vowels and in the final syllable for the contrast between neutral vowels and other vowels. There were no significant effects of vowel height, except for a trend in the initial syllable for high vowels to be more male, which runs counter the expected vowel height pattern.

For obstruent type, the presence of lenis obstruents indicates that a name was more likely to be male in the CART and univariate regression analyses for the full name and the final syllable. This factor was also included in the best fit multivariate regression analysis, though it did not have a significant effect. All fortis consonants appeared in the second syllable, with most being formed by a post-obstruent tensing process (Kim-Renaud, 1974; Sohn, 1999). Names with fortis consonants in the second syllable were more likely to be male, though only at the 0.10 significance level. Aspirated consonants indicated that a name was more likely to be male in the CART and univariate regression analyses for the full name and final syllable, though only at the 0.10 level for the univariate analysis in the final syllable. Finally, in the multivariate regression analyses for the full name, initial syllable and final syllable, the presence of an aspirated consonant meant a name was significantly more likely to be male.

The CART analysis suggests there may be interactions between phonological factors; however, this may be due to the nature of the analysis which only examines one factor at a time. Furthermore, it is not clear what interactions in the CART models might mean. The one possible meaningful interaction is differences between the initial and final syllables, which the analysis doesn't compare in the same model. Rather, each syllable is examined separately.

4.5 Discussion

The purpose of this corpus analysis was to address two questions. First, do Korean names follow the same sound symbolic patterns as names in other languages? In particular, how do Korean names compare to Cantonese names, with which they have shared etymological roots. And second, how do language-specific Korean sound symbolic patterns fit into the phonological patterns found in names? More specifically, do these patterns transfer over from the sound-symbolic vocabulary, and if so, how do they interact with more universal patterns?

The results of the Korean corpus analysis are compared to those of previous studies in Table 11. This is an updated version of Table 1 which compared the results of corpus analyses from previous studies to each other. The percentages in the final column have also been updated. A pattern was considered to occur in Korean if it was significant in at least one of the three models for the full name and for at least one model in one of the two individual syllables. Vowel height and type were combined into the vowel height factor in this table, resulting in the trend in Korean going opposite the expected direction. Diphthong type was dropped as it is correlated with roundness and backness. The obstruent types were combined into one factor.

Table 11: Summary of the results of previous corpus analyses of English (ENG), French (FRN), Armenian (ARM), Kutchi (KUT), Urdu (URD), Cantonese (CAN), Japanese (JPN) and Korean (KOR) by factor. The final column indicates the percentage of languages tested which displayed the expected pattern, with the opposite pattern in brackets, for all factors that were tested in more than one language. Legend: ✓– trend in the expected direction; X – trend in the opposite direction, ? – unknown, NA – not investigated to my knowledge, * Not a factor in the initial syllable

	ENG	**FRN**	**ARM**	**KUT**	**URD**	**JPN**	**CAN**	**KOR**	**%**
Length	✓	✓		X	✓	X	NA	NA	50% (33%)
Syllable Weight	✓	✓	NA	NA	✓	✓	✓	✓	100%
Initial Open Syll	✓		✓		NA		✓	✓	67%
Final Open Syll	✓	✓	✓	✓	NA		✓	✓	86%
Initial Vowel		✓	✓	X	NA	✓	NA		50% (17%)
Vowel Height	✓		✓	X	NA	NA	✓	X	50% (33%)
Vowel Backness	✓		✓			NA	✓	✓	57%
Round Vowels	NA	NA	NA	NA	NA	NA	✓*	✓*	100%
Nasal Vowels	NA	✓	NA	NA	NA	NA	NA	NA	
Sonorancy		✓	✓		✓	NA	✓	✓	71%
Coronal Place	NA	NA	NA	NA	NA	NA	✓	NA	
Stress	✓	NA	NA	NA	NA	NA	NA	NA	
Tone Height	NA	NA	NA	NA	NA	NA	X	NA	
Vowel Length	NA	NA	NA	NA	NA	NA	NA	✓	
Obstruent Type	NA	NA	NA	NA	NA	NA	NA	?	

Overall, Korean has similar patterns to the other languages investigated. Like most other languages, the majority of the patterns investigated, including the syllable type factors, are found in the corpus in the expected direction, but there are some factors which are not predictive or trend in the opposite direction in Korean. None of the trends which flow in the expected direction in Korean run opposite in the other languages, though most of them are not significantly predictive in at least one language.

Comparing Korean to Cantonese shows that the vast majority of patterns trend in the same direction in both languages. In fact, when comparing the individual syllable analyses in Cantonese (Wong & Kang, 2019) and Korean, vowel roundness is predictive of maleness in the final syllable but not the initial syllable in both languaegs. This suggests that there may be some genetic reason for this similarity in pattern; however more research on unrelated languages would be needed to verify this. Given that shape-symbolism (Köhler, 1929; Maurer et al., 2006; Nielsen & Rendall, 2011; Westbury, 2005) associates sonorants with roundness and, by extension, roundness with femaleness (Sidhu & Pexman, 2015), it is possible that other languages may associate round vowels with more female names, though round vowels also tend to be back vowels, including in Korean, so that could result in them being perceived as more male.

The one major difference between the two languages is in vowel height. Cantonese (Wong & Kang, 2019), like English (Sullivan, 2018) and Armenian (Ananthathurai et al., 2019), follows the universal vowel height pattern but Korean does not, which may be due to the language-specific dark-light symbolism in Korean. This pattern is evident in the univariate analyses of dark vowels in the full names and in the multivariate analysis for the first syllable where the height pattern runs in the opposite direction of what would be expected based on the more universal pattern. It is also seen in non-significant trends in the proportion of names containing light and dark vowels that are male and female (Figure 4). It is not clear if the pattern is actually present in given names and as a consequence, whether it extends beyond the sound symbolic vocabulary. However, while the pattern is not particularly strong, it does, at a minimum, seem to reduce the effect of the universal vowel height pattern, suggesting that it may interact with or override the more universal pattern. This would suggest that dark-light symbolism is in fact present in names, though its effects may be mitigated by the universal height pattern. Further support for this comes from the final syllable where the height pattern is not a factor, despite the fact that the neutral vowels, which are both high, occur significantly more in female names than male names. Thus, even though it is not significant, the fact that more names with dark vowels than light vowels are male seems to be enough to disrupt the height effect caused by the neutral vowels.

In addition to dark-light vowel symbolism, obstruent type is also a language-specific factor in Korean. The results of this corpus study show that names with more obstruents, regardless of obstruent type, are more likely to be male than female (though there are not enough fortis stops in the corpus to make any firm conclusions about them), which is expected given the sonorancy patterns observed in other languages and shape-sound symbolism which argues for a contrast between sonorants being associated with round shapes and voiceless stops being associated with sharp shapes (Köhler, 1929; Maurer et al., 2006; Nielsen & Rendall, 2011; Westbury, 2005). In this case, the roundness is associated with femaleness resulting sonorants occurring more in female names and voiceless stops in male names (Sidhu & Pexman, 2015, 2019). In order to see if certain obstruent types are more strongly associated with maleness than others, it is necessary to compare the obstruents directly. This is done for the initial obstruent in each syllable in Section 5

Given that sound symbolic patterns are present in the corpus, one question that could be asked is if these patterns are active in speakers' minds or if they're just lexical patterns. I conducted a name gendering experiment to test this with manipulations of the syllable structure, vowel rounding, vowel type and obstruent type factors. The syllable structure and vowel rounding factors were included as they had strong effects where they were active in the corpus and have been used in the English (Sullivan & Kang, 2019) and Cantonese (Wong & Kang, 2020) name gendering experiments, allowing for comparison with the results of those studies. Participants in the study were English and Korean speakers which allowed results to be compared for speakers of the two languages. This addresses the question of whether language-specific patterns are active for Korean, but not English speakers, justifying the inclusion of the vowel and obstruent type factors.

5 Obstruent and Vowel Types in a Corpus of Korean and English Names

The primary purpose of this corpus analysis was to prepare for the experiment by verifying the obstruent and vowel type patterns in English and Korean to establish hypotheses about how participants will behave. A secondary purpose was to directly compare the three different obstruent types (fortis, lenis, aspirated) in Korean in syllable initial positions to determine if certain types are more male than others. If there are differences, aspirated and fortis obstruents may be more male than lenis ones.

For the vowel type factor, the vowels /o/ and /u/ were chosen to represent light and dark vowels, respectively, because these vowels both occur in English and are unambiguously light and dark in Korean, occurring in both the sound symbolic and vowel harmony dark-light patterns (Larsen & Heinz, 2012; Sohn, 1999). As neither the corpus analysis in Section 4 nor studies of vowel height in English (Cutler et al., 1990; Sullivan, 2018; Wright et al., 2005) make this comparison directly, I conducted an analysis to verify that the trends from the larger dataset hold for this comparison. For Korean, /u/ is expected to be more male than /o/ as it is a dark vowel. For English, /u/ should be more female because it is a high vowel and the height pattern holds in English.

For the obstruent type factor, manipulations occur on the initial segment in each syllable, so this analysis compares syllable-initial segment types in the initial and final syllable. For Korean, this means a comparison of fortis, lenis and aspirated obstruents, as well as sonorants and vowels. For English, the comparison is between voiced and voiceless obstruents, and sonorants and vowels. As there is limited work on obstruent type in English, this will inform predictions for the experiment. (Though Wright et al. (2005) did find that word-initial voiced consonants occurred more in male names than female names, relative to voiceless ones.)

5.1 Data Collection

5.1.1 Korean Names

This analysis used the phonetic transcription of the same 1944 names used in the Korean name corpus analysis (1974 female; 970 male). A link to the full list of names can be found in Appendix B.

5.1.2 English Names

English names were retrieved from the baby name databases compiled by the government of Ontario (ServiceOntario, 2016a, 2016b). The top 1000 baby names in 2013 (by frequency) for each gender were chosen for analysis. After eliminating duplicates (and the name *Baby* which was presumably assigned to children who were not given a name) from this list, 1500 names remained (731 Female; 769 Male). These names were further reduced by eliminating names that were not of European, Biblical or American (African American or English American) origin according to behindthename.com (Campbell, 2020), leaving 1259 names for analysis (632 Female; 627 Male). A link to the full list of names can be found in Appendix B.

5.2 Coding & Analysis

For both languages, coding occurred at the level of individual syllables or parts of the word. Korean names were coded based on the phonetic transcription from the Korean name corpus analysis. English names were coded by a native speaker of Canadian English. Separate analyses were conducted for each syllable, factor and language. The purpose of the analysis was primarily to determine if the overall trends in the data held for the smaller subsets to be tested in the experiment. All models were constructed in R.

5.2.1 Vowel Type

For vowel type, each name was coded for the presence of /u/ and /o/. More specifically the vowel in each syllable was coded as being /u/, /o/ or '0' (other vowel). In English, separate analyses were for the final syllable and the remainder of the word, rather than for the initial and final syllable as in Korean. Vowels in monosyllabic words were included in the final syllable only.

All items that did not contain /u/ and/or /o/ in the relevant syllable were removed for the analysis. The vowel type factor was contrast coded with /o/ and -0.5 and /u/ as 0.5. The Korean analyses consisted of mixed effects univariate logistic regression models using the *glmer()* function (Bates et al., 2015; Kuznetsova et al., 2017) with name gender as the response variable, vowel type as the predictor variable and a random intercept for the relevant syllable (initial or final), for the reasons described in Section 4.3.3. The English analyses consisted of univariate logistic regression models using the *glm()* function with name gender as the response variable and vowel type as the predictor variable. (Mixed effects were not necessary for English as no names or syllables repeat in a systematic way.)

