論文

# A Functional Load Quantification of the Vowel Systems of Four Asian Englishes

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**要　旨**

本研究は，４つのアジア英語，すなわち，香港英語，インド英語，フィリピン英語，およびシンガポール英語における母音体系を機能的負荷の点から分析し，その結果を考察する。機能的負荷（FL）の枠組みを用いることで，コーパスにおける生起頻度の点から言語的特徴を量的に明らかにすることができる。つまり FL により，言語の構造面の記述に言語の運用面に関する記述を加えることができる。本論文では，４つのアジア英語の各母音体系を International Corpus of English の ICE-HK, ICE-IND, ICE-PHI, and ICE-SIN から得た生起頻度に基づき，明らかにする。最後に，体系的に一般的な傾向について論じる。

キーワード：機能的負荷，母音体系，諸英語，言語類型論，音声処理

**Keywords:** functional load, vowel systems, world Englishes, linguistic typology, speech processing

## 1. Introduction

The investigation reported in this paper adopts a corpus-based approach to the description of phonological systems by means of functional load (FL) analyses. Specifically, FL rankings are provided for the vowel systems of Hong Kong English

(HKE), Indian English (IndE), Philippine English (PhilE), and Singapore (SingE) based on usage data obtained the spoken component of the *International Corpus of English* subcorpora (ICE; https://www.ice-corpora.uzh.ch/en.html).

FL has been proposed as a parameter by which to assess the relative amount of work carried out by each element of a linguistic class (Hockett, 1955; King, 1967a; Mathesius, 1929). It has been used extensively in phonology, in particular, and has been shown to be an informative means by which to observe "…how much a language relies on phonological constructs" (Surendran & Niyogi, 2006, p. 11) as well as the nature and dynamics of the systemic relationships they form (Oh et al., 2015, p. 155). This paper focuses on vowels systems and provides FL data that is otherwise unavailable in the literature.

Interest in and applications of FL, originally proposed by Prague School scholars, have recently re-emerged as the relevance of usage frequency in speech processing and cognition has been demonstrated by work undertaken in psycholinguistics, corpus linguistics, and cognitive linguistics (see Brysbaert et al., 2018; Divjak & Caldwell-Harris, 2015 for psycholinguistic and cognitive linguistic reviews respectively). FL complements structural descriptions of phonological systems because it makes it possible to quantify certain aspects of usage by means of corpus-based observed frequencies, probabilities of reoccurrence, and other more sophisticated measures derived from these metrics (e.g., entropy). This method of analysis has, over time, contributed additional data and insights that has furthered understanding of issues of intelligibility (Munro & Derwing, 2006; Sewell, 2017) as well as cognition and mental representations (Kang, 2012, 2015; Oh et al., 2015; Warren, 2001; Wedel, 2012; Wedel et al., 2013).

Accumulated findings from diverse domains indicate that speech processing involves multiple cues beyond the obvious auditory input and includes visual, physiological, as well as additional linguistic information (Huettig et al., 2011; McGurk & Macdonald, 1976; Scarbel et al., 2014). Furthermore, recent developments in neuroscience have evidenced neural correlates of motor activity directly related to speech perception and production (Devlin & Aydelott, 2009). This latest data has renewed interested in gesture-based theories of speech processing such as Motor Theory proposed by Liberman (1985) and Articulatory Phonology proposed by Browman and Goldstein (1992). The current investigation contributes to this ongoing discussion, by providing an interpretation of results in terms of vowel quadrant activation and the corresponding anatomical actors (e.g., tongue, lips, jaw) and actions (e.g., tongue protraction/protrusion, lip rounding, jaw lowering) underlying speech production.

## 2. Background

Traditionally, FL has been associated with phonemic systems (Hockett, 1966; King, 1967a; Trubetzkoy, 1939). As King (1967b, p. 831) explains:

> "The term functional load is customarily used in linguistics to describe the extent and degree of contrast between linguistic units, usually phonemes…In its simplest expression, FL is a measure of the number of minimal pairs which can be found for a given opposition [Phoneme Pairings (PP), LG]. More generally, in phonology, it is a measure of the work which two phonemes (or a distinctive feature) do in keeping utterances apart - in other words, a gauge of the frequency with which two phonemes contrast in all possible environments."

It is important to note that the prevalent contemporary approach to the study of FL adopts an information-theoretic perspective based on the notion of entropy, a construct borrowed from information theory (Shannon & Weaver, 1949). In the context of FL studies, entropy is used to refer to the amount of information lost by a linguistic class when two of its constituent elements merge or coalesce. The earliest formulation of these kinds of entropy measures was done by Hockett (1966). Fundamental to Hockett's method is the idea that the absence of an element leads to a redistribution of work across the remaining elements. From this perspective, phoneme pairings are not independent. "They cannot be deleted; they can only coalesce" (Hockett, 1966: 10). This initial formulation has been further elaborated within information-theoretic frameworks. Surendran and Niyogi (2003, 2006) demonstrated its usefulness in examining phonological classes larger than phonemes and phonemic contrasts such as vowels, consonants, tone, and stress. Entropy-based FL analyses have been conducted on several large languages including Cantonese, Mandarin, English, French, German, Italian, Japanese, Korean, and Swahili (Oh et al., 2015). In the case of English, researchers have relied on the CELEX lexical database which contains phonological forms based on a British Received Pronunciation (BRP) phonological model and corpus frequencies from the COBUILD corpus (Burnage, 1990).

