Bassetti, B. (2012) Sound and spelling. In C. A. Chapelle (ed.) *The encyclopedia of applied linguistics* **(pp. 5312-5317). Oxford: Wiley-Blackwell.**

Spelling means representing a language in writing by using the letters of an alphabet according to conventions. This entry will first describe the principles by which spelling represents sound, and review differences in phonological transparency among alphabetic writing systems. It will then overview the consequences of the sound-spelling relationship for reading, spelling, literacy acquisition, metalinguistic awareness, pronunciation, and linguistic descriptions of spoken language.

The representation of sound in alphabetic writing systems
Unlike other types of writing systems that represent syllables, consonants or other language units, an *alphabetic writing system* represents each phoneme of a spoken language with one symbol. It is therefore a *phonographic system* (it represents the sounds of the spoken language), and in particular a *phonemic system* (it represents phonemes; for an overview, see Coulmas, 2003). Alphabetic writing systems are written with *scripts* (sets of written symbols) called *alphabets*, whose smallest units are called *letters*. Although there are just a few alphabetic scripts, many languages are written with an alphabet. The most widely used one is the roman alphabet, other often-cited examples are Greek and cyrillic, and less well-known ones include the Armenian and Georgian alphabets. Writing a language using letters is called *spelling* (although the term can also used for non-alphabetic writing systems).

Alphabetic writing systems work on the principle of segmenting spoken language into phonemes and representing each phoneme with a grapheme, for instance representing the English word /kæʃ/ with <cash> (the symbols '<…>' denote an orthographic form). A *grapheme* is the smallest identifiable unit in a writing system (see Coulmas, 1999,). In an alphabetic writing system, a grapheme can be a letter or a letter combination. For instance, in English the grapheme <b> consists of one letter and represents the phoneme /b/, the grapheme <sh> is a digraph (combination of two letters) and represents the phoneme /ʃ/. Since in English there are more phonemes (e.g., 44 in British English Received Pronunciation) than letters (26), it is not possible to represent all phonemes by means of a single letter. The higher number of phonemes compared with letters can explain why /θ/ is represented by the digraph <th>, and why <th> represents both /θ/ and /ð/.

The correspondences between graphemes and phonemes in alphabetic writing systems are called *grapheme-phoneme correspondences* ('GPC', also 'grapheme-phoneme conversion rules'), and in the opposite direction the correspondences between phonemes and graphemes are called *phoneme-grapheme correspondences* ('PGC'; see Coulmas, 2003). For instance, in English the grapheme <d> corresponds to the phoneme /d/, and the phoneme /ʃ/ to the grapheme <sh>. Correspondences are specific to each writing system. For instance, in both the English and Italian writing systems the grapheme <b> corresponds to /b/, but whereas the grapheme <ch> corresponds to /k/ in Italian, in English it corresponds to /k/ ('chaos'), /ʃ/ ('machine') and /tʃ/ ('child'). Therefore, the same orthographic word <china> is pronounced /kina/ in Italian and /ˈtʃʌɪnə/ in English (meaning 'cinchona' and 'ceramics' respectively).

Phonological transparency
In an ideal alphabetic writing system, the same phoneme should always be spelled with the same grapheme and the same grapheme should always be pronounced with the same phoneme. This is the *alphabetic principle*. No writing system follows this principle entirely, but different writing systems are more or less close to it.