5.2.2 Consonant Type

For consonant type, each syllable was coded based on its initial sound. For Korean, it was coded as being fortis, aspirated, lenis, sonorant or a vowel. For English, it was coded as being voiceless, voiced, sonorant or a vowel. In English, separate analyses were conducted for the initial and final syllables as comparisons for those syllables in Korean. Monosyllabic words were included in both analyses.

All items were included for analysis. The levels of the categorical variable were centred and custom coded to allow for comparisons between obstruents and sonorants (including vowels), between sonorants and vowels and between types of obstruents. For English, the comparison between types of obstruents was between voiced and voiceless obstruents. For Korean, there were two comparisons between obstruent types for the final syllable – between fortis and the other types of obstruents, and between lenis and aspirated obstruents – but only one for the initial syllable (aspirated vs lenis, as there were no fortis consonants in the initial syllable). Aside from using consonant type as the predictor variable and including all items in the analysis, these models were constructed in the same way as the vowel type models.

5.3 Results

All graphs were generated in R using ggplot 2. Complete results of the regression models can be found in Appendix B.

5.3.1 Vowel Type

Of the 1259 English names in the English corpus, 160 contained /o/ (66 in final position; 94 in non-final position) and 46 contained /u/ (12 in final position; 34 in non-final position). Of the 1944 Korean names in the Korean corpus, 407 contained /o/ (229 in the initial syllable, 278 in the final syllable) and 543 contained /u/ (140 in the initial syllable, 403 in the final syllable). Figure 10 shows the proportions of male and female names containing /u/ and /o/ in both positions in each language. In Korean, male names are more likely to contain /u/ than /o/ in both syllables while the opposite is true in English names. However, the only significant effect is for the final syllable of Korean names ($\beta = 1.1442$, $SE = 0.5695$, $z = 2.009$, $p = 0.04453$).

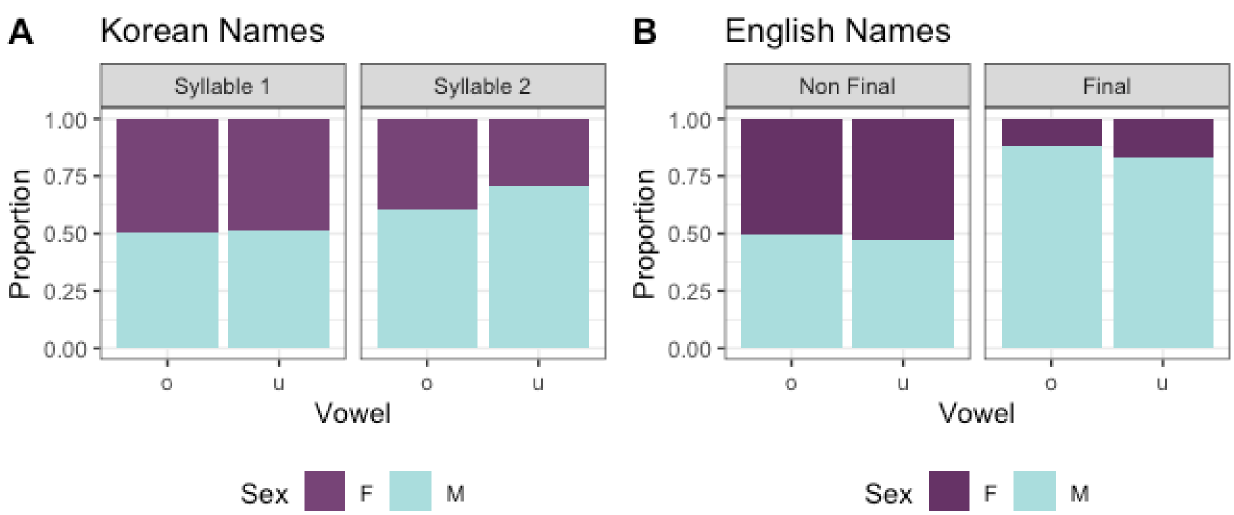

Figure 10: Bar charts showing the proportion of male and female names containing /u/ and /o/ in the initial (1)/non-final and final (2) syllables

5.3.2 Consonant Type

Figure 11 shows the proportions of male and female names with different types of onsets in the initial and final syllables in Korean (A) and English (B). In Korean, the highest proportion of male names occur in syllables with aspirated and fortis consonants, followed by lenis consonants. Syllables with sonorant consonants have the highest proportion of female names, followed by those without an onset (the 'Vowel' condition). The only significant difference between types of onsets is between obstruent and sonorant onsets in both the initial ($\beta = 2.0277764$, SE = 0.9209393, z = 2.202, p = 0.0277) and final ($\beta = 6.1858$, SE = 1.9713, z = 3.138, p = 0.0017) syllables, in which case syllables with an obstruent onset were more likely to be male.

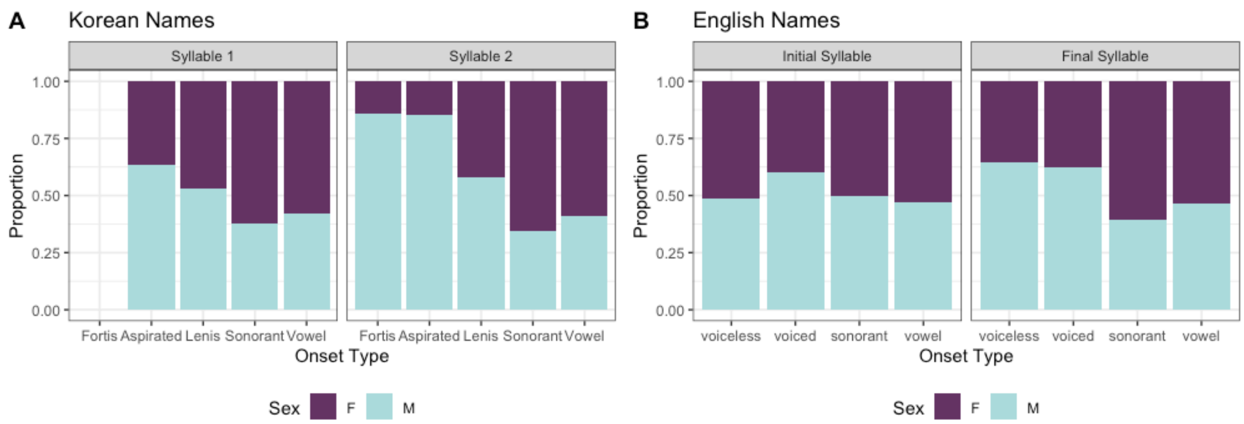

Figure 11: Bar charts showing the proportion of male and female names containing different onset types in the initial (1)/non-final and final (2) syllables

In English, the highest proportion of male names in the initial syllable occurs in voiced consonants, with all other onset types being very similar and around 50% male. Initial syllables with obstruent onsets are significantly more likely to be male than those with sonorant onsets ($\beta = 0.48081$, SE = 0.21019, z = 2.287, p = 0.02217) and those with voiceless obstruent onsets are significantly more female than those with voiced obstruent onsets ($\beta = -0.45675$, SE = 0.14436, z = -3.164, p = 0.00156). No other trends are significant. In the final syllable, by contrast, voiceless consonants have a slightly higher proportion of male names than voiced consonants, though these proportions are quite similar. Together, the two obstruent types make up the highest proportion of male names. Sonorants have the highest proportion of female names, followed by onsetless syllables (the 'vowel' condition). Final syllables with obstruent onsets are significantly more likely to be male compared to those with sonorant onsets ($\beta = 1.68077$, SE = 0.23747, z =

7.078 , $p < 0.001$) and those with sonorant onsets are more likely to be female than those without an onset (β = -0.29492, SE = 0.17536, z = -1.682, p = 0.0926). No other trends were significant.

5.4 Discussion

For vowel type, the results indicate that /u/ is more male on the final syllable, but not the initial syllable, in Korean, whereas it is non-significantly more female in English in both syllables (Table 12). These trends are in the expected direction given the results in Section 4 and Sullivan (2018). As this factor will be manipulated on the final syllable only, I will not focus on the lack of difference between the two vowels in the initial syllable in Korean.

Table 12: Expected English and Korean vowel patterns for the vowels [u] and [o] based on the results of the corpus analysis

	Pattern	**[o]**	**[u]**
Korean →	Dark/Light	Female	Male
English →	Height	Male	Female

For consonant type, the results indicate that aspirated and fortis consonants may be more male than lenis consonants in the syllable onset in Korean, which is consistent with the hypothesis that this is modulated by intensity rather than F0 or size symbolism (as highlighted in Table 13, though this effect is non-significant. Obstruent onsets, regardless of type, are more male than sonorant onsets or onsetless (vowel) syllables, consistent with shape-symbolism and the findings in other languages (Ananthathurai et al., 2019; Sullivan, 2018; Mohsin et al., 2019; Wong & Kang, 2019). There are low numbers of names with aspirated, and especially fortis, obstruents compared to lenis obstruents, which could possibly explain the lack of significant effect.

Table 13: Hypotheses about how obstruent type is related to name-gender in Korean names

Hypotheses	**Fortis**	**Aspirated**	**Lenis**
Size Symbolism	Female	?	Male
Intensity	**Male**	**Male**	**Female**
F0	Female	Female	Male

For English names, voiced obstruents in the onset are more male than voiceless ones in the initial syllable, but not in the final syllable where they are quite similar. In the final syllable, sonorant onsets (and onsetless syllables) are more female than obstruent onsets whereas syllables with sonorant and voiceless obstruent onsets and onsetless syllables are all quite similar in the initial syllable.This suggests that, in English, position may have an effect on how sonorancy and obstruent type are used to assign gender to names.

6 Name Gendering Experiment

I conducted a name gendering experiment in which English and Korean speakers rated nonce names which were manipulated based on syllable structure, vowel rounding, vowel type and obstruent type as male or female on a six point scale to assess how psychologically real these patterns were. It also addressed how speakers of another language (in this case, English) make use of sound patterns to assign gender to names in a foreign language. Syllable structure was manipulated by closing one or both of the syllables in a target name. Vowel rounding was manipulated by adding a /w/-onglide to the final vowel in a name. This was done because the front round vowels /y ø/ do not exist in English, the front round vowels are realized as diphthongs with /w/-onglides by some speakers of Korean (Sohn, 1999) and the presence of a /w/-onglide behaved similarly to vowel rounding in the corpus analysis.

Vowel type was manipulated by changing the final vowel to /u/ (dark) or /o/ (light). Obstruent type was manipulated by changing the voice onset time (VOT) and fundamental frequency (F0) of the onset of each syllable (one per manipulation). VOT is manipulated holistically to match lenis, fortis or aspirated obstruents in the relevant position. F0 is manipulated to be either high or low. Separate manipulations were done for VOT and F0 because Korean stop perception is dependent on both factors (Kim-Renaud, 1974; C.-W. Kim, 1965) and, more recently, F0, rather than VOT has become the primary acoustic measure distinguishing lenis and aspirated stops (Silva, 2002). Thus, it is likely that obstruents (in initial position) in the middle of the VOT continuum will be categorized perceptually as aspirated or lenis based on their F0, rather than their VOT, which could result in Korean listeners classifying nonce names differently based on F0, rather than VOT in these circumstances.

