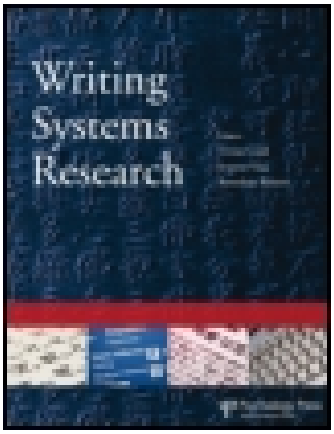

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Aksharas, alphasyllabaries, abugidas, alphabets and orthographic depth: Reflections on Rimzhim, Katz and Fowler (2014)

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Aksharas, alphasyllabaries, abugidas, alphabets and orthographic depth: Reflections on Rimzhim, Katz and Fowler (2014)

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We contend that, contrary to Rimzhim, Katz and Fowler (2014), consonants and vowels in the Brahmi-derived scripts are not "on a par", and, therefore, that it is inaccurate to depict these scripts as alphabetic. Furthermore, we consider the popular terminology "alphasyllabic" to be misleading because these scripts are neither alphabetic nor syllabic. We argue on historical grounds that Brahmi-derived scripts (the script family known as Indic) are in a category of their own and merit a unique descriptor such as "abugida". We also consider the authors' concept of orthographic depth to be problematic outside the context of European alphabets because orthographic depth across the full spectrum of the world's writing systems is multi-dimensional rather than uni-dimensional. We suggest that at least 10 dimensions of orthographic depth (or complexity) are needed to capture writing system diversity. Finally, we briefly discuss some educational implications of classification and mis-classification of writing systems.

Keywords: Akshara; Alphasyllabary; Abugida; Alphabet; Orthographic depth.

Rimzhim, Katz and Fowler (hereafter RKF) argue that, like alphabets[1], Brahmi-derived writing systems such as Devanagari represent both vowels and consonants 'on a par'. "*[T]he presence of both full and half forms of vowels puts them orthographically on a par with the full and half forms of consonants respectively. … This equivalence is a defining feature of an alphabetic writing system*" (Rimzhim, Katz, & Fowler, p. 5).

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[1]Use of the term 'alphabet' varies from author to author and has been used to refer more narrowly or more broadly to writing systems that (1) represent all consonants and all vowels on an equal footing, as do RKF; (2) represent all consonants and all vowels but with vowels having only subordinate status; or (3) represent all consonants but with vowels either incompletely represented or entirely unrepresented. Since we share RKF's strict or 'narrow' definition (for historical reasons elaborated in Daniels, in preparation), we confine our arguments to this definition alone.

We disagree and list six reasons why these scripts cannot be considered structurally alphabetic.

(1) The overwhelming majority of vowels are not full-sized letters but are either *matras* or else inherent and unmarked; the overwhelming majority of consonants are full-sized letters.[2]
The prototypical akshara[3] consists of a full-sized consonant (with inherent vowel or) with a physically smaller vowel *matra* appended to the larger consonant, unlike Western (Greek-derived) alphabets such as Roman, Greek and Cyrillic, in which letter size and shape are similar for vowels and consonants.[4] The primacy of consonants makes sense historically given that Indic scripts derived from a Semitic (Aramaic) abjad (see point (3) below). Indeed, many words provide signs that denote[5] only consonants but no vowels (see, for example, RKF's five-letter, five-akshara example वक्तव्य/vəktəvyə/).

(2) Reduced consonants are not equivalent to the vowel *matras*; conjunct or 'half' consonantal letters usually preserve the distinctive portion of the shape of the regular full-sized letter form, but the vowel *matras* do not exhibit such a relationship (Daniels, 2008, in preparation). The sole exception is the ⟨r⟩, which in conjuncts is the only consonant truly on a par with vowel *matras* (प ⟨pa⟩, र ⟨ra⟩, प्र ⟨pra⟩, र्प ⟨rpa⟩).[6] For the primary vowels, in most cases, there is no resemblance between the word-initial vowel form[7] and the non-initial diacritic. Some aksharas with consonant clusters (e.g., ⟨kṣa⟩ and ⟨jña⟩) coalesced over time into a single (complex) akshara unit, making it very difficult to decompose these virtually unanalysable akshara blocks.

(3) The most common vowel in Hindi[8] has no sign at all—the inherent schwa (historically /a/).

(4) Consonant signs are not alphabetic/phonemic. In all consonant symbols there is an inherent vowel; thus consonant signs, unlike alphabets, represent not phonemes but an open Cə syllable. A word-final consonant with no following vowel has a vowel nullification ('killer') stroke (*virama*).

[2]For present purposes, we retain RKF's cover term 'letter', but note that although this term (or the term 'grapheme') is widely used (but not entirely unproblematic) in European alphabets, its applicability to many writing systems such as Brahmi-derived Indic aksharas, Chinese characters, Japanese kanji, or Mayan glyphs is questionable.