Scholarly interest in phonological systems of varieties of world Englishes has produced a rather large body of literature in a relatively short period of time. Since the 1980s, the focus has been on expanding the pool of resources available on British and U.S. varieties and dialects with comparable descriptions of the varieties spoken in postcolonial regions (Hughes et al., 2012; Kortmann & Schneider, 2004; Wells, 1982). It is thanks to strong structural traditions that we have been able to accumulate parallel systemic descriptions of the phonemic inventories of English found in locales across the continents. Some specialists see this type of research as fundamental to “English as a World Language” studies (Mair, 2005). Perhaps the most current and comprehensive work to date is the *Handbook of Varieties of English* (HVE) edited by Kortmann & Schneider (2004). The volume includes descriptions that follow a common template and thus provide a framework for not only inspection of individual varieties but a platform for speculation based on the aggregation of insights associated with regional ecologies and historical trajectories. The treatments provided in HVE have made it possible to observe patterns based on the survey of features across a great number of varieties and to propose both regional and global tendencies (Kortmann & Schneider, 2004). The accumulation of datasets has thus allowed for broader and more robust observations regarding distributional characteristics of the English sound system, in its multiple manifestations. These efforts are acknowledged to be “a magnificent testimony to the amount of research which has been carried out in the last quarter century on variation in English around the world” (Britain, 2007, p. 746).

This paper focuses on vowels because they are of particular interest due to their multifunctionality. Briefly, vowels play a role in speech processing because of their relative perceptual prominence which helps listeners parse the speech stream (Bonatti et al., 2005). The human speech processing mechanism appears to be attuned to the sonority peaks that vowels contribute to the acoustic signal, exploiting this cue in order to identify words and grammatical structures in a continuous stream of sounds (Bonatti et al., 2005; Fogerty & Kewley-Port, 2009; Stilp & Kluender, 2010). Moreover, vowels have been found to be largely responsible for the rhythmic qualities of speech. The musicality of speech is determined by alternations in prominence among phonological units (Ramus et al., 1999). Vowels carry prosodic cues such as stress and tone that constitute melody and are associated with indexical and emotional cues (Nespor et al., 2002). It can thus be said that vowels carry the lilt and cadence of speakers’ phonological signatures and thus convey this aspect of identity.

The investigation makes use of four parallel corpora from the *International Corpus of English* (hereafter ICE; https://www.ice-corpora.uzh.ch/en.html). The availability of these data sources makes it possible to produce analogous descriptions that reflect localized and situated use of the English language as it manifests itself uniquely in different society. The four varieties under investigation represent locales particular in their historical, social, political, and economic profiles. The role of the English language within each milieu is similarly particular, acquiring additional differentiation as each society follows its own evolutionary trajectory (Schneider, 2003). Furthermore, various languages cohabitate in these environments and, naturally, multiple registers coexist in them as well. In this manner, the linguistic habitus of the members of each community of speakers reflects an intricate and idiosyncratic interplay of a wide array of linguistic, social, interactive, and cognitive factors (Blommaert & Backus, 2012; Busch, 2012; Canagarajah, 2018; Hruschka et al., 2009; Mufwene & Vigouroux, 2017; Van Rooy, 2010; Wei, 2011). Results may thus shed light on systemic relationships formed among phonological categories and be used in future research concerning how communicative experiences shape multilingual linguistic repertoires (Bybee, 2006; Mauranen, 2018; Pierrehumbert, 2012; Wedel, 2007).

## 3. Methodology

### 3.1. Data

The spoken components of ICE-HK, ICE-IND, ICE-PHI, and ICE-SIN were analyzed in order to elicit their corresponding dominant vocabularies (DOVO) following the methodology described in Gilner and Morales (2020). The size of the corpora and the number of phonemically transcribed wordforms analyzed for each one are shown in

**Table 1.** *Description of corpora and data sets*

| | Corpus size | Transcribed wordforms | Coverage |
|---|---|---|---|
| ICE-HK | 919,082 | 811,308 | 88.27% |
| ICE-IND | 667,116 | 570,456 | 85.51% |
| ICE-PHI | 653,075 | 563,183 | 86.24% |
| ICE-SIN | 661,728 | 580,664 | 87.75% |

Table 1. Coverage values indicate the percent of all the running words in each corpus that were transcribed.

As is established practice in FL studies, phonological representations of citation forms were used for the analyses undertaken by this investigation.[1] Transcriptions were produced based on the phoneme inventories and lexical sets provided by Hung (2000) for HKE, Gargesh (2004) for IndE, Tayao (2004) for PhilE, and Low (2016) for SingE. These descriptions are widely accessible, comprehensive, and correspond to the pronunciation models adopted by the Oxford English Dictionary[2]. Inter-rater and intra-rater reliability checks of phonemic transcriptions were conducted, yielding an average of 95.86% agreement.

## 3.2. Functional load calculations

As Oh et al. (2015) explain, the information-theoretic approach to FL analysis views language *L* as a source of sequences made up of word-forms *w* taken from of a finite set of size $N_L$.