Previous studies using this methodology have looked at how native speakers of Armenian (Ananthathurai et al., 2019), Cantonese (Wong & Kang, 2020), English (Sullivan & Kang, 2019), Kutchi (Ananthathurai et al., 2019) and Urdu (Mohsin et al., 2019) have made use of a number of possible factors to assign gender to nonce names. In most of these studies, participants were tested using nonce words recorded by a native speaker of their language. In these cases, participants normally rated names as male or female in line with the statistically significant trends in the corpus study for that language. However, there were some cases, such as stress placement in the English study and non-significant trends in the Kutchi study, where either no pattern was observed (English) or the more universal, rather than language-specific pattern was observed (Kutchi). A similar study (Sidhu et al., 2016) tested English and French listeners on names manipulated for shape symbolism spoken by speakers of both languages and found that their participants used this factor to assign gender to nonce names, regardless of listener or speaker language.

Given these findings, it is likely that Korean speakers will make use of the vowel rounding and syllable structure patterns as they are (a) consistent with other languages (though only Cantonese was tested for vowel rounding) and (b) statistically significant in the expected direction in Korean. More specifically, Korean speakers should rate names with round vowels and more closed syllables as more male.

For vowel and obstruent type, the results are less clear. There are trends in the data for these factors whereby dark vowels and aspirated/fortis obstruents are more strongly predictive of a male name than light vowels and lenis obstruents; however neither of these factors are significant where they are being manipulated (in the onset of each syllable for obstruents and in the final syllable for vowels). If, like in Kutchi, non-significant trends revert to the more universal patterns, the opposite pattern would be observed for vowel type, consistent with the vowel type pattern and no discernible difference should be observed for obstruent type (that is, all obstruents should be rated as equally male), consistent with shape-sound symbolism and sonorancy patterns. On the other hand, if speakers do make use of these language-specific patterns, they should rate names with /u/ as more male and those with /o/ as more female for the vowel type factor and names with aspirated and/or fortis obstruents as more male than those with lenis obstruents for the obstruent type factor.

The obstruent type factor may also be influenced by the F0 manipulation. It is possible that high and low tones affect ratings such that names with higher tones are rated more female and those with lower tones more male, as predicted by the frequency code hypothesis (Ohala, 1984, 2004). On the other hand, the opposite may be true if the patterns found in the Wong and Kang (2019) Cantonese corpus analysis hold. F0 may also influence the categorization of some obstruents, particularly those with less extreme VOTs (like lenis obstruents). If this is the case, certain VOT and F0 combinations may be rated based on their perceived category rather than their VOT category. For example, obstruents with lenis VOT and high F0 may be perceived as aspirated. If this is the case, they may be rated consistent with aspirated stops (more male) rather than lenis stops (less male).

In addition to looking at how native speakers rate names, English speakers have also been tested on their responses to French (Sullivan & Kang, 2019) and Cantonese (Wong & Kang, 2020) names. For the French names, English speakers were able to make use of patterns present in both languages and nasal vowels, a factor not found in English, to assign gender to nonce names in the expected direction. In the case of nasal vowels, it is possible that participants had internalized the pattern itself without influence from French, however it is also possible that they are extrapolating patterns found in their language to this pattern, or that exposure to French had an effect. Likewise English speakers in the Cantonese study made use of the tested patterns in the directions consistent with English patterns for segmental factors.

Given the results of these studies, in conjunction with those of Sidhu et al. (2016) which also found that participants made use of a proposed universal trend similarly in their native and non-native language, English speakers might be expected to respond to stimuli in line with patterns in their language. For the syllable structure factor, they should behave the same as Korean speakers, rating names with more closed syllables as more male than those with more open syllables. For vowel rounding, they might be expected to rate round vowels as more male, which would be consistent with the results in the Cantonese study (Wong & Kang, 2020) and the fact that all round vowels in English are also back vowels, which tend to occur more in male names than female names in English (Sullivan, 2018). This would also match the Korean participants' expected results.

For the vowel type factor, English follows the height pattern, so /u/ should be rated more female than /o/, which is contrary to the predictions for Korean. However, as /u/ and /o/ are both higher vowels in English (/u/ being high and /o/ being mid-high, contrasting with the low and mid-low back vowels) it is possible that this effect may be reduced or that no significant effect would be observed. Such a finding would be consistent with the results of the corpus analysis in Section 5 which found a non-significant trend in line with a vowel height pattern.

For the obstruent type factor, English speakers' ratings will depend on their categorization of the obstruents as voiced or voiceless, which is likely to be modulated primarily by VOT rather than F0 (Francis & Nusbaum, 2002; Schmidt, 2007). If F0 itself has an effect, English speakers are likely to rate names with high F0 as more female than those with low F0, consistent with the frequency code hypothesis and the findings of the Cantonese study (Wong & Kang, 2020).

In initial position, English speakers are likely to perceive aspirated and lenis stops as voiceless and fortis stops as voiced. Since voiced obstruents occur more in male names in this position, fortis obstruents should be rated more male than aspirated and lenis obstruents. In the final syllable, stops occur intervocalically (all stimuli for this factor have open syllables), which would result in lenis stops being voiced. Thus, in this position, English speakers are likely to perceive fortis and lenis stops as voiced and aspirated stops as voiceless. As English speakers don't rate names with voiced or voiceless obstruents in this position as more male, it is likely that all obstruents will be rated equally.

6.1 Methodology

6.1.1 Participants

Forty-one participants completed the study: 20 native speakers of North American English (8 male, 12 female) and 21 native speakers of Korean (6 male, 14 female, 1 unknown due to data loss). (Note that all the data for one Korean participant was lost, so that participant is not included in the numbers that follow.) Participant ages are listed in Table 14. All the English participants and 20 of the Korean participants were recruited on Prolific (www.prolific.co) [May 2020] and paid $5.00 Canadian for participating in the study. One Korean participant was recruited by word of mouth and paid $5.00 Canadian by e-transfer for participation. Participants were free to withdraw at any time.

Table 14: Participant Age Groups

Age Range	English	Korean
<20	2	0
20-29	7	12
30-39	4	6
40-49	1	2
50-59	2	0
60-69	1	0
70-79	1	0

The English speakers were raised in Canada (10) and the United States (10). All but one had no knowledge of Korean and that participant rated their knowledge as beginner. Many participants spoke a language other than English, but none beyond an intermediate level. The languages included Spanish, French, Japanese, Greek and German.

The Korean participants were raised in South Korea (18), Canada (1) and the United States (1). All the Korean participants had some knowledge of English, ranging from intermediate (2) and advanced (9) to native (3) and native-like (6). Many participants spoke additional languages, including Japanese, French, Spanish and Cantonese. Other than two participants who said they had advanced knowledge of Japanese, all participants listed their knowledge of other languages as beginner.

Two Korean participants were excluded from the analysis, one for data loss and one because they rated their knowledge of Korean as intermediate, leaving 19 Korean participants for analysis.

6.1.2 Background Questionnaire

Participants completed a background questionnaire to collect basic demographic and language background information. Participants were asked about their sex, age, country of birth, primary country of residence during childhood, proficiency in English and Korean, and proficiency in any other languages they speak.

To check their familiarity with Korean names, English participants also completed two Korean name familiarity tasks. Twenty names (10 male, 10 female) were selected from the Korean name corpus for these tasks. The first name in each 100 names by frequency rank and gender was selected, up to 10 names per gender (i.e. name 1, 101, 201... etc.). These names were checked by a native speaker of Korean and one was replaced with the second name in that 100 because the native Korean speaker was not familiar with it. In the first task, English participants were asked to indicate which of the names they were familiar with. In the second task, they were asked to decide whether each name was male or female. Participants were told that the orthography used might be slightly different than they were familiar with.

The complete background questionnaire can be found in Appendix C.

6.1.3 Stimuli

The stimuli were CV(C)C(w)V(C) nonce names which were manipulated in groups based on syllable structure (closed vs open syllables), vowel rounding (V or wV), syllable-initial obstruent type (lenis, fortis, aspirated) and vowel type (/u/ or /o/). The base CVCV names were pseudorandomly selected from a list of all the possible CVCV structures containing the vowels /i e ɛ a u o ʌ/ and consonants /p t k m n h s l/ which were present in both English and Korean. This list was trimmed down by removing sequences which were real words in English and Korean, as well as sequences which were Korean names or contained non-Sino-Korean syllables. Sequences which contained two of the same vowel or consonant were also removed.

For the syllable type factor, five sequences containing one sonorant and one obstruent consonant were selected as base names and manipulated to create four levels: no closed syllables (CVCV), closed initial syllable (CVCCV), closed final syllable (CVCVC) and both syllables closed (CVCCVC). In all cases the additional consonant that was added was a sonorant to avoid confounds due to assimilatory changes with obstruent codas in the initial syllable (see Section 3 for more details of these changes).

For the vowel rounding factor, five sequences were selected as base names for each pair. The initial obstruent of two of these sequences was removed to make them sound less male, creating VCV bases. The second name in each pair was created by adding a /w/-onglide to the final vowel.

For the syllable-initial obstruent type factor, ten sequences were selected as base names, five for manipulation on the initial syllable and five for manipulation on the final syllable. For manipulation on the initial syllable, the initial consonant was /t/ or /p/ and the second consonant was a sonorant. For the final syllable, the first consonant was a sonorant and the second was /t/ or /p/. The second and third names in each group were created by changing the /p/ and /t/ to /p^h/ or /t^h/ and /pp/ or /tt/, respectively. That is, changing the lenis stop to an aspirated or fortis stop. The stimuli were then further manipulated so that each target syllable began with either a high or a low tone. This is because obstruent type in Korean is determined by both F0 and VOT (Kim-Renaud, 1974; C.-W. Kim, 1965; Silva, 2002).

For the vowel type factor, five sequences which contained either /u/ or /o/ as the final vowel were selected as the base name for each pair. Each sequence contained one obstruent and one sonorant consonant. The second name in each pair was constructed by changing the last vowel to /u/ or /o/, depending on which vowel was present in the base name.

The total number of target words was 100 (10 for vowel type, 60 for consonant type). In addition to these manipulations, eight training stimuli were constructed. None of the nonce names were words or names in Korean or English. The complete list of 108 stimuli can be found in Table 15.

The stimuli were recorded by a middle-aged male native speaker of the Seoul dialect of Korean. Recording took place over the internet using the Gorilla platform (Anwyl-Irvine, Massonnié, Flitton, Kirkham, & Evershed, 2020). Stimuli were presented to the speaker in Korean orthography (Hangul) and he was asked to say each stimulus item three times before moving on to the next one. The clearest of each of the three repetitions was selected as the target stimuli.

One possible concern with the stimuli is that Korean /o/, despite being a mid-vowel, is

Table 15: Experiment Stimuli By Factor

Vowel	**S1 Obstruent**	**S2 Obstruent**	**Syllable Type**	**Rounding**	**Training**
mopu	poma	natu	mɛpo	ise	simɛ
mopo	p^{h}oma	nat^{h}u	mɛŋpon	iswe	silmɛk
	ppoma	nattu	mɛŋpo		silmɛ
			mɛpon		simɛk
pɛmo	pilɛ	mɛpi	mitu	noka	natɛ
pɛmu	p^{h}ilɛ	mɛp^{h}i	mintun	nokwa	namtɛk
	ppilɛ	mɛppi	mintu		namtɛ
			mitun		natɛk
tano	pɛmo	mopɛ	soma	nuhɛ	
tanu	p^{h}ɛmo	mop^{h}ɛ	soŋmal	nuhwɛ	
	ppɛmo	moppɛ	soŋma		
			somal		
huno	tano	nuto	mopu	uki	
hunu	t^{h}ano	nut^{h}o	moŋpun	ukwi	
	ttano	nutto	moŋpu		
			mopun		
pɛno	tulo	muta	naso	kuha	
pɛnu	t^{h}ulo	mut^{h}a	namsoŋ	kuhwa	
	ttulo	mutta	namso		
			nasoŋ		

raised, behaving acoustically as a high vowel (Kang, 2014) and overlapping significantly with /u/, which may lead to perceptual difficulties for English speaking participants (Ryu, 2018a). Despite this, as a native English speaker, I found the Korean speaker's productions of /o/ and /u/ to be quite distinct.