[3]We prefer to retain the standard English technical terminology borrowed from Sanskrit long ago rather than the authors' transliterations of Hindi words (akshar, Devnāgrī, etc.).

[4]A simple explanation for the equivalent sizes of European consonants and vowels falls out of the hypothesis (Jeffery 1961, p. 22; Daniels, 1992b, 2007) that the Greek vowel letters derived from a misperception of several Phoenician letter names that began with initial laryngeal/pharyngeal phonemes that did not exist in Greek and were (fortuitously) misinterpreted to represent only the following vowel (e.g., /he/ => /e/ (later called *epsilon*) (see also Gnanadesikan's elaboration of this idea, 2009, p. 208–214).

[5]For 'denote' used in this sense, see Swiggers 1984.

[6]A possible explanation for this anomaly comes from the fact that /r/ tended to disappear in all Prakrits except Gandhārī Prakrit (Salomon, 2007, p. 93; Oberlies, 2007, p. 165). It seems likely that when Brahmi was devised, or adapted from Kharoṣṭhi, *r* was overlooked and only added later as a 'diacritic'. It may not be a coincidence that ⟨r⟩ is the narrowest C akshara in Brahmi and, following it, Devanagari and other modern Indic scripts.

[7]We thank one of our anonymous reviewers who called our attention to the existence in Hindi of the presumably onomatopoeic कौआ ⟨kau.ā⟩ 'crow', pl. कौए ⟨kau.e⟩, with non-initial vowel aksharas.

[8]Whitney (1877) counted 10,000 phonemes of Sanskrit from a wide variety of texts and found that nearly half of all the vowels (1,978 out of 4,352) were /a/ (with a further 819 /ā/).

(5) In all alphabetic systems, vowels and consonants are arrayed linearly. Devanagari has a great deal of nonlinearity, as do many other non-alphabetic systems such as Chinese,[9] Tibetan, Hebrew and Arabic. In alphabets (with the exception of Korean) consonants and vowels are arrayed on a common (linear) axis and are similar in size. For many non-alphabetic scripts, including Brahmi-derived ones, those non-initial vowels that are included are subordinated (both in size and spatial location) to the main array of consonants—appearing above, below or beside them.

(6) All European alphabets (except Yiddish) feature both majuscule (upper-case) and minuscule (lower-case) letters, but, with the exception of Javanese, not Brahmi-derived scripts.

RKF might have had a stronger case for their claims had they considered 'Phags Pa, a derivative of Indic scripts (see van der Kuijp, 1996), in which vowel signs are more similar in size to consonants than are *matras* (and not mere appendages) and are arrayed on the same (linear, vertical) axis, and therefore are more on a par with consonants.

Summing up, contrary to RKF, vowels and consonants are not on an equal structural footing as in alphabets.

ARE INDIC SCRIPTS FUNCTIONALLY ALPHABETIC?

Bi-literates versus mono-literates

We have no reason to dispute the findings in the lexical decision study summarised by RKF. Indeed, RKF's study reinforces similar data from skilled bi-literate adults (e.g., Bhide, Gadgil, Courtney, Zelinsky, & Perfetti, 2014; Kandhadai & Sproat, 2010; Vaid & Gupta, 2002), who also show phoneme-level processing of Brahmi-derived scripts. Our concern, however, is the interpretation of these data. Skilled adult Devanagari readers are also highly literate in alphabetic English. Indeed, it may even be the case that highly educated adults are *more* fluent readers of English than of their own native Devanagari script.

A wealth of data from studies of bi-literacy among both children and adults consistently highlights reciprocal influences between scripts (see, e.g., Bialystock, Luk, & Kwan, 2005; Geva, 2008; Koda, 2008; Schwartz, Leikin, & Share, 2005), including Indic scripts (Mishra & Stainthorp, 2007; Prakash, Rekha, Nigam, & Karanth, 1993). For example, Mishra and Stainthorp (2007) reported that among fifth-graders in Oriya-medium schools, syllable awareness but not phoneme awareness correlated with Oriya reading; but in a comparable English-medium school, only phoneme awareness correlated with Oriya reading. (English in both groups was, as expected, correlated with phoneme awareness alone.) Thus, it seems highly likely that reading English may have altered the way bi-literates process the phoneme-level information in the script (Mishra & Stainthorp, 2007; Padakannaya, 2009; Reddy & Koda, 2013). Developmental findings from young children learning to read Indic scripts but with as yet minimal exposure to the alphabetic script of English, as well as data from adult mono-literates, would be crucial for disentangling the cross-script influence of alphabetic literacy.