Different writing systems then have different levels of *phonological transparency*, and are described as more 'transparent' or 'opaque'. This has also been called *orthographic depth*, and different writing systems have been described as 'deeper' or 'shallower' (e.g., Katz & Frost, 1992). Examples of phonologically transparent alphabetic writing systems include Finnish, German and Spanish, while French is an example of an opaque one (for descriptions of various writing systems, see Coulmas, 1999; Daniels & Bright, 1996; Joshi & Aaron, 2006). Italian and English are often cited as examples of writing systems at the opposite ends of this phonologically transparency continuum, and will be used as examples in this entry. In transparent writing systems such as Italian there are mostly (but not only) one-to-one correspondences between graphemes and phonemes and between phonemes and graphemes. For instance, in Italian <a> is always pronounced /a/ and <b> is always pronounced /b/; in the opposite direction, /a/ is always spelled <a> and /b/ is always spelled <b>. In English, the grapheme <a> can represent many phonemes (e.g., /æ/ in 'cat', /ɛ/ in 'many', /ɔː/ in 'call', /ɑː/ in 'father',), and <b> can represent /b/ or be silent ('debt'); in the opposite direction, /b/ can be spelled <b> or <bb>. Some English graphemes correspond to high numbers of phonemes, for instance even the relatively rare grapheme <gh> can correspond to /g/ ('ghost') or /f/ ('enough'), be silent ('high'), or even correspond to /p/ ('hiccough') and /ə/ ('Edinburgh'). In English there are then one-to-many grapheme-phoneme correspondences, and one-to-many phoneme-grapheme correspondences; furthermore, correspondences for vowels are more complex than for consonants, due to the large number of vowels and the small number of vowel letters (see Carney, 1994, for British English correspondences, and Venezky, 1999, for American English ones). The degree of transparency is not the same across directions, whether grapheme-to-phoneme or phoneme-to-grapheme, and in various writing systems GPCs are more transparent than PGCs (e.g., see Harris and Giannuoli, 1999, for Greek). There is currently no agreement on how to calculate degrees of phonological transparency, although various proposals have been put forward, for instance calculating the phoneme-to-grapheme ratio (Coulmas, 2003)

Beyond the alphabetic principle: The case of English spelling

English is often presented as a clear example of a phonologically opaque alphabetic writing system, but its low level of phonological transparency is partly due to a higher level of morphemic transparency than other writing systems.

The low level of transparency of written English has several causes. It is partly due to historical reasons, because the spoken language evolved but the spelling of words remained fixed (for a history of written English, see Scragg, 1974). For instance, the <k> in <know>, which is silent in contemporary English, was pronounced in Old English, and it therefore represents a phonemic transcription of an earlier spoken word. Another reason is that foreign words were introduced from languages that had different grapheme-phoneme correspondences, so in English the same grapheme <c> is pronounced /k/ or /s/ in words of French origin ('cab', from 'cabriolet'; 'cede', from 'céder') and /tʃ/ in words of Italian origin ('cello', from 'violoncello'). English GPCs can then derive from those of classical languages, Romance languages and other languages.

Another reason why English is phonologically opaque is because it is more morphologically transparent, and phonological transparency is sacrificed in order to maintain morphological transparency. For instance, the past tense morpheme is pronounced /t/, /d/ or /ɪd/ depending on the phonological context, but it is always spelled <ed>. In a fully alphabetic writing system there would be three different spellings, for instance <t>, <d> and <ed>. Also, in English /saɪn/ is spelled as <sign> with a <g> to show its common morpheme with <signature> regardless of the pronunciation. The Italian writing system instead represents the sound of words regardless of their morphology, spelling <segno> with <e> and <significato> with <i> to

represent the spoken forms /ˈseɲːo/ and /siɲːifiˈkato/, whereas a morphologically transparent representation could for instance be <signo> with an <i>. English can therefore be placed lower than Italian on the phonological transparency continuum, but higher on the morphological transparency continuum.