The speaker's F0 at the beginning of the vowel following the target consonant was found to vary by approximately 40Hz between lenis stops and fortis/aspirated stops. The target words for the consonant type factor were manipulated in Praat (Boersma, 2001) as follows: F0 measurements on the vowel following the target consonant were taken at the beginning (initial) and end (final) of the vowel (for the final vowel, this measurement was taken before the final rise). For lenis consonants, F0 is low, so the low F0 version of the stimulus item was created by replacing the F0 contour on the target vowel with one that began with the initial F0 measurement and ended with the final F0 measurement. To get the stimulus with high F0, the initial measurement was manipulated by adding 40Hz and the final measurement remained the same, resulting in a higher initial F0 and more of a falling pitch contour. For fortis and aspirated stops, F0 is high, so the high version was constructed using the original initial and final measurements and the low version by subtracting 40Hz from the initial measurement and leaving the final measurement the same, resulting in a lower initial F0 and more of a rising pitch contour. These manipulations are illustrated in Figure 12.

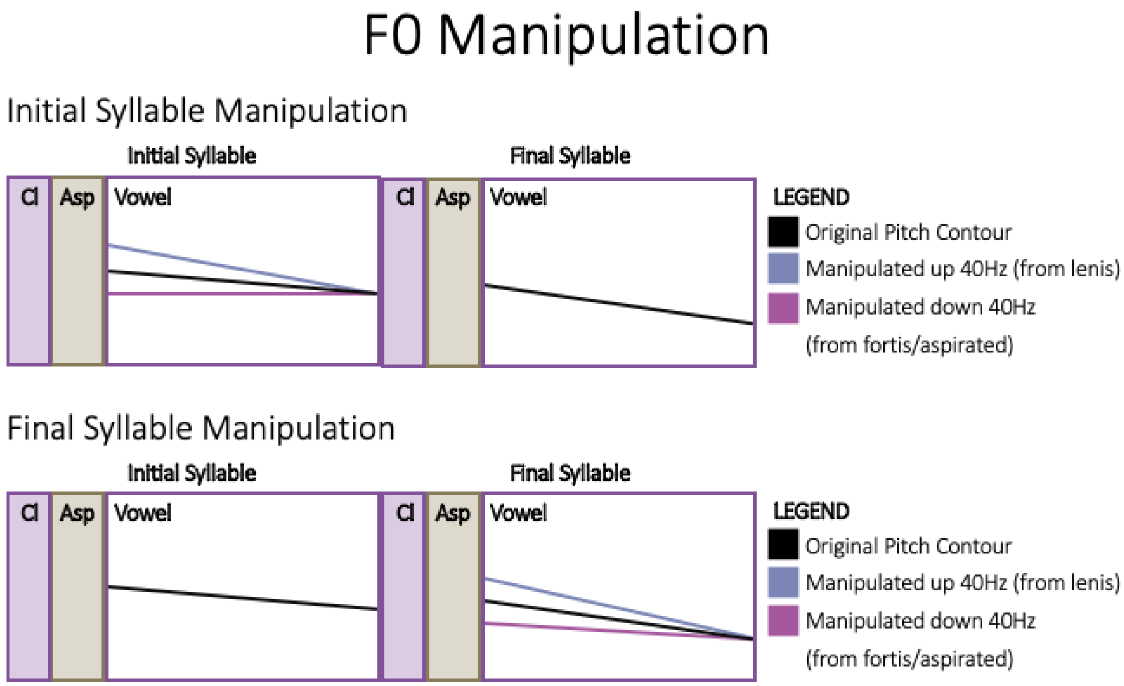

Figure 12: F0 manipulation from the original pitch contour of each token

The intensity of all stimuli were normalized to 70Hz. As this made a few stimuli quieter than the others, these stimulus items had their intensity adjusted to a higher intensity so their loudness matched the others. The stimuli were saved as wav files and converted to mp3 for use on the internet. All manipulations and measurements were done in Praat.

6.1.4 Procedure

The procedure was implemented online using jsPsych (de Leeuw, 2015; Ryu, 2018b) and consisted of two tasks (name gendering and consonant identification) and a language background questionnaire. The tasks were presented in that order, beginning with a consent form (Appendix C), a headphone check and a sound check. The headphone check reminded the participants to use headphones by asking them to indicate which kind of headphones they were wearing. In the sound check, the participants played an 80dB intensity pure tone and adjusted their computer volume to a level that was comfortable for them. The sound check also activated automatic audio playback on the participant's web browser.

For the name gendering task, participants were instructed to imagine that a Korean family with a boy and a girl had moved in next door and they were trying to figure out what each kid's name was. They were told they would hear a name and be asked to rate how male or female they thought it was. An audio symbol was presented to the participant on the screen while each name was played. Following each name, the participant was presented with a 6-point Likert-type scale ranging from 'Definitely Female' to 'Definitely Male'. The 8 training stimuli were presented to the participant first, followed by the 100 target items. Each block of items (training and target) was randomized by participant.

Next, a consonant identification task was conducted to assess how speakers categorized the target obstruents in the initial obstruent type stimuli. Participants were told that they would hear a word and were asked to determine which consonant the first (for initial syllable targets) or second (for final syllable targets) obstruent was. English participants were asked to indicate whether the consonant was voiced or voiceless (/t/ or /d/; /p/ or /b/). Korean participants were asked to indicate whether the consonant was fortis (/tt/ or /pp/), lenis (/t/ or /p/) or aspirated (/t^h/ or /p^h/). The target stimuli for this task were the initial consonant stimuli from the name gendering task. The task was blocked by position (initial syllable, final syllable). Prior to each block 6 training stimuli with nasals in the relevant position were presented to the participant. These stimuli were taken from the other stimuli for the name gendering task. Stimulus presentation was similar to the name gendering task. Participants were presented with the audio while an audio symbol was displayed on the screen. They were then presented with the relevant options presented in Roman orthography for the English version and Hangul (Korean orthography) for the Korean one.

Finally, Participants were given the language background questionnaire, thanked for their time and redirected to the Prolific site to receive compensation. Separate experiments were created for English and Korean participants. The materials were translated into Korean by a female native speaker of Seoul Korean for the Korean version of the experiment. All instructions were presented in Roman orthography for the English version and Hangul for the Korean one.

6.1.5 Analysis

The results of the two tasks were analyzed separately. For the identification task, the primary purpose was to check how listeners were perceiving the manipulated target sounds.

Separate CART models were constructed for each language with participants' response as the response variable and VOT and F0 as the predictor variables. CART analysis was chosen for this as the response variable for Korean had three levels: fortis, lenis and aspirated. The English response had two levels: voiced and voiceless. The CART analyses were conducted using the method described in Section 4.3.2.

For the name gendering task, which was the main task, separate analyses were conducted for each phonological factor (vowel type, vowel rounding, syllable closure, obstruent type). For all factors, full interaction mixed effects linear regression models were constructed using the *lmer()* function from the lme4 package (Bates et al., 2015) and the lmerTest package (Kuznetsova et al., 2017) to obtain significance values in R (R Core Team, 2019). Participants' ratings of the names as male or female were converted to a numerical six point scale ranging from 1 (definitely female) to 6 (definitely male). Rating was the response variable and the phonological factor and participant language (English or Korean) were the predictor variables. For the initial consonant type factor, separate analyses were conducted for the initial and final syllables with both VOT and F0 as fixed effects (alongside language). Random intercepts for participant, participant sex and item (defined as the base name) were included. No random slopes were included as models with random slopes failed to converge. Due to singular fit issues, item was excluded as a random intercept from the vowel type model containing participants of both languuges.

The factors were coded as follows. Two level factors (Vowel Type, Vowel Rounding, Language, F0) were contrast coded such that the alphabetically first item was coded as -0.5 and the second level was coded as 0.5. (i.e. for vowel type /o/ was -0.5 and /u/ was 0.5). The initial consonant type factor (underlying consonant) was Helmert coded to have comparisons between aspirated and the other two levels, and between fortis and lenis. The syllable type factor was Helmert coded for comparisons between 0 closed syllables and 1 or more closed syllables, between 1 and 2 closed syllables and between closed initial and final syllables.

In addition to the models for the full dataset which included language as a fixed effect, separate models were constructed for each language group. These had the same structure as the models which included both languages except that language was removed as a predictor variable. Due to singular fit issues, participant sex was excluded as a random intercept from the English and Korean vowel rounding models and the initial and final obstruent models for English.

6.2 Results

The classification tree was generated using the *plot()* and *text()* functions. All other plots were generated using ggplot 2. A link to the complete results of the regression models for the name gendering task can be found in Appendix C.

6.2.1 Identification Task

Figure 13 shows the proportion of Korean participants' categorization of syllable-initial obstruents as fortis, lenis and aspirated by VOT, F0 and syllable. Figure 14 shows the results of the CART analysis for Korean participants categorizations. Fortis and aspirated obstruents tend to be perceived as fortis and aspirated, regardless of position or F0, though there is a nonsignificant increase in lenis perception when the aspirated obstruent is in the initial syllable and has low F0. Lenis obstruents tend to be perceived as lenis in the final syllable, regardless of VOT; however, in the initial syllable, they tend to be perceived as aspirated if F0 is high and lenis if F0 is low.

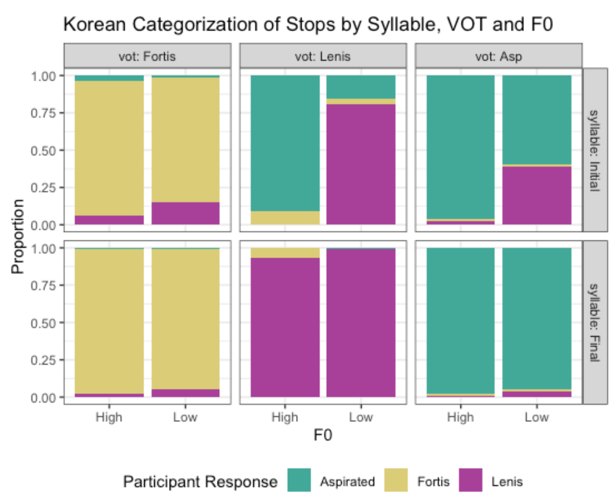

Figure 13: Bar chart showing Korean participants' categorization of initial obstruents as fortis, lenis and aspirated by VOT, F0 and syllable

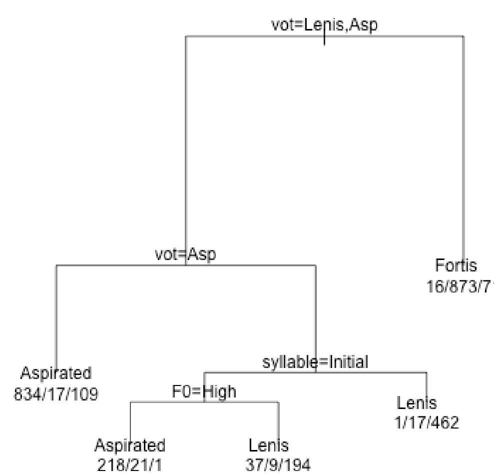

Figure 14: Trimmed CART tree (cp = 0.025) of Korean participants' initial obstruent categorization by VOT, F0 and syllable. Counts: Aspirated/Fortis/Lenis

Figure 15 shows the proportion of English participants' categorization of syllable-initial obstruents as voiced or voiceless by VOT, F0 and syllable. Figure 16 shows the results of the CART analysis for English participants categorizations. Aspirated obstruents are perceived as voiceless, regardless of syllable or F0. In the final syllable, lenis obstruents are more likely to be perceived as voiced, whereas they are more likely to be perceived as voiceless in the initial syllable. There is more variation in the perception of fortis obstruents, but, in contrast with lenis obstruents, they are more likely to be perceived as voiced in the initial syllable and voiceless in the final syllable. There is no significant effect of F0, though there is a trend in which obstruents with high tones are perceived more often as voiceless in all conditions.