Syllables versus phonemes

A number of studies with young children who are learning to read in the native Indic scripts (and have had little or no exposure to alphabetic English) have found that Indic

[9]Referring to the fact that within a Chinese character, the 'semantic' and 'phonetic' components can be left and right, right and left, above and below, inside and outside, etc.

scripts require awareness of syllables *and* phonemes, and not phonemes alone (Nag, 2007; Nag & Snowling, 2011, 2012; Nakamura, Koda, & Joshi, 2014; Prakash et al., 1993, Study 1; Reddy & Koda, 2013).[10] For example, Reddy and Koda (2013) examined (spoken) syllabic CV and CCV deletion and phoneme deletion in children who had been learning to read and write Kannada for three years and English for one year (almost all were children of illiterate parents from low socio-economic-status [SES] homes). Both syllable deletion and phoneme deletion correlated well with Kannada word reading (.63 and .50, respectively), but only phoneme deletion correlated with English reading (.60). Moreover, syllable deletion made a significant contribution to Kannada even after partialling out phoneme deletion, but phoneme deletion was no longer significant once syllable deletion had been partialled out.

Reinforcing these correlational findings, Nag and Snowling (2011) examined the cognitive profiles of poor readers in Kannada. Poor readers in Grades 4–6 from mixed SES backgrounds were found to have deficits on both syllable *and* phoneme awareness compared to controls. Beyond the group averages, an analysis of individual cases (defined by performance falling one standard deviation below the mean) revealed *twice* as many cases of a syllable deficit than of a phoneme deficit (20/29 versus 10/29). These studies clearly demonstrate that both syllable and phoneme awareness, not just phoneme awareness (as in English), are important in learning Indic scripts. And most, but not all, also show that phoneme awareness is less crucial than syllable awareness. The exception is Nag and Snowling (2012), who found that although both phoneme and syllable awareness correlated with Kannada reading *accuracy* in a heterogeneous sample from Grades 4, 5 and 6, reading *rate* was better predicted by phoneme awareness.

A study by Nag (2007) sheds light on which aspects of reading Brahmi-derived scripts depend on syllable-level or phoneme-level processing. Nag (2007) examined the correlations between syllable and phoneme awareness and mastery of different types of aksharas. In early Grade 4, phoneme awareness had a negligible correlation with the simple (inherent-vowel Cə) aksharas, rising to a substantial .6 for complex (consonant-cluster) CC(C)V aksharas. The inverse occurred for syllable awareness, declining from .51 for simple aksharas to .37 for the complex aksharas (see Table 4, page 17). This same developmental 'inversion' was replicated in a comparison of above-average readers and below-average readers in Grades 4, 5 and 6 (Nag & Snowling, 2012). Nag (2007) proposed that "*The growth [in reading] appears to be a shift from treating the akshara system as a syllabary to treating it like an alphasyllabary*".

Turning to the data on adult mono-literates, a series of studies by Prakash et al. (1993) compared the phonemic awareness of adults who were either illiterates, mono-literates in Hindi (Study 2), or Kannada–English bi-literates. Phoneme deletion was at ceiling (99%) among the bi-literates and floor among the illiterates, with the mono-literates scoring at an intermediate (above-chance) level of 46%. Although differences in levels of education (secondary for mono-literates versus tertiary for bi-literates) potentially confound these data, they appear to confirm the developmental findings reviewed above, regarding a low but non-negligible degree of phoneme-level processing of Indic scripts among mono-literates.

Finally, Das, Kumar, Bapi, Padakannaya, and Singh (2009) have reported patterns of brain activation among skilled adult Devanagari readers who they claimed shared areas of activity associated with both syllabic and alphabetic processing.

[10]The exception here is Mishra and Stainthorp (2007), who found that only syllable but not phoneme awareness correlated with Oriya reading in Oriya-medium schools.

Contradicting RKF's claim that Devanagari is functionally alphabetic, all these studies unanimously highlight a major role of supra-phonemic akshara-level processing in young and old (mono-literate) readers alike.[11] The findings on phoneme awareness—the hallmark of an alphabetic script—are also fairly consistent (with the exception of Mishra & Stainthorp, 2007) and, on balance, suggest that phoneme-level processing is also important but probably less so than syllable-level processing, at least for reading accuracy. Nag's (2007) data suggest that phoneme awareness is mainly relevant at higher (post-initial) levels of reading ability primarily for complex aksharas with consonant clusters. It is also unmistakable that learning to read English creates a powerful alphabetic bias: bi-literacy, not bilingualism, is the critical element (Schwartz et al., 2005). It must also be acknowledged that the interpretation of all these studies is complicated by the diversity of scripts, teaching methods, task differences, degrees of exposure to English and SES.

The conclusion emerging from this work, and quite a compelling one, is that Indic scripts are functionally aksharic ***and*** *alphabetic.*[12]

ARE BRAHMI-DERIVED SCRIPTS BEST CHARACTERISED AS 'ALPHASYLLABIC'?

