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Are onsets and codas important in processing letter position? A comparison of TL effects in English and Korean

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ABSTRACT

When two consonants within an English word were transposed to create a nonword, difficulty in lexical decision responses to that nonword was revealed, most strongly when the coda of the first syllable was exchanged with the onset of the second (e.g., *nakpin* derived from *napkin*), but also when onsets were exchanged between syllables (e.g., *kapnin*) as well as codas (e.g., *nankip*). The latter findings are incompatible with current models of letter processing. Moreover, such transposed letter (TL) effects were shown to be considerably reduced in Hangul, the alphabetic script used in Korean. Because Hangul physically demarcates the onset and coda positions for every consonant, it is argued that it is ambiguity in assignment of a consonant to an onset or coda slot that leads to the TL effect in a linear script such as English. Such a conclusion implies that models of letter processing should incorporate the involvement of subsyllabic structure, something that is currently lacking.

Introduction

When a nonword is created from an English word by transposing two of its interior letters (e.g., *nakpin*), it is hard to distinguish from its baseword (*napkin*). This has been amply demonstrated in lexical decision experiments where such "transposed letter" (TL) nonwords are erroneously classified as words more often than nonTL nonwords (e.g., *nagbin*) and/or have longer response times when being correctly classified as nonwords (e.g., Andrews, 1996; Chambers, 1979; Frankish & Turner, 2007; O'Connor & Forster, 1981; Perea & Lupker, 2004; Perea, Rosa, & Gómez, 2005). Such a finding has implications for the issue of how information about letter position is encoded during reading because it suggests that the exact position of a letter in the middle of a presented letter-string is not very important when that letter-string is encoded.

There are several recent accounts of letter position coding that readily handle the TL effect, namely, "open-bigram coding", "spatial coding", and "overlapping distributions". In the first of these (e.g., Grainger & van Heuven, 2003; Grainger & Whitney, 2004; Schoonbaert & Grainger, 2004; Whitney, 2001; Whitney & Cornelissen, 2008), a word is coded in terms of the correctly ordered pairs of letters (i.e., bigrams) that are found within it, both adjacent and nonadjacent (though distant letter pairings only make a weak contribution, if any). For example, *napkin* would be coded at the bigram level as *na, np, nk, ak, pk, pi, kn, in*, and so on. When *nakpin* is presented, units representing the bigrams *np* and *nk* are activated while the unit representing *pk* is not, thus providing a slightly different coding to that associated with *napkin*, but with considerable overlap. In contrast, none of the bigrams relevant to *napkin* that contain *k* or *p* will be activated by *nagbin* and, therefore, it is less confusable with the baseword.

In the spatial coding account (e.g., Davis, 2006a; Davis & Bowers, 2004, 2006), words are coded in terms of their individual letters, but are maximally responsive to a specific pattern of activation within the letter-level nodes. The amount of activation generated within a letter node is determined by its position in the letter-string, with the

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highest activation for initial letters and the lowest for final letters. For example, the lexical representation for *napkin* will be maximally responsive when the amount of activation in the *p* unit is appropriate for the third letter of a letter-string and the amount of activation for the *k* unit is slightly less. The stimulus *nakpin* will activate the *p* and *k* letter nodes, but with the latter being activated somewhat more than the former. Thus, the pattern of activation in the letter nodes will not quite match the expected pattern for *napkin*, but will match it more closely than that generated by a stimulus that does not activate the *p* and *k* letter nodes at all (e.g., *nagbin*).

The final account has coding in terms of slots, but letter identification for a particular slot is imprecise (Gómez, Ratcliff, & Perea, 2008). While the first letter of a stimulus is quite precise in its association with the initial slot, other letter identities activate a range of slots with a decreasing level of probability the further away those slots are from their correct position. Thus, although the *k* and *p* of the TL stimulus *nakpin* are most strongly associated with the third and fourth slot respectively, the *k* will also be associated to some extent with the fourth slot and *p* with the third slot. As a result, the lexical representation for *nakpin* will be partly activated because it is responsive to having a *k* and *p* in those positions. Hence, TL interference will ensue.