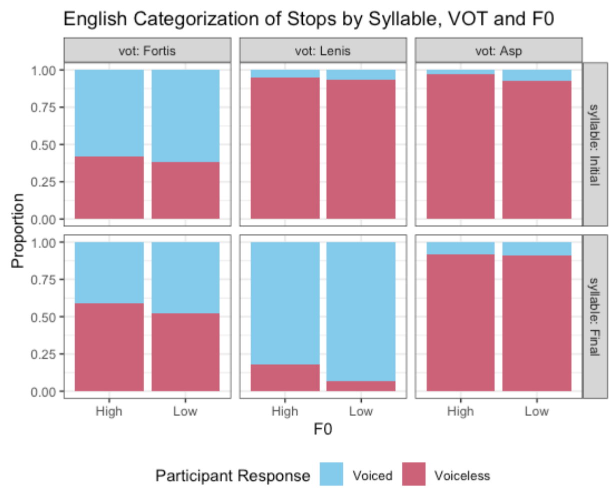

Figure 15: Bar chart showing English participants' categorization of initial obstruents as voiced or voiceless by VOT, F0 and syllable

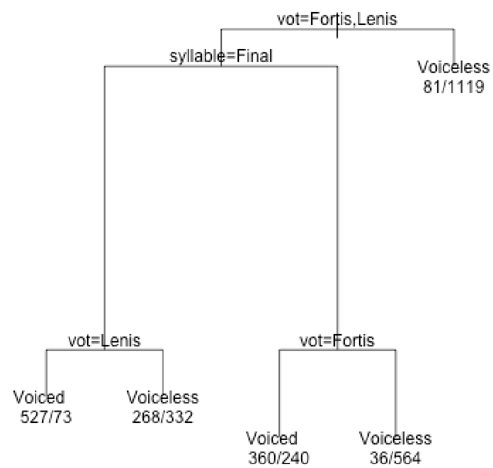

Figure 16: Trimmed CART tree (cp = 0.022) of English participants' initial obstruent categorization by VOT, F0 and syllable. Counts: Voiced/Voiceless

6.2.2 Name Gendering Task

Figure 17 shows participants' mean ratings for nonce names for the four phonological factors tested in the name gendering experiment. Panel A represents vowel type, which compared /u/ and /o/. English speakers rate names with /o/ (e.g. /tano/) as slightly more male than those with /u/ (e.g. /tanu/), though this is not statistically significant. In contrast, Korean speakers rate names with /u/ as more male than those with /o/. In the regression model comparing the two languages (Table 16), there was a significant effect of language whereby Koreans rated the names as more male than English speakers. There was also an interaction between vowel type and language which was significant at the 0.10 level. Whereas English speakers do not rate names with either vowel as significantly more male, Korean speakers rate those with /u/ as more male than those with /o/ at the 0.10 level (β = 0.2375, p = 0.05776).

Panel B represents vowel rounding, which compared vowels with and without a /w/ onglide. English speakers rate names with rounded vowels as more female (e.g. /iswe/ is rated more female than /ise/) while Koreans rate names with both vowel types approximately equally. There were no significant effects of vowel type in either language,

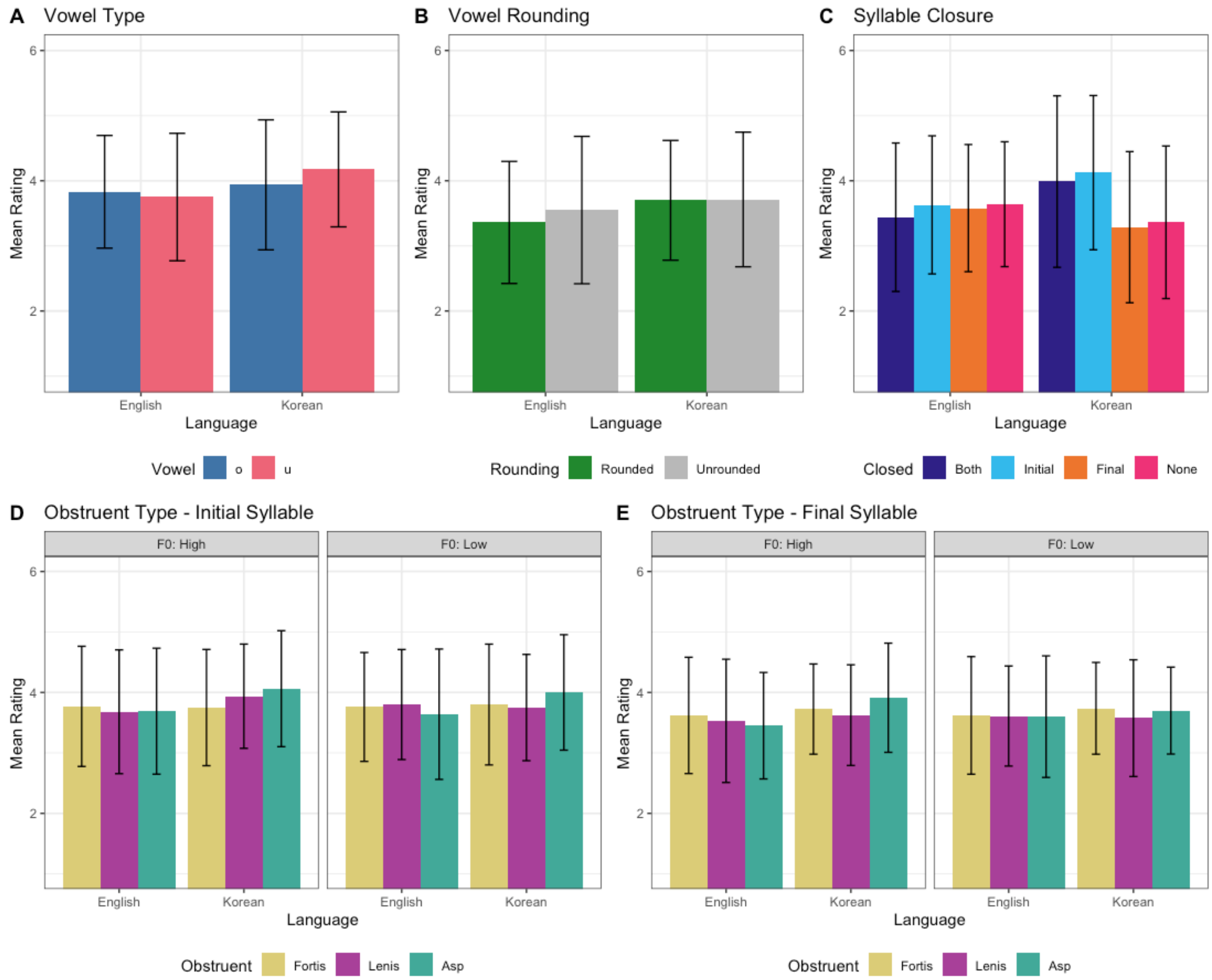

Figure 17: Bar charts showing participants' mean ratings of nonce names as male or female on a 6 point scale ranging from 1 (most female) to 6 (most male) for each of four factors (A - Vowel Type; B - Vowel Rounding, C - Syllable Closure, D - Initial Obstruent Type in the Initial Syllable; E - Initial Obstruent Type in the Final Syllable) by language and factor level. Error bars represent 1 standard deviation above or below the mean

though there was a significant effect of languages at the 0.10 level whereby English speakers rated names as more female overall compared to Korean speakers, as shown in Table 17.

Panel C shows the results of syllable closure, which compares names with two open syllables (e.g. /mitu/), two closed syllables (e.g. /mintun/) and either a closed initial syllable (e.g. /mintu/) or a closed final syllable (e.g. /mitun/). English speakers rate names with two closed syllables as more female than names with at least one open syllable. Korean speakers rate names with no closed syllables or with a final closed syllable as more

Table 16: Mixed effects linear regression model for the name gendering results (vowel type factor) with rating as the response variable, vowel type (Vowel Type) and participant language (Language) as predictor variables, and random intercepts for participant and sex. The second value in each comparison is the reference category (negative value).

	Estimate	*SE*	df	t	p	
(Intercept)	3.97631	0.17217	0.97896	23.095	0.0293	*
Vowel Type: Dark vs Light	0.06875	0.09186	304.00001	0.748	0.4548	
Language: Korean vs English	0.30101	0.13814	31.23552	2.179	0.0370	*
Vowel Type * Language	0.33750	0.18372	304.00001	1.837	0.0672	.

Table 17: Mixed effects linear regression model for name gendering results (vowel rounding factor) with rating as the response variable, vowel rounding (Rounding) and participant language (Language) as predictor variables, and random intercepts for participant, sex and item. The second value in each comparison is the reference category (negative value).

	Estimate	*SE*	df	t	p	
(Intercept)	3.61501	0.10738	2.26051	33.665	0.000422	***
Rounding: Unround vs Round	0.06736	0.09864	300.00001	0.683	0.495217	
Language: Korean vs English	0.20770	0.11948	31.72624	1.738	0.091839	.
Rounding * Language	-0.10972	0.19729	300.00001	-0.556	0.578522	

female than those with two closed syllables or a closed initial syllable.

The regression model with speakers of both languages (Table 18) shows a significant effect of the comparison between having one and two closed syllables at the 0.10 level whereby names with two closed syllables are more female. It also shows interactions between language and syllable closure for all three comparisons: no closed syllables vs 1 or 2 closed syllables, two closed syllables vs one closed syllable and an initial closed syllable vs a final closed syllable. The regression models for individual languages reveal the nature of these interactions. For the no closed syllables vs at least one closed syllable condition, Koreans rate names with no closed syllables as significantly more female (β = -0.4375, p = 0.00152) whereas English speakers rate them as more male (β = 0.1963, p = 0.0698), though in the latter case, only at the 0.10 significance level. For the comparison between two closed syllables and one closed syllable, Koreans rate names with two closed syllables as more male (β = 0.2812, p = 0.05341) whereas English speakers rate them as more female, (β = -0.2222, p = 0.0530), both at the 0.10 significance level. For the comparison between the initial and final closed syllables, Koreans rate names with initial closed syllables as more male ($\beta = 0.8375$, $p < 0.001$) whereas there is no significant difference between these two conditions for English speakers.

Table 18: Mixed effects linear regression model for the name gendering results (syllable closure factor) with rating as the response variable, closed syllables (CVC) and participant language (Language) as predictor variables, and random intercepts for participant, sex and item. The second value in each comparison is the reference category (negative value).