For more than a century, the misguided belief has prevailed that scripts come in just three 'types', logographies (such as Chinese), syllabaries (such as Cherokee or Japanese *kana*) and alphabets (such as Greek, Roman or Cyrillic) (Taylor, 1883/1899). For more than half a century, the equally misguided belief has endured that the historical evolution of scripts always passes through exactly those three steps in that order (Gelb, 1952/1963).[13] Taylor, though, was unaware of the workings of Indic-script orthography, and Gelb was misled by his ingrained need for order and symmetry in whatever he investigated (Daniels, 2000, 2002). It is in fact not the case that the alphabet[14] evolved from a syllabary; in fact it evolved from a script that notated only consonants (the type Daniels, 1990, has named *abjad*).

Similarly, the Indic scripts, too, developed from a consonantary—but one in which certain consonant letters, primarily ⟨y⟩ and ⟨w⟩, did double duty to mark the presence of /i ~ e/ and /u ~ o/ vowels respectively. The model script was Aramaic, all but the same script as is used for Hebrew today and a not very remote ancestor of Arabic script. It seems likely that the absence of notation for *a* and the frequent presence of notation for the other vowels is what led the pandits to devise a script for Gandhārī Prakrit that assumed an /a/ after every consonant but provided for marking each other vowel. Closed syllables (CVC)

[11]Often referred to in the literature as 'syllabic awareness'.

[12]We use the term 'alphabetic' to denote phoneme-level processing, although it seems a reasonable hypothesis that, in Indic scripts, consonants enjoy privileged status.

[13]While many writing-systems scholars have abandoned the classification of the Phoenician and similar abjads as 'consonantal syllabaries' that was required by Gelb's 'Principle of unidirectional development', some have not—e.g., Venezky, 1999, p. 4 ('not totally defendable'); Salomon, 2012, p. 126; Rayner, Pollatsek, Ashby, & Clifton, 2012. The 'Principle' provided the theoretical underpinning for the influential Gleitman and Rozin 1973; and its refutation has generally not trickled down to elementary linguistics textbooks (the latest edition of the most popular one, Fromkin, Rodman, & Hyams, 2014, p. 537, finds it necessary to mention that "*[s]ometimes [the Semitic systems] are considered syllabaries because once the vowel is perceived, the consonantal letter seems to stand for a syllable*"), or to popular treatments. Among reading researchers, lamentably, Gelb's views still predominate (see Share, 2014).

[14]The Greek alphabet is the ancestor of all past and current evolved alphabets: predominantly the Roman and Cyrillic, but also national alphabets including the Armenian and Georgian, so it is legitimate to speak of *the* (one) alphabet.

were entirely or almost entirely absent from their language, so there was no potential for confusion where a symbol might stand now for C*a* and now for C. This first such script is what is now known as Kharoṣṭhi. The date of its invention cannot be specified, but since the letter shapes are manifestly borrowed from Aramaic letters, it must have appeared between 500 BCE, when the Aramaic-using administrators of the Achaemenid Empire reached the western marches of India, and ca. 250 BCE, when Emperor Aśoka decreed that inscriptions be placed on rocks in the local languages and scripts.

Kharoṣṭhi did not last long in its homeland, though it served for several centuries more along the Silk Road to the north and east, before being replaced by the Brahmi script, which appears to be a regularisation and rationalisation of it (Salomon, 2012, p. 130) and was used for Aśoka's inscriptions throughout the rest of his realm, again in the various local Prakrits. It is Brahmi that gave rise to the immense variety of scripts throughout India and Southeast Asia, as local polities continued to write without much communication with each other. It was only with the coming of the British Raj and the introduction of printing that a double handful of scripts became standardised. It was during the last days of Brahmi—before regionalisation had irrevocably set in—that the sacred language Sanskrit first could be profaned by writing it down. With written Sanskrit, and with the vernaculars changing to admit closed syllables, the scripts needed to devise ways of notating consonants not followed by vowels—closed syllables, and syllables beginning with consonant clusters.

The various scripts adopted a variety of solutions. Some examples are attested in Brahmi inscriptions, with the second member of a consonant cluster written as an appendage to the first member. Devanagari, the eventual script of Hindi and Marathi as well as other varieties of Indic languages, and the script that has been adopted for Sanskrit in the western world, took a different route and appends a truncated form of the first consonant to a full or nearly full form of the second one. But when a syllable ends with a consonant cluster and/or the following syllable begins with a consonant cluster, all but the last consonant appear in reduced forms. It is thus *not* the case that a written akshara necessarily corresponds to a spoken syllable, and in any akshara-written language that admits closed syllables, such a correspondence will *not* exist (see also Nag, 2014a).