Equation 1 shows the entropy *H* of language *L* calculated over its lexicon.

$$\mathrm{H(L)} = -\sum_{i=1}^{N_L} p_{w_i} * \log_2(p_{w_i})$$

**Equation 1.** *Amount of information or entropy in language L*

Equation 1 calculates the probability of word-forms ($p_{wi}$) as a factor of the frequency of occurrence of a word in a corpus. The entropy measure $H(L)$ is used to represent the initial state of the system (Shannon, 1948).

$$FL_{\varphi,\psi} = \frac{H(L) - H(L^*_{\varphi\psi})}{H(L)}$$

**Equation 2.** *Functional load of the contrast between two phonemes φ and ψ*

Equation 2 shows the FL of a contrast between two phonemes φ and ψ. $FL_{\varphi,\psi}$ is defined as the relative difference in the entropies between two system $H(L)$ and $H(L^*_{\varphi\psi})$, often normalized as shown in Equation 2 (Surendran & Niyogi, 2003). Note that $H(L^*_{\varphi\psi})$ is calculated by coalescing the frequencies of all the mergers involving the phonemes φ and ψ.

$$FL'_{\varphi} = \frac{1}{2}\sum_{\psi} FL_{\varphi,\psi}$$

**Equation 3.** *Functional load of a phoneme φ*

Again following Oh et al. (2015), it is possible to estimate the FL of a phoneme by adding all the mergers it participates in (as shown in Equation 3) with the normalization factor ½ to ensure that the FL of mergers are not counted twice since φ, ψ = ψ, φ.

### 3.3. Complementary measures

Where useful, the discussion of results also includes the following two measures: dominant relative normalization (DRN) and least-dominant relative normalization (LDRN). The first measure, DRN, is found in various forms in the literature (Brown, 1988; Catford, 1987; Gilner & Morales, 2010; Herdan, 1958) and expresses the FL of each member as a fraction of the member with the highest FL. The second measure, LDRN, expresses the FL of each member as a magnitude of the member with the lowest FL. DRN and LDRN express equivalent ratios that provide a means by which to assess the measures in relation to each other rather than as a fraction of the whole.

a) $DRN_{\varphi} = \frac{X_{\varphi}}{X_M} = \frac{LDRN_{\varphi}}{LDRN_M}$

b) $LDRN_{\varphi} = \frac{X_{\varphi}}{X_m} = \frac{DRN_{\varphi}}{DRN_m}$

**Equation 4.** *Equivalent relationships between DRN and LDRN*

As shown by Equation 4 a and b, given a set S of values X, the DRN and LDRN of an element φ all express equivalent ratios, each relative to a different measure, namely, the largest value ($X_M$), and the smallest value ($X_m$), respectively.

This supplementary manner of presentation expresses proportional relationships relative to a given member. This approach is particularly suitable for FL analyses which seek to quantify the relative amount of work done by members of class and thereby reveal the systemic synergy of usage-driven patterns of organization (Pellegrino et al., 2009). DRN and LDRN measures contribute to the construction of a referential framework for describing the system and its dynamic behavior, what Pellegrino et al. (2009) refer to as the macroscopic level of complex patterns.

# 4. Results and discussion

## 4.1. Usage-driven description of the HKE vowel system

The results for the model of the HKE vowel system (Hung, 2000) reveal a markedly uneven distribution of work across the 15 members, as shown in Chart 1 below. Each phoneme is plotted along the horizontal axis in descending order of the relative FL that is plotted along the vertical axis. It can be seen that the phoneme /i/ obtained the greatest FL, the phoneme /eɪ/ obtained the 2nd greatest FL, the phoneme /ɑ/ the 3rd greatest and so on. A steep downward slope is established by the plotted points that correspond to these three top ranked members. A leveling off in the FL of the phonemes /u/ and /aɪ/ ranked 4th and 5th is observed. Another steep downward slope is created by the FL corresponding to the next two phonemes /ɛ/ and /ɔ/. From there on, FL values continue to decline in smaller and more regular increments.

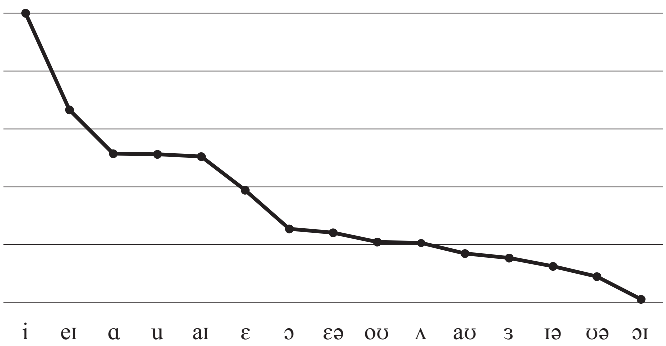


**Chart 1.** *HKE FL distribution curve*

Table 2 presents the actual FL values, which range from a maximum of 0.0242 to a minimum of 0.0003. As explained in the Methodology section, DRN values make it possible to describe FL values in terms of fractions of the member with the highest FL. In this manner, it can be seen that the 2nd ranked member carries out 66.61% of the work the 1st ranked member does. The 3rd, 4th, and 5th ranked members make lesser but rather similar contributions, each carrying out approximately half of the amount of work that the 1st ranked member does.