	Estimate	***SE***	**df**	**t**	**p**	
(Intercept)	3.5981	0.2298	2.3908	15.654	0.001823	**
CVC: 0 vs 1-2	0.1963	0.1219	636.0000	1.610	0.107902	
CVC: 2 vs 1	-0.2222	0.1293	636.0000	-1.718	0.086217	.
CVC: Initial vs Final	0.1111	0.1493	636.0000	0.744	0.457107	
Language: English vs Korean	0.1694	0.1325	31.1981	1.279	0.210293	
CVC (0 vs 1-2)*Language	-0.6338	0.1777	636.0000	-3.566	0.000390	***
CVC (1 vs 2)*Language	0.50357	0.1885	636.0000	2.671	0.007763	**
CVC (Initial vs Final)*Language	0.7264	0.2177	636.0000	3.337	0.000896	***

Panels D and E in Figure 17 show the results of the initial obstruent type factor for the initial and final syllables, respectively. This factor compares how speakers rate names with the VOT of fortis, lenis and aspirated obstruents and either high or low F0. In the initial syllable condition (D), English speakers rate fortis obstruents (e.g. /ppoma/) as the most male in the high F0 condition, with lenis (e.g. /poma/) and aspirated (e.g. /p^homa/) obstruents yielding similar ratings. In the low F0 condition, lenis obstruents are the most male, followed by fortis and aspirated ones, in that order. For Korean speakers, aspirated obstruents are rated the most male in both F0 conditions. In the high F0 condition, lenis obstruents are rated more male than fortis obstruents whereas fortis obstruents are rated more male in the low F0 condition.

The regression model with both languages for the initial syllable (Table 19) shows an effect of language, significant at the 0.10 level, whereby Koreans rate names as more male than English speakers and an interaction between the comparison of aspirated and other obstruent types and language. The results of the individual language models show no significant effects in English, but a significant effect of the comparison between aspirated and other obstruents whereby aspirated obstruents are rated as more male ($\beta = 0.22187$, $p = 0.00243$). This suggests Koreans rate aspirated obstruents as more male but English speakers don't. There were no other significant effects in the Korean analysis.

In the final syllable condition (E), English speakers rate fortis obstruents (e.g. /nattu/) as the most male and aspirated ones (e.g. /nat^hu/) as the most female, with this effect being most evident in the High F0 condition (the first panel). Korean speakers rate aspi-

Table 19: Mixed effects linear regression model for the name gendering results (initial obstruent type factor) with rating as the response variable, obstruent type (VOT), F0 (F0) and participant language (Language) as predictor variables, and random intercepts for participant, sex and item. The second value in each comparison is the reference category (negative value). Table shows main effects and significant interactions only. Full results are available at the link in Appendix C

	Estimate	***SE***	**df**	**t**	**p**	
(Intercept)	3.81457	0.17514	4.59014	21.780	<0.001	***
VOT: Aspirated vs Fortis/Lenis	0.07760	0.05766	971.99999	1.346	0.1786	
VOT: Fortis vs Lenis	-0.02882	0.06658	971.99999	-0.433	0.6652	
F0: Low vs High	-0.01296	0.05436	971.99999	-0.238	0.8116	
Language: Korean vs English	0.19326	0.10142	31.45105	1.906	0.0659	.
VOT (A vs F/L)*Language	0.28854	0.11532	971.99999	2.502	0.0125	*

rated obstruents as the most male and lenis obstruents (e.g. /natu/) as the most female in the High F0 condition. In the low F0 condition, ratings are more similar, though fortis and aspirated obstruents are rated more male than lenis ones.

The regression model with both languages for the final syllable (Table 20) shows significant interactions between the comparisons between aspirated and other obstruent types and language, between F0 and language and between the comparison between aspirated and other obstruent types, F0 and language, though the latter two interactions were only significant at the 0.10 level. In the individual language models there are no significant effects for the English speakers, but there are significant main effects of obstruent type for the Korean speakers. Koreans rate aspirated obstruents as more male than other obstruents ($\beta = 0.14062$, $p = 0.022745$) and fortis obstruents as more male than lenis ones ($\beta = 0.13125$, $p = 0.065350$), though in the latter case, only at the 0.10 level. This suggests Koreans rate aspirated obstruents as more male but English speakers don't. There aren't any significant effects related to F0 to explain the latter two interactions, however there is a trend whereby English speakers rate lower F0s as more male while Korean speakers rate them as more female, suggesting there may be a diverging pattern of F0 perception between speakers of the two languages. This pattern also holds for the interaction between F0 and the comparison between aspirated and other obstruent types.

6.2.3 Summary

The results of the experiment, which are summarized in Table 21, suggest that English and Korean speakers behave differently with regards to assigning gender to unfamiliar

Table 20: Mixed effects linear regression model for the name gendering results (final obstruent type factor) with rating as the response variable, obstruent type (VOT), F0 (F0) and participant language (Language) as predictor variables, and random intercepts for participant, sex and item. The second value in each comparison is the reference category (negative value). Table shows main effects and significant interactions only. Full results are available at the link in Appendix C

	Estimate	***SE***	**df**	**t**	**p**	
(Intercept)	3.68955	0.19742	4.43046	18.689	2.2e-05	***
VOT: Aspirated vs Fortis/Lenis	0.04115	0.04871	972.00000	0.845	0.3985	
VOT: Fortis vs Lenis	0.09062	0.05624	972.00000	1.611	0.1074	
F0: Low vs High	0.00463	0.04592	972.00000	0.101	0.9197	
Language: Korean vs English	0.11504	0.12501	31.44879	0.920	0.3645	
VOT (A vs F/L)*Language	0.19896	0.09742	972.00000	2.042	0.0414	*
F0*Language	-0.17593	0.09185	972.00000	-1.915	0.0557	.
VOT (A vs F/L)*F0*Language	-0.35486	0.19484	972.00000	-1.821	0.0689	.

Korean names based on most of the phonological factors examined. Vowel rounding had no effect in either language, however, there were effects of vowel type, syllable closure and obstruent type which differed between the languages. For vowel type, Koreans rated /u/ as more male than /o/ whereas English speakers made no distinction or did the opposite. For syllable closure, Koreans rated names with an initial closed syllable as more male, regardless of the closure of the second syllable while English speakers rated names with two closed syllables as more female.

For obstruent type, Korean speakers rated names with aspirated obstruents as more male, regardless of syllable while English speakers made no distinction between obstruent types. There do also appear to be possible diverging effects of F0 in the final syllable between the two languages whereby lower F0 results in a more male rating for English speakers but a more female rating for Korean speakers, though this result is questionable. The results of the identification task show that VOT (obstruent type) is of primary importance in determining obstruent type in the final syllable, where the obstruent is intervocalic. In the initial syllable, F0 plays a larger role, but for Korean speakers only, in that low VOT results in more lenis perception and high VOT in more aspirated perception for obstruents with lenis and aspirated VOT.

Figure 18 compares the results of the identification and name gendering tasks for the English participants. There does not appear to be any correlation between participants' identification of obstruents as voiced or voiceless and their ratings in the name gendering task. Figure 19 compares the results of the identification and name gendering tasks for the

Table 21: Summary of Name Gendering Experiment Results. ✓ = results match hypothesis; X = results do not match hypothesis

	Korean		English	
	Hypothesis	*Result*	*Hypothesis*	*Result*
Syllable Closure	More closed syllables = more male	✓	More closed syllables = more male	X
Vowel Rounding	Round = more male than unround	X	Round = more male than unround	X
Vowel Type	Dark ([u]) = more male than light ([o])	✓	High ([u]) = more female than low ([o])	X
Obstruent Type	Aspirated = more male than lenis	✓	No difference between obstruent types	✓
	Fortis = more male than lenis	X	Fortis = more male in initial syllable	X

Korean participants. These participants rate the obstruents they identified as aspirated as the most male, followed by those they identified as fortis. They rate the names they identified as lenis as the most female. Of particular interest are the initial lenis obstruents with high VOT which are categorized as aspirated obstruents in the discrimination task and have a mean rating closer to that of the aspirated obstruents than the other lenis obstruents.

6.3 Discussion

The purpose of the experiment was twofold: first, to determine if Korean speakers made use of the patterns present in the corpus analysis, and, second, to investigate how native (Korean) vs. non-native (English) language speakers use language-specific and more universal patterns to assign gender to nonce names. With regards to the first question, Korean speakers appear to use most of the phonological factors in assigning gender to nonce names. With regards to the second, English and Korean speakers appear to either use the phonological factors differently or make use of different factors to assign gender to nonce names. I discuss the findings of the name gendering experiment, with reference to these goals, for each factor separately below.

Syllable	F0	Fortis ID Percentage	Fortis Rating	Lenis ID Percentage	Lenis Rating	Aspirated ID Percentage	Aspirated Rating
Initial Syllable	High F0	Voiced 58% Voiceless 42%	3.77	Voiced 5% Voiceless 95%	3.68	Voiced 3% Voiceless 97%	3.69
Initial Syllable	Low F0	Voiced 62% Voiceless 38%	3.76	Voiced 7% Voiceless 93%	3.80	Voiced 7% Voiceless 93%	3.64
Final Syllable	High F0	Voiced 41% Voiceless 59%	3.62	Voiced 82% Voiceless 18%	3.53	Voiced 8% Voiceless 92%	3.45
Final Syllable	Low F0	Voiced 48% Voiceless 52%	3.62	Voiced 93% Voiceless 7%	3.61	Voiced 9% Voiceless 91%	3.60

Figure 18: Comparison of the results of the identification and name gendering (rating) tasks for obstruent type for the English participants. Cells are colour coded based on the obstruent type most commonly chosen by the participants in the identification task (red = voiceless, blue = voiced). The large number represents the mean rating for each cell (syllable, VOT and F0). Higher ratings are more male.

Syllable	F0	Fortis ID Percentage	Fortis Rating	Lenis ID Percentage	Lenis Rating	Aspirated ID Percentage	Aspirated Rating
Initial Syllable	High F0	Fortis 90% Lenis 6% Aspirated 4%	3.75	Fortis 9% Lenis 0% Aspirated 91%	3.94	Fortis 2% Lenis 3% Aspirated 96%	4.06
Initial Syllable	Low F0	Fortis 83% Lenis 15% Aspirated 1%	3.80	Fortis 4% Lenis 81% Aspirated 15%	3.75	Fortis 2% Lenis 39% Aspirated 59%	4.00
Final Syllable	High F0	Fortis 97% Lenis 3% Aspirated 1%	3.72	Fortis 7% Lenis 93% Aspirated 0%	3.62	Fortis 2% Lenis 0% Aspirated 98%	3.91
Final Syllable	Low F0	Fortis 94% Lenis 5% Aspirated 1%	3.74	Fortis 0% Lenis 99% Aspirated 0%	3.58	Fortis 2% Lenis 4% Aspirated 95%	3.70

Figure 19: Comparison of the results of the identification and name gendering (rating) tasks for obstruent type for the Korean participants. Cells are colour coded based on the obstruent type most commonly chosen by the participants in the identification task (yellow = fortis, purple = lenis, green = aspirated). The large number represents the mean rating for each cell (syllable, VOT and F0). Higher ratings are more male.

6.3.1 Syllable Structure

Korean participants rated names with a final closed syllable (and open initial syllable) or no closed syllables as more female than those with two closed syllables or an initial closed syllable (and open final syllable). The findings, overall, are consistent with what was expected, increasing the number of closed syllables increases participants' tendencies to rate names as more male. However, there is also a significant difference between which syllable is closed when only one is. Names with an initial closed syllable are rated more male than names with a final closed syllable.