It has been shown above that akshara-based scripts are *not* fundamentally alphabetic. Here, we argue that they are *not* fundamentally syllabic. We begin by stating the obvious: in a syllabic script such as Japanese kana, syllable signs cannot be analysed into constituent consonants and vowels. Therefore, the term 'alphasyllabic', suggesting that they are somehow a hybrid or mix of the two long-established types, is misleading.[15]

The term 'alphasyllabic' dates only to 1992; no use has been found predating Bright (1992). William Bright's prestige among Indian linguists, particularly Dravidianists, probably aided its rapid diffusion in that community.[16] About the same time (Daniels, 1990, p. 730), the term *abugida* was offered, which parallels the terms 'alphabet' (from the first two Greek letters) and 'abjad' (from the first four Arabic letters): it comprises the first four Ethiopic letters combined with the first four vowels as traditionally taught in the

[15]This is brought out especially clearly in an expression by an author who fully accepts the typology: "*The difference between the Indian alphasyllabaries and the true syllabaries is clear enough …*" (Sproat, 2010, p. 61).

[16]As is clarified by Bright (2000), 'alphasyllabary' is meant to refer to the *formal* property of vowels other than /a/ being denoted by *matras*, and 'abugida' is meant to refer to the *functional* property of /a/ being inherent in the basic symbol. The test case proved to be the 'Phags pa script, which is an abugida but not an alphasyllabary.

Ethiopic script chart.[17] For, outside South and Southeast Asia, the Ethiopic script is the only one that operates on such a pattern.[18]

ORTHOGRAPHIC DEPTH

RKF also apply the concept of orthographic depth to Devanagari. This term was originally developed in the context of European alphabets and referred to the fact that English orthography does not reflect the surface phonemics (or phonetics) of the English language particularly well, whereas Serbo-Croatian (as it then was) orthography does.[19] English was labelled a 'deep' orthography and Serbo-Croatian a 'shallow' orthography (Katz & Feldman, 1981, 1983). This pioneering work was the first to offer a theoretical framework to guide cross-linguistic reading research and remained the only framework until quite recently (Perfetti, Liu, & Tan, 2005; Ziegler & Goswami, 2005). But does the concept of orthographic depth have value in the description of orthographies other than European alphabets?

Katz, together with Frost, went on to apply the concept of orthographic depth to a general (universal) theory of reading, the Orthographic Depth Hypothesis (Katz & Frost, 1992; Frost, 2005). Frost (1992, p. 260) "*suggested that [orthographic depth] can be regarded as a continuum on which [all] languages can be arrayed. [We] proposed that the Hebrew orthography could be positioned at the extreme end of this continuum, since it represents the phonology in an incomplete manner*". But, as Shimron (2006) has pointed out, Hebrew depth is very different from English depth. In fact, at least 10 dimensions of orthographic depth can be enumerated (expanding on Daniels, 2012, and further elaborated in Daniels and Share, in preparation). It might be wise in the future to adopt some less theory-laden term than 'depth', which connotes a narrow, one-dimensional concept of script accessibility.

I. *Historical orthographic inertia*

(a) In English, French and Thai, for instance, depth is morphophonemic due to retention of historical spellings despite language change, accounting for the many pronunciations of ⟨ough⟩ exemplified by the words *bough*/*cough*/*dough*/*through*/*tough*, which once all shared the same pronunciation. In Hindi, the inherent vowel (/ə/ in this language) is omitted in some circumstances (apparently not fully predictable) without indication by either conjunct formation or *virama*. Pandey (2007, p. 153) provides, among others, the particularly telling examples दर्शन ⟨dəršənə⟩ /dəršən/ 'view' ~ दार्शनिक ⟨dāršənikə⟩ /dāršnik/ 'philosopher' (with the

[17]It is probably not a coincidence that the first inscription using vocalised Ethiopic script is also the first inscription in which King Ezana (mid fourth century CE) professes Christianity. It is quite likely that his conversion was effectuated by missionaries who had sailed from the Christian community of the western India coast (Daniels, 1992a).

[18]To be sure, by dint of population a name based in some aspect of Indian culture might have been more suitable, but 'kakhāgighī' or some such is less than inspiring. Now that the order of both consonants and vowels used by Kharoṣṭhi scribes has become known (Salomon, 2006), a name like 'arepiconu' might have suggested itself.

[19]The terms 'alphabet' and 'phoneme' cannot be taken as simple pre-theoretic givens. In the scheme adopted in Daniels (1990), an alphabet 'assigns a segment (consonant or vowel) to each symbol'. Thus Greek (and its descendants), Korean, and fully pointed Hebrew and Arabic are all written with alphabets. A phoneme is "*the smallest unit of sound in a language capable of causing a difference of meaning*" (Barry 2006, p. 345). 'Grapheme', by contrast, has had so many different interpretations that in writing systems theory it is meaningless (Daniels, 1991).

⟨r⟩ diacritic) and सरल ⟨sərələ⟩ /sərəl/ 'easy' ~ सरला ⟨sərələā⟩ /sərlā/ 'Serla' (not reducing the र to its diacritic form). These alternative pronunciations create ambiguity for the reader translating from print to sound.