**Table 2.** *FL ranking of the vowel inventory of HKE*

| Rank | Segment | FL | DRN | LDRN |
|---|---|---|---|---|
| 1 | i | 0.0242 | 100% | 85.55 |
| 2 | eɪ | 0.0161 | 66.61% | 56.98 |
| 3 | ɑ | 0.0125 | 51.45% | 44.02 |
| 4 | u | 0.0124 | 51.18% | 43.79 |
| 5 | aɪ | 0.0122 | 50.46% | 43.17 |
| 6 | ɛ | 0.0094 | 38.85% | 33.23 |
| 7 | ɔ | 0.0062 | 25.46% | 21.79 |
| 8 | ɛə | 0.0058 | 24.09% | 20.61 |
| 9 | oʊ | 0.0051 | 20.91% | 17.89 |
| 10 | ʌ | 0.0050 | 20.57% | 17.60 |
| 11 | aʊ | 0.0041 | 16.91% | 14.46 |
| 12 | ɜ | 0.0037 | 15.42% | 13.19 |
| 13 | ɪə | 0.0030 | 12.48% | 10.68 |
| 14 | ʊə | 0.0022 | 8.98% | 7.68 |
| 15 | ɔɪ | 0.0003 | 1.17% | 1.00 |

Recall that LDRN values express FL in terms of magnitudes relative to the member with the lowest FL. In this manner, it is possible to easily see that the 1st ranked member does 85.55 times the amount of work than the lowest-ranked member; the 2nd ranked member 56.89 times more; the 3rd ranked member 44.02 times more and the 4th and 5th ranked members approximately 43 times more work than the lowest-ranked one.

These values expose a tendency toward close articulations. Among the anterior-based phonemes, the most close phoneme /i/ does 2.5 times the amount of work as the least close member /ɛ/; the intermediate member /eɪ/ does a bit less than twice the work the least close counterpart. Among the posterior-based phonemes, however, there is very little difference between the FL values obtained by the most open member /ɑ/ and most close member /u/.

Figure 1 provides a visual display of these usage-driven trends. The members of HKE phonemic inventory that obtained DRN values >= 1% as presented in Table 2 are indicated by circles. The circle around each member is proportional to its relative amount work so that the phoneme /i/ (DRN=100%) is the largest, the circle surrounding the phoneme /eɪ/ is approximately 67% the size of the largest one (DRN=66.61%), and so on.

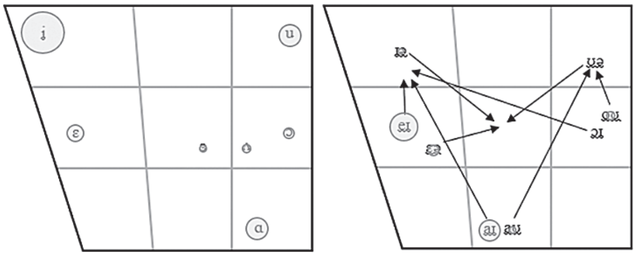

**Figure 1.** *Vowel quadrant activation of HKE*

This visualization shows that anterior-based articulations are relatively most active. The high, front, tense /i/ contributes most to the work carried out by this system. The role of anterior-based articulations is further reinforced by the occupant of the next position in this ranking, the diphthong /eɪ/. Further scrutiny reveals that the seven members which populate the frontal region of the vowel space (including initial and terminal targets of diphthongs) collaborate to undertake 58.1% of the total amount of work carried out by this system. The 1st and 2nd ranked members account for more than half of that portion.

## 4.2. Usage-driven description of the IndE vowel system

Chart 2 displays results for the 20 members of the phonological model of IndE (Gargesh, 2004). Again, a markedly uneven distribution of work across the members of the system is revealed. The phoneme /e:/ is the member with the greatest FL and establishes the highest point on the curve. A relatively steep downward slope is observed among the plotted points corresponding to the phonemes which follow ranked 2nd, 3rd, and 4th, namely, /ɪ/ - /aɪ/ - /i:/. Relatively short steep downward slopes are seen at two points

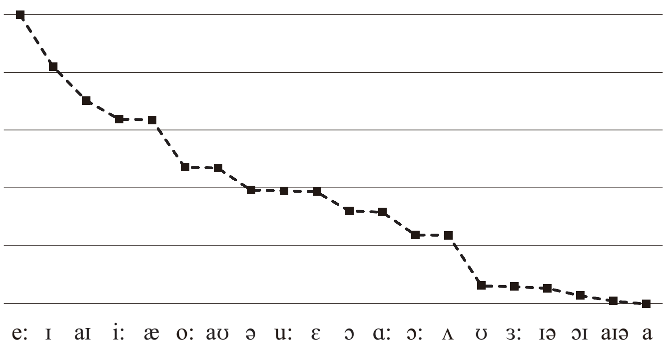


**Chart 2.** *IndE FL distribution curve*

in the curve: towards the lower-upper end of the ranking between the phonemes /æ/ and /o:/ and rather farther down toward the lower end of the ranking between the phonemes /ʌ/ and /ʊ/. The middle of the curve is characterized by clusters of members with similar FL values (indicated by fairly parallel lines) interspersed with incremental drops while the tail end shows relatively steady and small declines in FL.

Table 3 presents the raw FL measures along with DRN and LDRN values. FL ranges from a maximum of 0.0092 to a minimum of 0.0001. The 20th ranked member, /a/, does not establish contrastive relationships with any other members and, consequently, its FL is 0 since its coalescing with any member in the system would not lead to a change in entropy. The DRN values indicate that the 2nd ranked member contributes 0.8209, or 82.09%, the amount of work that the 1st ranked one does; the 3rd ranked member 0.7030,