Some of the irregular correspondences between sounds and spellings in English are then due to the fact that the writing system does not only aim at representing sound. Although having different written forms for the same phonological form creates difficulty for spelling, it can facilitate reading, for instance with homophone disambiguation, as when in English /raɪt/ is spelled as <right>, <write> or <rite>, or content words such as 'inn' and 'bee' are spelled with three letters but function words such as 'in' and 'be' are spelled with two letters (Cook, 2004). Such spellings may confuse writers but may facilitate readers. Still, despite the advantages of a morphemically transparent writing system, there is a commonly held view that the best alphabetic writing system is a phonologically transparent one. For this reason, there have been various proposals for spelling reforms to bring spelling closer to sound, from Noah Webster's American spelling to the proposals of the English Spelling Society in the UK, or for simpler spelling systems to be used with children, such as the Initial Teaching Alphabet, which have enjoyed varying degrees of success (for an overview, see Sampson, 1985).

Consequences of the relationship between sound and spelling

The level of phonological transparency of a writing system affects reading and spelling processes, literacy acquisition, and even literate speakers' metalinguistic awareness and pronunciation. For instance, children learn more phonologically transparent writing systems faster than more opaque ones, so that literacy acquisition is faster in Greek and Italian children than in English-speaking children (Elley, 1994), and the latter struggle particularly in reading pseudowords, i.e. non-existing words that can be pronounced using grapheme-phoneme correspondence rules (Seymour, Aro, & Erskine, 2003). Phonemic awareness, i.e. the ability to identify and manipulate phonemes, also develops earlier in children who acquire literacy in more transparent alphabetic writing systems (Spencer & Hanley, 2003). Compared with readers of more phonologically transparent writing systems, readers of more opaque writing systems rely more on the whole-word strategy and less on grapheme-phoneme decoding (Frost, Katz, & Bentin, 1987); they need to decode longer orthographic units such as onsets, rimes, and syllables (the 'psycholinguistic grain size theory', Goswami, Ziegler, Dalton, & Schneider, 2003); and they need to rely more on analogy for reading words (Gombert, Bryant, & Warrick, 1997). Dyslexia may be more widespread among users of more phonologically opaque alphabetic writing systems (Smythe, Everatt, & Salter, 2003), and dyslexic users of such writing systems may display more severe difficulties (Paulesu et al., 2001). Second language learners are often influenced by the relative levels of phonological transparency of their first and second language writing systems in their reading and spelling processes and second language phonemic awareness (Cook & Bassetti, 2005), and the spelling of second language words can even affect second language learners' pronunciation (Bassetti, 2008).

Finally, another important issue is whether the relationship of sound and spelling affects the development of linguistic theories. Spelling provides a permanent visual representation of language, which is likely to affect people's ideas about their spoken language. Non-linguists are affected by the orthographic representations of sound when performing metalinguistic awareness tasks, such as counting or manipulating phonemes in spoken words, so that literate English speakers count more phonemes in a word that is spelled with more letters (e.g. <pitch> vs. <rich>, Derwing, 1992). Such effects of orthography on phonemic awareness appear in children concurrently with literacy, when for instance children start considering nasal consonants as separate phonemes (Treiman, Zukowski, & Richmond-Welty, 1995) and counting more

phonemes in words spelled with more letters (Ehri & Wilce, 1980). In some cases, words' pronunciations have changed due to their spellings: *spelling pronunciations* happen when people pronounce a word by using grapheme-phoneme correspondences to sound out the word's written form, and such pronunciations can then become standard. This is why 'author' is pronounced with a /θ/ rather than its original pronunciation with a /t/ (Bloomfield, 1927). Some scholars have then even argued that linguists' analyses of the spoken language might also be influenced by the characteristics of their writing systems. For instance, it has been suggested that the concept of phoneme only emerged because western linguists were literate in alphabetic writing systems (Linell, 2005), and that the phoneme was originally conceived as the unit that would be represented by a grapheme in an ideal writing system (see Sampson, 1985).

Conclusion

In conclusion, the relationship between sound and spelling is more complex than saying that spelling represents sound, as different alphabetic writing systems vary in their position along the phonological and morphological transparency continua. The complex relationship between sound and spelling affects reading, spelling, literacy acquisition, metalinguistic awareness, pronunciation, and possibly linguistic descriptions of spoken language.

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