(b) Conversely, originally distinct sounds once spelled differently can merge while the spelling is retained: *peak*/*peek*/*pique*, even *relieve*/*receive*. In English, these can reflect dialect differences within the language (which are sometimes retained in local pronunciations) as well as borrowing both spellings and pronunciations from different sources. In Hebrew, ancient spellings with ⟨ʔ ʕ h⟩, ⟨t ṭ⟩, ⟨k q⟩ and ⟨s ś⟩ are retained even though in the modern language those groups of letters have merged to Ø, /t/, /k/ and /s/ respectively (see Ravid, 2012). Similarly, many languages influenced by Sanskrit retain letters for three sibilants ⟨ś ṣ s⟩ for spelling loanwords from that language, even though in the modern languages they have merged to /s/; and many languages influenced by Arabic retain letters for the interdentals, emphatics, laterals and pharyngeals ⟨t̲ d̲ ṭ ṣ ḍ ẓ ḥ ʕ⟩ for spelling loanwords from that language, even though in the modern languages they have merged (in different ways and different combinations according to the language; Daniels, 2008, 2014).[20] These ambiguities in converting speech to print create difficulties for the speller and demonstrate that even the classic psycholinguistic dimension of spelling–sound regularity/consistency embodied in the notion of orthographic depth is not uni-dimensional. Compared to English, pointed Hebrew, for example, is almost perfectly regular/consistent (or shallow) for the reader, but spelling ambiguity abounds as in English (Ravid, 2006).

II. *Spelling constancy despite morphophonemic alternation*

In English and Russian, for instance, depth is morphophonemic because the orthography does not change when either morphemes or phonemes undergo conditioned alternations: /haws/ ⟨house⟩ becomes /hawz/ when the plural suffix is added, but the spelling does not change: ⟨houses⟩ (cf. ⟨huis/huizen⟩ in Dutch). In Sanskrit, on the other hand, the spelling reflects morphophonemic alternation: तत् + भवति = तद्भवति ⟨tat + bhavati = tadbhavati⟩, तत् + श्रुत्वा = तच्छ्रुत्वा ⟨tat + šrutvā = tacchrutvā⟩, तत् + हि = तधि ⟨tat + hi = taddhi⟩ (Allen, 1953, p. 9), so, in these cases, the orthography is more phonologically transparent but more morphemically opaque.

III. *Omission of phonological elements*

In Hebrew and Arabic, for instance, depth is purely orthographic, in that most vowels are normally not written: Modern Hebrew orthography writes all of the consonants, and some of those vowels that in Classical (Biblical) Hebrew were long. This becomes a significant source of complexity when a consonant string is homographic (e.g., ספר) as is frequently the case (see, Share, in press). Similarly, the lack of stress marks in many scripts including English also constitutes a source of ambiguity (e.g., *contrácт* [v.]/*cóntract* [n.]). For many of the world's tonal languages, the lack of tone marking also introduces a significant measure of impenetrability. This is particularly acute in Africa where tone languages

[20] Anecdotal evidence of this sort of depth in Spanish—a language conventionally placed at the 'very shallow' end of the single dimension of 'orthographic depth'—is provided by Morrison (1945), who observes the word 'I' spelled both ⟨yo⟩ and ⟨llo⟩ and offers a number of other instances of uncertainty as to the correct spelling of various phonemes. Valle-Arroyo (1990) confirms these observations in a systematic investigation of spelling errors in Spanish.

predominate, yet much of the continent uses European alphabets which were not designed to represent tone (Roberts, 2013).

IV. *Dual-purpose letters*

In Modern Standard Arabic, just about every long vowel is written, using two letters that also represent consonants and a third that has no consonantal value. (The short vowels are normally not written.) In English, ⟨h⟩ doubles as a diacritic in the digraphs ⟨ch ph sh th wh⟩, indicating a pronunciation similar to that of the bare consonant.

V. *Diglossia*

Modern Standard Arabic with its spelling is very different from any spoken Arabic language (considerably more so than for any English dialect, thanks precisely to the morphophonemic nature of English orthography), so the dimension of diglossia is an important component of orthographic depth in Arabic and other languages like it (see Ferguson, 1959; Myhill, 2009).

VI. *Graphic considerations*

In an inversion of Dimension I, orthographic complexity can result from differentiation for solely graphic reasons. The anomalous spelling of English [ʌ] with ⟨o⟩ (as in *come*, *monk*, *worry*) is attributed with some hesitation by Scragg (1974, p. 44), and with considerable certainty by Venezky (1976, pp. 358f.), to the earlier occurrence of ⟨u⟩ adjacent to other letters written entirely with minims, to alleviate potential confusion: ⟨monf⟩ was considered easier to read than ⟨munf⟩.