**Table 3.** *FL ranking of the vowel inventory of IndE*

| Rank | Segment | FL | DRN | LDRN |
|---|---|---|---|---|
| 1 | e: | 0.0092 | 100% | 98.43 |
| 2 | ɪ | 0.0076 | 82.09% | 80.80 |
| 3 | aɪ | 0.0065 | 70.30% | 69.20 |
| 4 | i: | 0.0059 | 63.97% | 62.97 |
| 5 | æ | 0.0059 | 63.57% | 62.57 |
| 6 | o: | 0.0044 | 47.32% | 46.58 |
| 7 | aʊ | 0.0043 | 46.87% | 46.13 |
| 8 | ə | 0.0036 | 39.35% | 38.73 |
| 9 | u: | 0.0036 | 38.95% | 38.34 |
| 10 | ɛ | 0.0036 | 38.85% | 38.24 |
| 11 | ɔ | 0.0030 | 32.10% | 31.60 |
| 12 | ɑ: | 0.0029 | 31.69% | 31.19 |
| 13 | ɔ: | 0.0022 | 23.78% | 23.41 |
| 14 | ʌ | 0.0022 | 23.65% | 23.28 |
| 15 | ʊ | 0.0006 | 6.33% | 6.23 |
| 16 | ɜ: | 0.0006 | 6.02% | 5.92 |
| 17 | ɪə | 0.0005 | 5.31% | 5.22 |
| 18 | ɔɪ | 0.0003 | 2.83% | 2.79 |
| 19 | aɪə | 0.0001 | 1.02% | 1.00 |
| 20 | a | 0 | - | - |

or 70.30%; the $4^{th}$ and $5^{th}$ ranked members average 63.77% of the contribution that the $1^{st}$ ranked member does.

The LRDN values show that the $1^{st}$ ranked member carries out 98.43 times the amount of work as the member ranked $19^{th}$, the $2^{nd}$ ranked member 80.80 times the amount, the $3^{rd}$ ranked member 69.20 times and the $4^{th}$ and $5^{th}$ ranked members average 62.52 times the amount of work as the member ranked $19^{th}$. As observed in Chart 2, a noticeable cluster is formed by the members ranked $8^{th}$, $9^{th}$, and $10^{th}$, which each work roughly 38 times more than the member ranked $19^{th}$. The phonemes ranked $6^{th}$ and $7^{th}$ carry out roughly 46 times the amount of work of the member with the lowest FL.

Figure 2 provides a visual representation of these usage distributions. As was the case with HKE, the members with DRN values between 100% and 1% are represented with proportionally sized circles. The relative importance of the two top-ranked phonemes identifies the intermediate and upper zones of the anterior region of the vowel space as relatively most active. The anterior region of articulation is also activated by the three phonemes that follow in this ranking. The relevance of anterior articulations is reinforced by the phonemes /i:/ and /æ/, which are both articulated in the frontal areas of the oral cavity. The former targets the extreme upper and the latter the extreme lower perimeter defined by this vowel system. The most energetic intermediate member /o:/ is the greatest contributor among the posterior-based members. This phoneme does 7 times the amount of work as the lowest ranking posterior-based counterpart /ʊ/. The most close member in this system /u:/ works 6 times as much as its quadrant co-occupant.

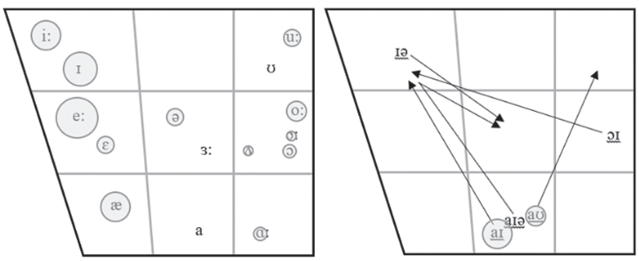


**Figure 2.** *Vowel quadrant activation of IndE*

Among the two monophthongs that co-occupy the high-anterior region, the less energetic member is more active. The opposite is true for the co-occupants of the intermediate-anterior region. The more energetic member tops the ranking while its lax counterpart is ranked 10th. Among the posterior-based members, the more energetic member of the intermediate region is the most active, ranked 6th; its co-occupants are ranked 11th, 13th, and 14th. The more energetic co-occupant of the upper-posterior region also obtains higher FL values than its lax counterpart. These members are ranked 9th and 15th, respectively.

## 4.3. Usage-driven description of the PhilE vowel system

Chart 3 displays the results for the 13 members of the of the PhilE model (Tayao, 2004) in the form of the FL distribution curve. A markedly uneven distribution of work across the members of this system is observed, as was the case in the previous varieties. The phoneme /i:/ obtains the greatest functional load and hence establishes the highest point of the curve. The plotted points of the following four members, namely, /ɑ, o, eɪ, ɑɪ/ form the relatively steepest slope of the curve. Noticeable dips in the curve are seen between the members /ɑɪ/ and /ɑʊ/, ranked 5th and 6th, and between the members /ʌ/ and /e/, ranked 9th and 10th. The slight downward slope seen in the middle of the curve indicates relatively small decreases in FL of the members /ɑʊ, u:, ɛ, ʌ/ and the relatively flat end of the curve indicative of rather similar FL among the members /e, ɪ, i, oɪ/.