All of these accounts of letter position coding assume that the only sublexical structure to play a role in orthographic processing is at the level of the single letter or the bigram. What is not taken into account is the fact that some letters are consonants and some are vowels (or "nuclei"), and moreover that, within a syllable, some consonants precede the nucleus (i.e., are "onsets") while others follow the vowel (i.e., are "codas"). For example, *n* is the onset and *p* is the coda of the first syllable of *napkin*, while *k* is the onset and *n* is the coda of its second syllable. The differential impact of the onset and coda in English orthographic processing is evidenced by the fact that the coda is processed more closely with the vowel than is the onset, creating an orthographic onset + body structure (where a "body" is the combination of the vowel and coda, e.g., the *ap* of *nap*). The analysis of a letter-string into its onset + body (such as *n* + *ap*, as opposed to an "antibody" + coda analysis, such as *na* + *p*[1], cf. Forster & Taft, 1994) has been revealed in a number of studies using a wide range of paradigms (e.g., Andrews & Scarratt, 1998; Bowey, 1990; Kay & Marcel, 1981; Taraban & McClelland, 1987; Treiman & Chafetz, 1987; Treiman, Mullennix, Bijeljac-Babic, & Richmond-Welty, 1995; Treiman & Zukowski, 1988).

As an example, Taraban and McClelland (1987) observed more irregular pronunciations to *jead* (i.e., saying /dʒɛd/ rather than /dʒi:d/) when preceded by an irregular word that shared its body (e.g., *head*) than when preceded by an unrelated control. In contrast, when the target shared its antibody with the irregular prime word (e.g., *heam* primed by *head*), the bias toward an /ɛ/ pronunciation was far weaker. Thus, there is priming on the basis of the pronunciation of the body, and not on the basis of the pronunciation of the antibody. This has been shown to be true not only with monosyllabic words, but with the first syllable of polysyllabic words as well (Taft, 1992). That is, *meadow* also primes the irregular pronunciation of *jead*, whereas *jealous* does not, and this indicates that the body of the first syllable (*ead*), and not its antibody (*jea*), plays a role in the processing of the letter-string. The models of letter position outlined above fail to incorporate the fact that words have an internal orthographic structure whereby the body of a syllable forms a unit of processing separate from the onset.

While the function of a letter as an onset, nucleus, or coda may only be determined after it has been assigned to its position in the letter-string, it is worth pursuing the possibility that the function of the letter plays a role in the actual assignment of that letter to its positional slot. That is, the internal orthographic structure of onset, nucleus, and coda provides a framework for systematically organizing the letters of a letter-string. The model put forward by Plaut, McClelland, Seidenberg, and Patterson (1996) is an account of this type because letter-strings are initially coded in terms of their onset, vowel, and coda. For a complex onset that is composed of more than one letter (e.g., the *pl* of *plant*), each of those letters will activate an onset unit (representing *pl*), and the equivalent is true for a complex coda (e.g., the *nt* of *plant*]. The correct order of those letters will be specified by the fact that they only have one possible combination as an onset (i.e., *lp* is not a possible onset, even though it is a possible coda). The major problem for the account of Plaut et al. (1996), however, is that it is impossible to differentiate a word with a complex onset or coda from the nonsense letter-string that has the letters of its onset or coda transposed (Davis & Bowers, 2006). For example, the letter-string *lpatn* should be totally indistinguishable from its baseword *plant* because *lp* will be re-organized to coincide with the existing onset *pl*, and *tn* with the existing coda *nt*.

It would be premature, however, to reject the idea of an onset/vowel/coda analysis merely on the basis of this particular instantiation of it. Alternatives can be envisaged. For example, words might be represented with an onset + vowel + coda structure and activated when the appropriate letters fill each type of slot. This is illustrated in Fig. 1 using the example of *plant*. The whole-word representation for *plant* is activated via sublexical units representing the

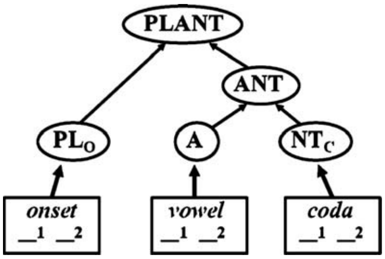

Fig. 1. A possible hierarchical framework for representing letter position in the lexical processing system using the word plant as an example. The subscript "o" refers to an onset and the subscript "c" refers to a coda.

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[1] Confusion in terminology can arise here because linguists sometimes refer to the combination of onset and nucleus as the "body" of the syllable. In relation to visual word recognition, however, the term "body" is typically used to refer to the orthographic representation of the nucleus plus coda, which leads to the use of "antibody" to refer to the onset plus nucleus.