VII. *Ligaturing*

(a) The coalescence of characters is an aspect of depth that until recently has been neglected in studying Indic scripts. But sometimes a combination is so trivial that it is never mentioned: the character sequence ⟨f⟩⟨i⟩ in standard English typography combines into ⟨fi⟩, which, to a novice reader at least, might look very like ⟨h⟩, but to our knowledge the ⟨fi⟩ ligature is never taught and no resulting confusion is ever reported. In Arabic script, all but six letters are ligatured to the following letter (Saiegh-Haddad & Henkin-Roitfarb, 2014), and this feature is often cited as a source of difficulty in learning to read (e.g., Abu-Rabia, Share, & Mansour, 2003): ال ⟨ʾl⟩ ‘the’ + عباب ⟨ʕbāb⟩ ‘torrents’ = العباب ⟨ʾlʕbāb⟩ ‘the torrents’; direct empirical investigation of this issue, however, has only just begun (Eviatar & Share, 2013).

(b) Looking at Indic scripts as a whole, conjunct formation is a more complicated matter than is recognised when only one script is studied. To take two that have received attention recently, compare Devanagari and Kannada. Devanagari reduces the first consonant in a cluster, Kannada the second: ग ⟨ga⟩ ग्ग ⟨gga⟩, but ಗ ⟨ga⟩ ಗ್ಗ ⟨gga⟩ respectively. Most Devanagari compound aksharas are horizontal, as in त्प ⟨tpa⟩, but some are vertical, as in प ⟨pta⟩.

VIII. *Visual complexity*

Another aspect of orthography that has been neglected yet may also contribute to orthographic depth is the graphic shape of a script. For instance, Shimron and Navon (1981) demonstrated that Hebrew letters are identified more slowly than English letters, possibly owing to their largely rectangular architecture. And Ibrahim, Eviatar and

Aharon-Peretz (2002) have shown that letter identification in Arabic is even slower than Hebrew letter identification. Nag, Snowling, Quinlan, and Hulme (2014) have shown that a measure of visual complexity of akshara symbols (pixel density) contributes significantly to variation in akshara knowledge among beginning readers of Kannada. Another aspect of visual complexity that is often overlooked is letter variants such as upper-case and lower-case letters (⟨O/o, A/a⟩); or in Indic scripts, initial and post-initial variants. In cases where the two allographs do not share the same form (⟨A/a⟩), this probably imposes an additional burden on beginning readers. In Arabic, for example, this problem is comounded because many letters alter their form fourfold depending on independent, word-initial, word-medial or word-final position (see the word-initial letter in the first example in VII. Ligaturing, which has the following four variants: ع, ـع, ـعـ, عـ).

IX. *Non-linearity*

Diacritical marks add an additional non-linear dimension to many of the world's scripts and also seem likely to be a source of orthographic depth. For example, the orthography of Ifè, a Defoid language of Togo and Benin, uses the tilde to mark nasalised vowels and accents to mark tone, sometimes resulting in diacritic stacking, e.g., ⟨lákũ̀-kà⟩ (Agbemadon & Boethius, 1989), raising concerns regarding visual crowding (Roberts, 2008).

X. *Inventory size*

Yet another aspect of orthographic depth is the size of the sign inventory. Nag (2007) has termed this the 'extensive/contained' dimension. Whereas alphabets have only a few dozen signs, there are hundreds of aksharas (if most are learned holistically, see Nag, 2014a, Figure 1), several hundred simple Korean syllable blocks, some 2000 Japanese kanji and several thousand Chinese characters.

We regard these 10 dimensions as merely a catalyst for discussion of the multi-dimensional nature of writing-system complexity. Only future analytic and empirical study by linguists and psycholinguists will be able to determine whether additional dimensions are required or existing dimensions should be coalesced or subdivided. Some dimensions clearly have wide application, while others only limited generality; it may even be the case that two or more dimensions interact—exacerbating or alleviating depth. This multi-dimensional framework also suggests that any one script's depth may be a unique combination of some or all of the above dimensions. The point we wish to emphasise, however, is that these dimensions *do not form a single continuum* on which all orthographies can be ranged. So it must be asked how appropriate it is to invoke an undifferentiated notion of 'orthographic depth' in psycholinguistics that can be generalised beyond alphabetic scripts.

EDUCATIONAL IMPLICATIONS

The way linguists, psychologists and, ultimately, educators conceptualise the writing system a child learns has profound consequences for reading instruction—for what we teach, how we teach it, even when we teach it (Share, 2008; Venezky, 1995). In the English-speaking world, few topics have fired such debate and acrimony for so long as the question of how to teach children to read (Adams, 1990; Chall, 1967; Goodman, 1989; Strauss & Altwerger, 2007); and still, dissatisfaction with general levels of literacy attainment and debate over methods continue (Buckingham, Wheldall, & Beamon-Wheldall, 2013; Seidenberg, 2013; Tunmer et al., 2013).