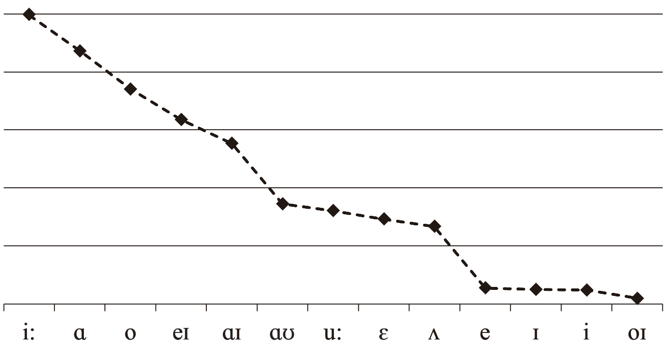


**Chart 3.** *PhilE FL distribution curve*

Table 4 presents the actual FL values in rank order for PhilE. The values range from a maximum of 0.0147 to a minimum of 0.0003. The DRN values instantiate the fairly steady decrease in relative contributions throughout the ranking, as observed in Chart 3. The 2nd ranked member contributes 0.8738, or 87.38%, of the amount of information that the 1st ranked one does; the 3rd ranked member 0.7424, or 74.24%; the 4th ranked member 63.66% and the 5th ranked member 55.5% of the information that the 1st ranked member does. The top two members demarcate the upper anterior and lower posterior regions of the vowel space. The next two members delineate the intermediate zone of articulation and demarcate the anterior from the posterior regions.

**Table 4.** *FL ranking of the vowel inventory of the PhilE*

| Rank | Segment | FL | DRN | LDRN |
|---|---|---|---|---|
| 1 | i: | 0.0147 | 100% | 48.76 |
| 2 | ɑ | 0.0129 | 87.76% | 42.61 |
| 3 | o | 0.0109 | 74.15% | 36.20 |
| 4 | eɪ | 0.0094 | 63.95% | 31.04 |
| 5 | ɑɪ | 0.0082 | 55.78% | 27.06 |
| 6 | ɑʊ | 0.0051 | 34.69% | 16.86 |
| 7 | u: | 0.0047 | 31.97% | 15.73 |
| 8 | ɛ | 0.0043 | 29.25% | 14.36 |
| 9 | ʌ | 0.0040 | 27.21% | 13.10 |
| 10 | e | 0.0008 | 5.44% | 2.74 |
| 11 | ɪ | 0.0007 | 4.76% | 2.46 |
| 12 | i | 0.0007 | 4.76% | 2.36 |
| 13 | oɪ | 0.0003 | 2.04% | 1.00 |

The LRDN values make evident certain differences in magnitudes of relative contribution. The 1st ranked member /i:/, for instance, carries out 21 times the amount of work as its quadrant co-occupants ranked 11th and 12th. This upper-anterior-based

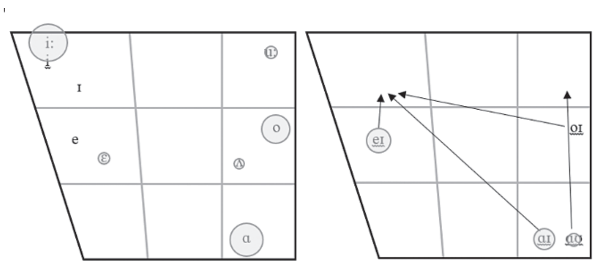


**Figure 3.** *Vowel quadrant activation of PhilE*

member also makes a noticeably larger contribution than its intermediate-anterior-based counterparts, ranked 4th, 8th, and 10th; 18 times greater than that of the phoneme /e/, 5 times greater than that of the phoneme /ɛ/, and 11 times greater than that of the phoneme /eɪ/. The differences in magnitude of contribution is not as great among the posterior-based members. The highest-ranking posterior-based phoneme /ɑ/ contributes 3.23 times the amount of its lowest ranked counterpart /ʌ/ and 2.73 times the amount of its closest ranked member /o/.

Figure 3 shows how the more active members are rather widely dispersed throughout the vowel space. The first two members occupy diametrically opposed quadrants, the upper-anterior and the lower-posterior. The 3rd ranked member occupies the intermediate zone of the posterior region and the 4th ranked member the intermediate-anterior. Articulation of the diphthong ranked 5th involves movement from lower-posterior to upper-anterior while the diphthong ranked 6th involves movement from lower-posterior to upper-posterior. Three of the members at the bottom of the ranking are anterior-based phonemes that co-occupy the vowel quadrant with a more active member.

## 4.4. Usage-driven description of the SingE vowel system

Chart 4 displays the curve of distribution of FL values for the 17 members of SingE (Low, 2016). As has come to be expected, the results reveal a markedly uneven distribution of work across the members. The phoneme /i/ obtains the greatest functional load and hence establishes the highest point of the curve. The plotted points of the following four members, namely, /e: - aɪ - ɛ - ɜ:/ form the relatively steepest slope of the curve. A leveling off in the curve is seen across the next few members in the ranking,

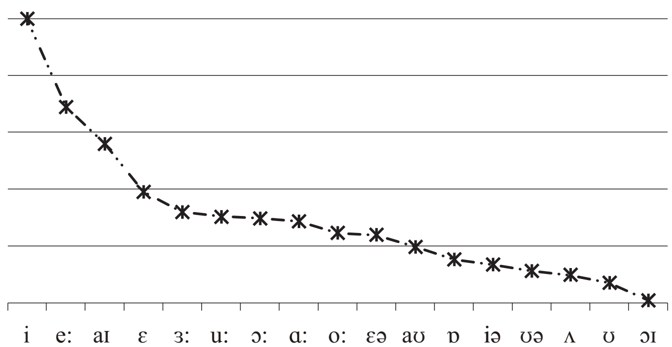


**Chart 4.** *Curve of FL distribution of SingE*

namely, /u: - ɔ: - ɑ:/. The latter half of the curve shows a relatively steady decline in FL values.