This finding is not entirely unexpected because the corpus studied showed that the proportion of Korean names with an initial closed syllable that were male was higher than that of names with a final closed syllable; however, it does mean that names with initial closed syllables are approximately as likely as names with two closed syllables to be rated more male and those with a final closed syllable elicit responses similar to those for names with two open syllables. In both cases, the names with one closed syllable had more extreme ratings than those with either two closed or two open syllables. These comparisons were not tested in the analysis, so it's not clear if they were significant or not. However, this does seem to suggest that Korean speakers pay more attention to the structure of the initial syllable than the final syllable when assigning gender to names. A closed initial syllable indicates a male name whereas an open initial syllable indicates a female one.

English participants were expected to behave similarly to Korean participants, rating names as more male if they contained more closed syllables, however this expectation was not realized in the results. English speakers rated names with two closed syllables as more female relative to the other three conditions, which contained at least one open syllable. English speakers rated these other conditions similarly to each other. This finding is unexpected and runs contrary to what had been found in English speakers' responses to English and French names manipulated for syllable closure (Sullivan & Kang, 2019).

One possible explanation for this is that this study used sonorants to close syllables whereas the voiced fricative /v/ was used in the English/French study (Sullivan & Kang, 2019). In the latter case, /v/ was chosen as it was neither a voiceless stop nor a sonorant. In the French/English study, English speakers also rated names which contained a sonorant consonant (/l/) as more female than those that did not. It is possible that English speakers are making more use of sonorancy, and this is overriding any effect syllable closure might have on their assignment of gender to the names.

Another possible explanation is that Korean is much more foreign to the English participants in this study than French was to the participants in Sullivan and Kang (2019). In that study, participants were mostly Canadian and would, therefore, have had at least some exposure to French. French is also much more closely related to English than Korean is. Given this, the participants in Sullivan and Kang (2019) would have had more familiarity with French and may, therefore, have been more comfortable extending sound patterns to French names than the participants in the current study, who had little to no familiarity with Korean, were extending them to Korean.

In order to investigate these two possibilities further, future research could look at manipulating the interactions between factors in the same language. For example, creating names with syllables closed by both sonorants and obstruents and seeing if that has an effect on ratings. It could also test the same participants on speakers of multiple languages using the same stimuli. For example, recording English, French and Korean speakers using the stimuli from this study and presenting all three to participants. Differences between the groups would suggest effects of familiarity on name gender assignment.

6.3.2 Vowel Rounding

Vowel rounding was the one factor where Koreans didn't behave as expected. There was no difference in their ratings of rounded and unrounded vowels, contrary to what was found in the corpus analysis where round vowels were more male. It is possible that this is because of the nature of the manipulation, which added a round onglide rather than rounding the vowel; however, /w/-onglides display similar patterns to round vowels in the corpus analysis. Another possibility is that the rounding factor is heavily influenced by backness. There were very few front round vowels in the corpus, thus the pattern observed for rounding may actually be a backness pattern. In that case, adding a /w/-onglide doesn't significantly change the position of the vowel, meaning the two vowels have the same property for the factor participants are using to assign gender to the name. A final possibility is that this is just a historical pattern, which would be consistent with Wong and Kang (2020) results for Cantonese speakers which found that they too did not make use of rounding. It is possible that vowel rounding is a shared artefact from the history of both languages' names. These factors could be teased apart by doing further studies on Korean which used a variety of manipulations of rounding, including type and position. Consistent results across studies would lend support to a historical explanation whereas conflicting results could provide support for one of the other two theories.

English speakers, likewise, do not show a significant pattern, suggesting speakers of the two languages behave similarly for this factor. There is, however, a nonsignificant trend in which the English speakers rate names with round vowels as more female. This finding runs contrary to the findings of the Cantonese and English/French studies which found that round and back vowels, respectively were rated more male. Further investigation into this factor with English speakers may shed more light on whether or not and how English speakers use vowel roundness and/or backness to determine gender.

6.3.3 Vowel Type

Korean participants rated names with /u/ (dark) as more male than names with /o/ (light), suggesting that speakers do make use of the language-specific light-dark sound symbolic pattern rather than the more universal vowel height pattern. On the other hand, English speakers show no difference in their choice of gender between the two vowels, which is consistent with the results of the corpus analysis in Section 5. This could be because they consider both vowels to be high. Regardless, it does suggest that English speakers do not make use of this Korean language-specific pattern.

6.3.4 Obstruent Type

In the onset of the initial syllable, Korean participants rated aspirated obstruents as more male than other obstruent types. In the onset of the final syllable, they rated names with an aspirated obstruent as more male than names with fortis and lenis obstruents, and those with fortis obstruents as more male than lenis obstruents. These results are consistent with the results of the corpus studies which show that aspirated and fortis obstruents may be associated with maleness more than lenis obstruents. There was no effect of F0 in the initial position, despite the fact that a high F0 did result in an increase in obstruents with lenis VOT being perceived as aspirated in the identification task, suggesting VOT may be more important than F0 for name gendering for Koreans. Overall, these results suggest that Korean speakers take onset type into consideration when assigning gender to nonce names.

Unlike in Korean, there was no effect of obstruent type in either syllable in English, even when both F0 and VOT are considered. This is consistent with the prediction that English speakers would not distinguish between obstruent types in the final syllable; however the possible difference between perceived voiced (fortis) and voicelss(aspirated and lenis) obstruents in the onset of the initial syllable, which was predicted by the results of the corpus analysis in Section 5, does not materialize, suggesting that this pattern may not be actively used by speakers, though it is possible that this could be due to the highly variable perception of initial fortis obstruents, which were only perceived as voiced about 60% of the time (see Figure 18). More importantly, this result suggests that English speakers do not make use of the Korean language-specific obstruent type pattern.

7 Conclusion

This study used corpus analyses and a name gendering experiment to investigate sound symbolism in Korean given names and expands the number of languages in which this phenomenon has been investigated. Korean presented an opportunity to investigate not just proposed universal patterns, but also language-specific sound symbolic patterns and how they interact with universal patterns, both in the lexicon of names and in speakers' minds.

The corpus analyses showed that Korean names have many of the same phonological patterns as names in other languages. Of the patterns investigated, only initial sound type had no predictive power and only vowel height trended in the opposite direction of what universal patterns would predict. In the latter case, this is likely due to the language-specific sound symbolic dark-light pattern present in Korean. This pattern runs somewhat, though not exactly, contrary to the height pattern in that lower vowels are light and higher vowels are dark, but light vowels are associated with femaleness and dark vowels, with maleness. The opposite is true in the height pattern where higher vowels are more female. This suggests that both universal and language-specific sound symbolic patterns are present in the language and that the language-specific factor may trump the more universal one, which is similar to what Shih et al. (2019) found in their cross-linguistic study of Pokémon names. The other language-specific factor, obstruent type, did not display any significant results in the corpus analysis (beyond obstruents being, in general, more male than sonorants); however, the results of the name gendering experiment showed some evidence of the non-significant trend observed in the second corpus analysis (Section 5), in which a higher proportion of the names with aspirated and fortis obstruents were male than of those with lenis obstruents, suggesting that this pattern too may be present in the lexicon.

Overall, the corpus results support the notion that both universal and language-specific sound symbolic patterns can be found in given names, and that they can interact, with the language-specific pattern prevailing. The findings with regards to vowel type are interesting because they do not match the acoustic explanations for the universal height pattern found in the frequency code hypotheses (Ohala, 1984, 2004). This suggests a that at least some sound symbolic patterns are phonological, rather than purely acoustic. These findings present an opportunity for modelling sound symbolic interactions in an Optimality Theoretic framework, such as those proposed by Alderete and Kochetov (2017) and Kawahara et al. (2019). Such a model could identify explicitly how the constraints interact.

Other directions for future research include continuing to expand the number of languages investigated to get a better understanding of which patterns may be universal, and how universal they are. More specifically, it would be interesting to investigate other languages which have language-specific patterns to see if these patterns are present in the names in those languages. Of particular interest would be languages with patterns like Korean's dark-light vowel pattern which run against the proposed universal patterns.

The name gendering experiment shows that, overall, Korean speakers appear to use both language-specific and sound symbolic patterns to assign gender to names. Where two patterns conflict, as is the case for vowel type and height, the language-specific pattern prevails over the more universal one, which is consistent with the findings of the corpus study. This finding suggests that, like in other languages, the many of the sound symbolic patterns found in the lexicon are also actively used by speakers to determine name gender. This includes the language-specific factors which appear to extend beyond the sound symbolic vocabulary and can be actively used to determine the gender of unfamiliar names. In the case of the vowel type pattern, like the corpus analysis results, these findings suggest that sound symbolism isn't fully acoustic and may have at least some phonological component. This finding is similar to the findings of the Kutchi (Ananthathurai et al., 2019) study in which participants assigned male gender to longer names, which mirrored the results of the Kutchi analysis and ran contrary to the more universal analysis (shorter names are more male); though, unlike in Korean, when a Kutchi factor ran contrary to the more universal pattern in a non-significant way, Kutchi participants followed the more universal pattern rather than the Kutchi one.

The vowel rounding factor was the only factor studied for which the expected pattern was not observed. In this case, there was no difference between the two conditions. This is similar to the finding of the Cantonese study (Wong & Kang, 2020) that Cantonese participants did not use this factor. This finding suggests that some trends in the data could be lexicalized and may, therefore, no longer be active in speakers' minds, especially as these two languages' names are etymologically related. However, more work is needed testing this factor in both Cantonese and Korean, as well as in languages where this is not a factor to determine if this is the case.

Additionally, the results for the English speakers show that Korean and English speakers make different use of sound symbolic patterns. While results were similar for the vowel rounding factor, English speakers showed no significant patterns for obstruent and vowel type. This was not unexpected as these were language-specific factors which English speakers were not expected to make use of and, for the vowel pattern, both vowels used are higher vowels in English, so the height pattern may not have had a strong effect there. English speakers also displayed unusual results for the syllable structure factor, rating names with two closed syllables as more female than male, contrary to expectations based on corpus studies (Slater & Feinman, 1985; Sullivan, 2018; Wright et al., 2005) and an experimental study where English speakers rated French and English nonce names with a closed syllable as more male than those with two open syllables (Sullivan & Kang, 2019). The possible explanations for this were discussed in Section 6.3.1.

Overall, the results of the name gendering experiment support the findings of the corpus analysis that universal and language-specific factors are at play, suggesting that they are actively used by native speakers to assign gender to unfamiliar names if they are present in the name lexicon. For non-native speakers, the results indicate that they do not use language-specific factors and that they may or may not use more universal factors, possibly depending on how foreign the language is to them. This last finding is less clear as possible reasons for the lack of effect for the syllable structure factor include an interaction with sonorancy patterns.

Further experimental research could look into the nature of interactions between factors in determining gender in nonce names. This would address questions about which factor overrides the other, and, if tested in different languages, could address whether the importance of factors varies across languages. For example, in this experiment, it appears that Korean speakers prioritize syllable structure over sonorancy to determine gender when both factors are present, but English speakers do the opposite, prioritizing sonorancy over syllable structure. Running an additional experiment using an English speaker could verify whether this is the case, or there is an effect of speaker language. If it is the case that there are interactions between factors, and that the interactions vary across languages, this could also be modelled in OT (Alderete & Kochetov, 2017; Kawahara et al., 2019). Finally, more testing of language-specific factors in more languages is needed to determine if these factors are used in all languages, and, if so, if speakers actively use them to override more universal factors. As such patterns may run contrary to acoustic tendencies, such a finding would support the idea that sound symbolism is not fully acoustic and may have a phonological component.