Much of this debate has been fuelled by opposing views of the English writing system. Whole-word (and subsequent whole-language) methods of instruction were partly a reaction to what many regarded as an irredeemably chaotic and unteachable spelling–sound code. The idea has even been propounded that English could and should be treated as a logography and taught via whole-word meaning-emphasis methods (see, e.g., Strauss & Altwerger, 2007). Advocates of the opposing pro-phonics camp (e.g., Ehri, Nunes, Stahl, & Willows, 2001; Rayner, Foorman, Perfetti, Pesetsky, & Seidenberg, 2001; Share, 1995) claim that English spelling is sufficiently regular to be teachable. Even within the pro-phonics camp, there remains lively debate in many parts of the English-speaking world regarding the appropriate approach to beginning reading: Should beginners be introduced first to individual letters and phonemes, or to larger sub-syllabic or supra-phonemic multi-letter units such as onsets and rimes (e.g., ⟨-all⟩, ⟨-ice⟩), which often have greater spelling–sound consistency than individual letters? This uniquely Anglo-American debate over teaching methods is now being exported worldwide.

If Indic scripts are, as RKF conclude, truly alphabetic, then all the accumulated scientific wisdom about English literacy learning and instruction (e.g., Lonigan & Shanahan, 2009; National Reading Panel, 2000; Snowling & Hulme, 2005) can be directly applied to them and the focus of instruction squarely placed on the alphabetic principle as in English orthography. If, on the other hand, Indic scripts are aksharic, instruction will need to focus instead on larger, more psycholinguistically accessible supra-phonemic units. In order to deal with more complex aksharas with initial consonant clusters, phonemic-level analysis might be advantageous, but access to phonemes is far more difficult than access to syllable- and akshara-level units. If all aksharas were to be learned holistically, some 600-plus signs would need to be memorised (Nag, 2007).

Why, then, *would* aksharas be taught holistically? Elementary textbooks for the Korean alphabet, which combines the letters into syllable blocks, present a chart of the simple consonant letters as one dimension and the vowel letters as the other dimension (Taylor & Taylor, 1995, pp. 232–234; see also Rickard & Lee, 2004, for a similar approach in alphabetic Malay).

It does not necessarily follow that a script that can be analysed into singleton phonemes, whether consonants or consonants and vowels, is best taught and learned alphabetically. Indeed, there is empirical evidence that, for languages with simple syllable structures, learning a true alphabetic script may be easier if taught as a syllabary (see Asfaha, Kurvers, & Kroon, 2009; McCarthy, 1995; Rickard & Lee, 2004). The same issues arise not only in abugidas but also in abjads such as Hebrew and Arabic: Do we teach larger, more accessible CV units, treating the Semitic scripts as a syllabary (akin to whole aksharas), or do we treat these systems as alphabetic and shift our instructional focus to the more cognitively demanding phonemic level? And what of the primacy of consonants as opposed to the largely subordinate vowels? Perhaps instruction need only emphasise consonants in isolation, with vowels learned as appendages to consonants. Only well-controlled empirical research can provide answers to these complex yet fundamental pedagogical questions.

Above all, we must avoid the Anglocentrism (Share, 2008) and Eurocentrism (Gaur, 1995) which pervade much of reading research and which go hand in hand with ‘alphabetic supremacism’ (Nag, 2014b; Rogers, 1995; Share, 2014): the often unspoken belief that alphabets are inherently superior to non-alphabetic systems. Some languages may be well suited to alphabetic writing systems (see Perfetti & Harris, 2013), others may

be better served by non-alphabetic systems (see Asfaha et al., 2009; McCarthy, 1995; Share, 2012, 2014).[21]

Since the beginnings of colonialism, the traders, colonisers and missionaries who disseminated European alphabets across the globe took it for granted that their own writing systems would be optimal for non-European languages (Gleason, 1996). Indeed, a long line of Western scholars has presumed that European alphabets are inherently superior to non-alphabetic systems (see, for example, Gelb, 1952/1963; Havelock, 1982; Taylor, 1883/1899). Not only does alphabetic elitism pervade much contemporary reading research and pedagogy (see, for examples, Share, 2014), but the dominant Anglo-American and European theorising almost invariably sets the theoretical and applied agenda around the world.

The pioneering cross-linguistic work of the Haskins team, on the other hand, and their work on the concept of orthographic depth, have stimulated more recent work expanding the scope beyond European alphabets. A number of first-generation approximations of a universal model of literacy learning have appeared (Frost, 2012; Perfetti, 2003; Perfetti, Liu, & Tan, 2005; Ziegler & Goswami, 2005) that treat worldwide linguistic and writing system diversity with the seriousness it deserves. This constitutes the major challenge for the next generation of literacy scholars.

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[21]It is clear that a syllabary would not serve English well, with its possible CCCVCCC syllables (e.g., ⟨strengths⟩ /streŋθs/ = [streŋkθs]!), whereas Hawai'ian, with CV syllables comprising just 7 or 8 consonants and 5 vowels, is an ideal language for a syllabography. The abugida was devised for a language with CV syllables and a great preponderance of /a/ over its other four vowels.

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