Table 5 presents the actual FL measures as well as DRN and LDRN values for SingE. DRN values indicate that that the 2nd ranked member does approximately 68.94% of the work that the 1st ranked member does. The 3rd ranked member makes 56.02% of the contribution of the 1st ranked member and the 4th ranked member 39.13%. Several posterior-based members cluster together in the middle of the ranking. The highest ranked posterior-based member does 30.35% of the work of the highest ranked anterior-based counterpart and is ranked 6th. This member occupies the upper zone of the vowel space. Its co-occupant is ranked 11th. The next largest contributor among the posterior-based members occupies the intermediate zone and is ranked 7th. It does a rather similar amount of work as the 6th ranked member. Its quadrant co-occupants are ranked 9th and 15th. A more open articulation among the posterior-based members, ranked 8th, contributes 28.75% of that of the 1st ranked member. Its quadrant co-occupant is ranked

**Table 5.** *FL ranking of the vowel inventory of the SingE*

| Rank | Segment | FL | DRN | LDRN |
|---|---|---|---|---|
| 1 | i | 0.0209 | 100% | 106.12 |
| 2 | e: | 0.0144 | 68.90% | 73.16 |
| 3 | aɪ | 0.0117 | 55.98% | 59.45 |
| 4 | ɛ | 0.0082 | 39.23% | 41.52 |
| 5 | ɜ: | 0.0067 | 32.06% | 34.00 |
| 6 | u: | 0.0064 | 30.62% | 32.21 |
| 7 | ɔ: | 0.0062 | 29.67% | 31.59 |
| 8 | ɑ: | 0.0060 | 28.71% | 30.51 |
| 9 | o: | 0.0052 | 24.88% | 26.14 |
| 10 | ɛə | 0.0050 | 23.92% | 25.44 |
| 11 | aʊ | 0.0041 | 19.62% | 20.88 |
| 12 | ɒ | 0.0032 | 15.31% | 16.26 |
| 13 | iə | 0.0028 | 13.40% | 14.32 |
| 14 | ʊə | 0.0024 | 11.48% | 11.93 |
| 15 | ʌ | 0.0021 | 10.05% | 10.58 |
| 16 | ʊ | 0.0015 | 7.18% | 7.56 |
| 17 | ɔɪ | 0.0002 | 0.96% | 1.00 |

12th and does about half the amount of work of its higher ranked counterpart.

Speaking in terms of magnitudes of contribution, LDRN values indicate the disparity among members of this vowel system. The 1st ranked member does more than 100 times the amount of work that the 17th ranked member does. The 3rd ranked member does almost 60 times the work that the lowest ranked member does. Nine out of the 17 members have LDRN values that are less than the average (=31.92). Among the anterior-based monophthongs, the LDRN of highest ranked member /i/ is 2.5 times greater than that of its lowest ranked counterpart /ɛ/. A wider range is observed among the posterior-based members. The LDRN values of the members ranked 6th, 7th, and 8th are roughly 4 times greater than that of the lowest ranked posterior-based member /ʊ/. The phoneme /ʌ/ adjacent to this one, ranked 15th, obtains an LDRN that is 1.4 times larger.

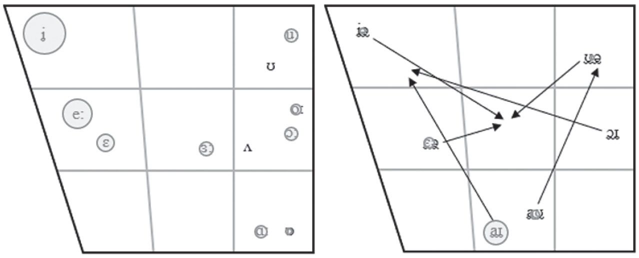


**Figure 4.** *Vowel quadrant activation of SingE*

Figure 4 shows how FL values correspond to vowel quadrant activation. The ranking reveals systemic articulatory patterns associated with raised and protracted tongue movements. Four of the top five members are anterior-based articulations, including the anterior-closing diphthong. Two of these members are co-occupants of the intermediate-anterior quadrant of the vowel space. The cluster of phonemes ranked 5th to 9th are all non-anterior-based lengthened articulations. The phoneme /ɜ:/ further reinforces the relevance of articulations produced in the intermediate zone and, at the same time, indicates the role of tongue retraction in articulating distinctive constituents. The phonemes /u: - ɔ: - ɑ:/ establish the relevance of posterior-based articulations in distinguishing members of this system. These three phonemes span the height of the vowel space, distributing activation similarly across the upper, intermediate, and lower zones.

## 5. General observations

This paper has presented results obtained from FL analyses of the vowel systems of four varieties of English. Findings demonstrate how this methodology can be applied to the domain of descriptive studies in order to provide a usage-driven quantitative perspective. Each of the four systems investigated displayed distinct patterns of uneven distributions and revealed systemic relationships among members in terms of relative operationality (Pellegrino et al., 2011). These findings thus provide additional data that serves to document the large diversity that is present among and within phonological systems.

From the perspective of articulatory features, these tendencies can be considered in terms of the front/back and open/close articulatory dimensions, operationalized as [front – central – back] and [high – mid – low], respectively. Chart 5 presents results of the FL of these articulatory features. In terms of the open/close dimension, the feature [mid] is comparably active in each of the four varieties. This feature is relatively most active in the SingE and IndE while slightly less so in HKE and PhilE systems. Generally speaking, the feature [high] does slightly more work than the feature [mid] in the HKE and PhilE systems while the tendency is reversed for the IndE and SingE systems. The feature [low] consistently obtains the lowest FL values across these systems.