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Appendix A: Full Results and Data for the Korean Corpus Analysis

Data

Korean names in Hangul, IPA, phonetic phonetic transcription and phonemic transcription coded for gender: http://lisasullivan.ca/gp2/korean_names.txt

Phonetic Analysis

Table 22: Summary of the phonetic analysis results of the three models (CART, UV - univariate regression, MV - multivariate regression) for the full name, the initial syllable and the final syllable analyses. ✓ = significant at the 0.05 level of above, ? = significant at the 0.10 level, X = significant in the opposite direction at the 0.10 level, • = included in the trimmed model, but not significant, NA = not evaluated in this model

	Full Name			**Initial Syllable**			**Final Syllable**		
	CART	UV	MV	CART	UV	MV	CART	UV	MV
Open Syllables	✓	✓	✓	✓	✓	✓	✓	✓	✓
Initial Sound	NA	NA	NA						
Vowel Type		✓							
Vowel Height						X			
Vowel Backness		✓		✓				✓	✓
Vowel Roundness	✓	✓	✓				✓	✓	
Vowel Length					?	?	•	✓	✓
Diphthong Type		✓	✓			✓	•		✓
Stops		✓	✓	✓	✓	✓			•
Sonorants		?						✓	
Lenis Obstruent	✓	✓					✓	✓	•
Fortis Obstruent				NA	NA	NA		?	
Aspirated Obstruent	✓	✓	✓			✓	✓	?	✓

Full Results: http://lisasullivan.ca/gp2/phonetic-results.html

Phonological Analysis

Table 23: Summary of the phonological analysis results of the three models (CART, UV - univariate regression, MV - multivariate regression) for the full name, the initial syllable and the final syllable analyses. ✓ = significant at the 0.05 level of above, ? = significant at the 0.10 level, X = significant in the opposite direction at the 0.10 level, • = included in the trimmed model, but not significant, NA = not evaluated in this model

	Full Name			**Initial Syllable**			**Final Syllable**		
	CART	UV	MV	CART	UV	MV	CART	UV	MV
Open Syllables	✓	✓	✓	✓	✓	✓	✓	✓	✓
Initial Sound	NA	NA	NA	•					
Vowel Type		✓	✓						
Vowel Height				•					
Vowel Backness		✓		✓				✓	
Vowel Roundness	✓	✓	✓				✓	✓	✓
Vowel Length							•	?	?
Diphthong Type		✓	✓		?		•	?	✓
Stops		✓	✓	✓	✓	✓			
Sonorants		?						✓	✓
Lenis Obstruent		✓					✓		•
Fortis Obstruent			•	NA	NA	NA			
Aspirated Obstruent		?	✓				✓		•

Full Results: http://lisasullivan.ca/gp2/phonemic-results.html

Appendix B: Full Results and Data for the English and Korean Corpus Analysis for Vowel and Consonant Type

Data

Korean names in Hangul, IPA, phonetic phonetic transcription and phonemic transcription coded for gender: http://lisasullivan.ca/gp2/korean_names.txt

English names in orthography, coded for gender: http://lisasullivan.ca/gp2/english_names.txt

Korean Results

Vowel Type

Table 24: Univariate mixed effects logistic regression model for the initial syllable with gender (M or F) as the response variable, vowel (u vs o) as the predictor variable, and a random intercept for syllable

	Estimate	*SE*	z-value	p
(Intercept)	-0.01862	0.41959	-0.044	0.965
Vowel: u	0.52957	0.84198	0.629	0.529

Table 25: Univariate mixed effects logistic regression model for the final syllable with gender (M or F) as the response variable, vowel (u vs o) as the predictor variable, and a random intercept for syllable

	Estimate	*SE*	z-value	p	
(Intercept)	0.9445	0.2872	3.288	0.00101	**
Vowel: u	1.1442	0.5695	2.009	0.04453	*

Onset Type

Table 26: Univariate mixed effects logistic regression model for the initial syllable with gender (M or F) as the response variable, initial consonant type (lenis, aspirated obstruent, sonorant, none) as the predictor variable, and a random intercept for syllable

	Estimate	***SE***	**z-value**	**p**	
(Intercept)	0.0003491	0.2297563	0.002	0.9988	
Onset: Obstruent vs Sonorant	2.0277764	0.9209393	2.202	0.0277	*
Onset: Aspirated vs Lenis	0.7718840	0.6951012	1.110	0.2668	
Onset: Sonorant vs None	-0.5733048	0.6034979	-0.950	0.3421	

Table 27: Univariate mixed effects logistic regression model for the final syllable with gender (M or F) as the response variable, initial consonant type (fortis, lenis, aspirated obstruent, sonorant, none) as the predictor variable, and a random intercept for syllable

	Estimate	***SE***	**z-value**	**p**	
(Intercept)	1.0579	0.4644	2.278	0.0227	*
Onset: Obstruent vs Sonorant	6.1858	1.9713	3.138	0.0017	**
Onset: Fortis vs Aspirated/Lenis	1.5845	1.8686	0.848	0.3964	
Onset: Aspirated vs Lenis	1.7944	1.2819	1.400	0.1616	
Onset: Sonorant vs None	-0.4657	0.7163	-0.650	0.5157	

English Results

Vowel Type

Table 28: Univariate logistic regression model for the non-final syllables with gender (M or F) as the response variable and vowel (u vs o) as the predictor variable

	Estimate	*SE*	z-value	p
(Intercept)	-0.05889	0.20038	-0.294	0.769
Vowel: u	-0.11778	0.40076	-0.294	0.769

Table 29: Univariate logistic regression model for the final syllable with gender (M or F) as the response variable and vowel (u vs o) as the predictor variable

	Estimate	*SE*	z-value	p	
(Intercept)	1.7952	0.4308	4.167	<0.001	***
Vowel: u	-0.3716	0.8615	-0.431	0.666	

Onset Type

Table 30: Univariate logistic regression model for the initial syllable with gender (M or F) as the response variable and initial consonant type (voiced, voiceless obstruent, sonorant, none) as the predictor variable

	Estimate	*SE*	z-value	p	
(Intercept)	0.06185	0.05255	1.177	0.23920	
Onset: Obstruent vs Sonorant	0.48081	0.21019	2.287	0.02217	*
Onset: Voiceless vs Voiced	-0.45675	0.14436	-3.164	0.00156	**
Onset: Sonorant vs None	0.10575	0.15278	0.692	0.48886	

Table 31: Univariate logistic regression model for the final syllable with gender (M or F) as the response variable and initial consonant type (voiced, voiceless obstruent, sonorant, none) as the predictor variable

	Estimate	***SE***	**z-value**	**p**	
(Intercept)	0.13920	0.05937	2.345	0.0190	*
Onset: Obstruent vs Sonorant	1.68077	0.23747	7.078	<0.001	***
Onset: Voiceless vs Voiced	0.08664	0.16013	0.541	0.5885	
Onset: Sonorant vs None	-0.29492	0.17536	-1.682	0.0926	.

Appendix C: Materials and Results for the Name Gendering Experiment

Note: This section contains the English versions of materials. Materials were translated to Korean for the Korean participants. Some parts of the background questionnaire were excluded from the Korean version of the study, as described in section 6.1.2

Consent Form

Linguistic Experiment: Consent for Participation in a Research Project

Invitation to Participate and Description of Project

You are invited to participate in a linguistic experiment. You are free to decline to participate if you wish. In order to decide whether or not you wish to be a part of this research study you should know enough about its general purpose, risks and benefits to make an informed judgment. This consent form gives you detailed information about the procedures of the experiment, as well as any risks of the procedures and any possible benefits of these studies. Once you understand the procedures, you will be asked to indicate if you wish to participate by selecting a radio button next to a statement indicating whether or not you consent to participate.

Purpose of research

The principal researcher is Lisa Sullivan under the supervision of Dr. Yoonjung Kang in the Centre for French and Linguistics at the University of Toronto Scarborough. The general purpose of the research is to understand the relationship between language and mind.

Description of the Procedure

The experiment will consist of three tasks. During the first task, you will hear names and be asked to indicate whether you think they are male or female names and how confident you are in that regard. In the second task, you will hear a word and decide which of two sounds you heard. The third task will be a demographic questionnaire. The experiment is expected to take 30 minutes to complete.

Risks and Inconveniences

The procedure involves no known risk or discomfort.

Benefits

This study will provide no benefit to you but will provide us with information that may lead to the future benefit of others.

Compensation

You will receive the equivalent of $5.00 CAD as compensation for 30 minutes of your time. Furthermore, you should know that if you fail to complete the full experimental procedure, you will, nonetheless, receive your compensation in proportion to the tasks you completed.

Confidentiality

Your name will not be recorded and, therefore, will not appear in subsequent scholarly presentations or publications. Other personal information gathered in this study will not be disclosed to any persons other than the investigators and their collaborators. Furthermore, effort will be made to keep this information secure and to destroy it once the results of the study have been published. Following the standard practice in linguistics research, recorded linguistic data, however, will not be disposed (unless by specific request of the participant), as its preservation is necessary for further studies involving wider samples of speakers or for studies examining linguistic change over time.

The research study you are participating in may be reviewed for quality assurance to make sure that the required laws and guidelines are followed. If chosen, (a) representative(s) of the Human Research Ethics Program (HREP) may access study-related data and/or consent materials as part of the review. All information accessed by the HREP will be upheld to the same level of confidentiality that has been stated by the research team.

Voluntary Participation

You are free to choose not to participate, and, if you do become a participant, you are free to withdraw from the experiment at any time during its course, by clicking on the "withdraw" button at the bottom of the screen. Due to the anonymous nature of the experiment, you will not be able to withdraw after you have completed the experiment. Should you terminate your participation, you may do so without jeopardizing any of the following that may apply to you, namely, any opportunities to serve as a participant in future experiments or your standing as a student if you are a student.

Authorization

By clicking next, you acknowledge that you have read this form and decided that you will participate in the experiment described above. Its general purpose, procedure, possible risks and benefits have been explained to your satisfaction.

If you have further questions about this project, please contact the principal investigator, Dr. Yoonjung Kang, 416-287-7172 or yoonjung.kang@utoronto.ca. If you have any questions about your rights as a research participant, please contact the Office of Research Ethics, 416-946-3273 or ethics.review@utoronto.ca

Background Questionnaire

Sex

Female Male Other

Age

$<$20 20-29 30-39 40-49 50-59 60-69 70-79 80$+$

What is your proficiency in English?

None
Beginner
Intermediate
Advanced
Native-like
Native

What is your proficiency in Korean?

None
Beginner
Intermediate

Advanced
Native-like
Native

Please list any other languages you speak, and your level of proficiency (beginner, intermediate, advanced, native-like or native)

What country were you born in?

What country did you spend the majority of your childhood in (up to 18 years old)?

Prolific ID

Please select all the Korean names that you recognize. Note that the spellings may vary slightly from what you are familiar with.

Han-sol
Ho-chan
Hui-u
Hui-yeong
Hye-seong
In-ae
Jae-jin
Jae-seong
Jeong-jun
Ji-ye
Kyu-pin
Min-jun
Seo-chan
Seo-yeon
Seul-ki
Tae-hyeong
Tae-jun
Ye-in
Ye-lang
Yu-jeong

Please indicate whether you think the following Korean names are male or female. Note that the spellings might differ slightly from what you are familiar with.

Han-sol
Ho-chan
Hui-u
Hui-yeong
Hye-seong
In-ae
Jae-jin
Jae-seong
Jeong-jun
Ji-ye
Kyu-pin
Min-jun
Seo-chan
Seo-yeon
Seul-ki
Tae-hyeong
Tae-jun
Ye-in
Ye-lang
Yu-jeong

Full Results of the Name Gendering Task

Full Results: http://lisasullivan.ca/gp2/experiment-results.html