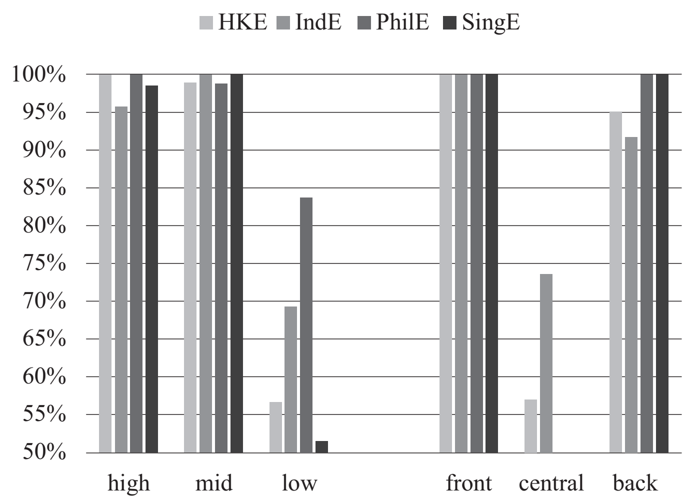


**Chart 5.** *FL of articulatory features across varieties*

Regarding the front/back dimension, the feature [front] makes comparably larger contributions to each of the four systems. The feature [back] obtains similar FL values as the feature [front] in PhilE and SingE and noticeably lesser FL in HKE and IndE. The feature [central] is noticeably less of a contributor across systems. This feature is relatively most active in the IndE system and not used at all in PhilE and SingE.

## 6. Conclusion

This summary review of findings encapsulates how the FL values have been used to quantify the usage of the phonemes that constitute each vowel system. Several venues of potential application for this usage-driven data present themselves. When it comes to contemporary English studies, documentation and description are of particular relevance. The large body of referential work available on the language has traditionally been based on a limited and limiting perception of its users, uses, and usage. The aggregation of descriptive data sets can help advance the field in efforts to characterize the contemporary reality of the English language in its various forms and functions. Referential works such as HVE which provide structural descriptions of phonological and grammatical features, encourage typological analyses and, as a consequence, afford a basis for more informed theorization regarding similarities and differences as well as speculating about the role of experience in cognitive categorization. Findings presented here add to the resource pool available to researchers interested in pursuing such topics.

These findings are also relevant to substance-based theories of speech communication which position patterning of speech sounds in human languages as crucial to understanding productive/perceptual mechanisms underlying speaker-listener interactions (Liljencrants & Lindblom, 1972; Schwartz et al., 1997; Stevens, 2002). Usage-based phonology, for example, considers exposure and experience with situated and embodied meaning fundamental to understanding mental representations of phonological systems. A central concern is understanding and explaining how phonological categories are formed from highly variable speech tokens (Silverman, 2013). Contextual, physiological, and psychological factors conspire to produce “dramatic” acoustic invariance (Taylor, 2009, p. 23) that makes understanding how verbal communication succeeds “a major challenge” (Pitt, 2009, p. 19). Accumulated evidence demonstrates that a usage-based framework accommodates the invariance problem by allowing mental representations of phonological targets and patterns to gradually build up over time and with experience (Bybee, 1994; McQueen et al., 2006, 2006; Norris, 2003; Pierrehumbert, 2001; Wedel, 2012). The FL measures obtained from this investigation provide usage-driven quantification of hierarchies of phonological categories. These findings might thus be used to pursue inquiry into usage-based, exemplar-driven speech communication models that propose cognitive schemata emerge through “the collection of echoes” (Pierrehumbert, 2006, p. 523) retained from usage events.

The world Englishes paradigm has increased the granularity of analysis of localized communicative practices and the distributed functions bestowed upon co-existing languages within particular societies. What we know about the multiple expressions of English as well as the distinct functions that co-existing languages and their associated registers serve in different linguacultural milieus is evolving as research continues to accumulate. Perspectives offered by Van Rooy (2010), for example, prompt speculation regarding the interplay between underlying cognitive processes and situational functionality in the shaping of linguistic varieties. Van Rooy proposes that individuals’ cognitive representations and the conventions of different societies of English users “cast new light on the role of variability in language” (Van Rooy, 2010, p. 16). Van Rooy’s discussion raises interesting questions regarding the nature of input, its role in impacting cognitive schemata and, consequently, mediating variability as well as shaping varieties. Results discussed here encourage speculation regarding processing biases rooted in linguistic experience based on encountered exemplars, for which behavioral evidence continues to accumulate (Clopper, 2014; Clopper & Bradlow, 2007, 2009; Cutler et al., 2008; McQueen, 1991; McQueen & Cutler, 2010). Thus, it is tentatively proposed that FL analyses have something to contribute to discussions regarding language typology (Kortmann & Schneider, 2004; Schwartz et al., 1997, 2015), language dynamics and evolution (Hruschka et al., 2009; Wedel, 2012) as well as inclusive and pluricentric approaches to the study and teaching of the English language (Canagarajah, 2013, 2018; Cook, 2017; Kirkpatrick, 2010).

## Notes

1 It merits mention that Surendran and Niyogi (2006) demonstrated an 82% correlation between FL measures obtained from corpora of phonetically-transcribed and phonologically-transcribed forms.

2 Confirmed at https://public.oed.com/how-to-use-the-oed/key-to-pronunciation/pronunciations-for-world-englishes/

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