단어재인 초기단계에서의 언어학적 변인의 역할

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Early Locus of a Linguistic Variable in Word Recognition

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요 약

The syllable and the morpheme are known to be important linguistic variables. This study examined whether these variables were activated in an early stage of word recognition using the fast priming task. Mixing the lettercase for the prime, the results of experiment 1 and 2 revealed effects of the syllable and the morpheme at a short SOA (Stimulus Onset Asynchrony), but not at a long SOA. Using the same manipulation in the experiment 3 and 4, an effect of syllable was found to be significant at the short SOA, but not at the long SOA. The study showed that the syllable plays a role in an early stage of word recognition.

The purpose of this study was to investigate whether two prominent linguistic units, syllable and morpheme, affect the cognitive process in printed word recognition. Evidence of the activation of syllabic or morphemic cognitive representations in an early stage of printed word recognition would indicate that the process is distinct from other types of visual processing.

There is some evidence from previous studies that the involvement of morphemes and syllables in word recognition is in the early stages of word recognition. Some experiments have used brief morphological priming (i.e., fast time scale priming) with a short Stimulus Onset Asynchrony (SOA) between the prime and the target word. These consistently show early activation of morphological representations (Deutsch, Frost, & Forster, 1998; Drews & Zwitserlood, 1995; Feldman, 2000; Frost, Forster, & Deutsch, 1997). These studies found effects of shared morphemes between prime and target over and above the effects of shared orthography (i.e., the orthographic control) or shared meaning between prime and target (i.e., meaning control). For example, Frost et. al. (1997) using a 50ms SOA, showed that a prime with the same root morpheme as the target facilitated processing of the target but a prime with merely similar meaning to the target did not. With regard to syllables, many studies show strong syllable effects in various kinds of lexical tasks (Butler & Hains, 1979; Klapp, Anderson, & Berrian, 1973; Spoehr & Smith, 1973; Prinzmetal, Treiman, & Rho, 1986). Prinzmetal, Treiman, and Rho (1986) used distinctly colored letters in a briefly presented word to identify the unit of perceptual analysis in word recognition. For example, for the target word *train*, the first, third, and fifth letters might be printed in red while the second and fourth were printed in blue. The perceptual grouping of the similarly colored letters would sometimes produce the illusion that the word presented was *TAN* (the letters that were in red). This kind of illusory conjunction between letters of a similar color occurred more frequently within a syllable than between syllables. In other words, it was easier to form an incorrect perceptual combination of letters within syllables than between syllables. This suggests that there was a barrier to combining letters from different syllables— that a natural cohesiveness to the syllable unit exists that may play a role in printed word recognition. In another example, Spoehr and Smith (1973) argued that the syllabic unit is the basic unit in the early stage of word recognition. In tachistoscopic letter detection, their results showed that one-syllable words were recognized faster than two-syllable words, suggesting the influence of the number of syllables in an early stage of word processing.

The methodology we use to investigate the role of linguistic units in word recognition is to divide words by mixing the case (e.g., reTAKE). Several studies on mixed case effects in word processing showed that case mixing leads to a disruption of transletter features, or to inappropriate letter grouping (Besner & Johnston, 1989; Mayall, Humphrey, & Olson, 1997; Mewhort & Johns, 1988; Paap, Newsome, & Noel, 1984). For example, T, A, and N in the word TrAiN would be grouped together because they are all uppercase, leading to slower recognition of the whole word. By this logic, if the process of recognition depends on syllabic or morphemic representations, it would be faster and easier to process a word that is, using mixed case, divided at the boundary of the representations (e.g., reTAKE) than divided by one letter before or after the boundary (i.e., rETAKE or retAKE).

Experiments in this study used a word of mixed case as a prime and its corresponding target word in normal case, e.g., reTAKE (prime) -> retake (target). The SOA of the prime-target relationship was also investigated. An appropriately divided prime (reTAKE) may facilitate recognition of the target (retake) only at short SOA, only at long SOA, at both lengths, or at neither length. If the linguistic variables play an early role in recognition, as the studies we cited suggest, then effects should be found at short SOA but not at long SOA.

Experiment 1

As the first step in investigating whether syllables and morphemes affect word recognition, multi-morphemic words were used for a naming task in which participants spoke aloud a target printed in normal case. The target was preceded by a mixed case prime. In Experiment 1, every stimulus word's syllables coincided with its morphemes (as in the word *retake,* for which each of the word's two syllables is also a morpheme). The mixed case prime had three "related" conditions, in which the prime was an identity prime, i.e., it was the same word as the target (e.g., reTAKE -> retake). In one of these related conditions, the prime was divided at the joint syllable-morpheme boundary (e.g., reTAKE). In the second and third conditions, the prime was divided at a point either one letter before or after the syllable-morpheme boundary (rETAKE and retAKE). Also, in order to assess the effect due to relatedness, a word prime unrelated to the target was used as the baseline for each condition (i.e., coSINE -> retake, controlling for reTAKE -> retake; cOSINE -> retake for rETAKE -> retake; cosINE -> retake for retAKE -> retake). Thus, there were six conditions, formed by the factorial combination of Relatedness and Boundary Division. If syllable-morpheme information is instrumental in the process of identifying and naming a printed word, we should expect an interaction; division on the syllable-morpheme boundary should be facilitative but only for related primes.

Method

Subjects. Forty-two students enrolled in the Introductory Psychology class at the University of Texas at Austin participated in the experiment. The choice of subjects is assumed to represent a sample of typical skilled readers.

Materials. Twenty-four multi-morphemic words were selected to construct the main stimuli. They were 4-6 letter words with an average frequency of 248±57.96 according to the CELEX database (Baayen, Piepenbrock & van Rijn, 1993). These stimuli were used as targets. The experimental conditions were differentiated by the kinds of primes. The six stimulus lists all had the same targets but different types of primes: Lists 1-3 had identity primes; a prime in list 1 consisted of a mixed case word where the transition from lower to upper case (left to right) occurred one letter before the syllable-morpheme boundary (e.g., rETAKE -> retake); a prime in list 2 consisted of a mixed case word whose transition exactly at the boundary (e.g., reTAKE -> retake); in list 3, a prime consisted of mixed case word that divided at one letter after the boundary (e.g., retAKE -> retake); list 4-6 were created with unrelated word prime as the baselines for lists 1-3; the prime condition in list 4 was the baseline for the list 1 (e.g., cOSINE -> retake), list 5 was the baseline for the list 2 (e.g., coSINE -> retake); list 6 was the baseline for the list 3 (e.g., cosINE -> retake). Constraints on the unrelated prime was that 1) there be no more than one letter overlapping with the target in the same position 2) the primes must be monomorphemic words. An additional 16 prime-target pairs were used as the practice trials. The stimuli for Experiment 1 are listed in the appendix.

Design and Procedures. There were two Relatedness and three Mixed Case types of primes, varied factorially, defining lists 1-6 (rETAKE, reTAKE, retAKE, cOSINE, coSINE, cosINE). These six lists were counterbalanced across participants in order to avoid a repeated target exposure to a subject. Participants were randomly assigned to the six different lists. Each subject saw a total of 24 stimulus pairs. During the experimental session, stimuli were presented to each subject in a different random order. The main experiment was preceded by 16 practice stimulus pairs. Participants faced a computer monitor from a viewing distance of about 60cm.

Participants were instructed that two stimuli would appear at the center of computer screen one after the other, and that their task was to read aloud the target with accuracy and speed. A four-field priming paradigm with the sequence of Mask-Prime-Mask-Target was used. The stimuli were presented with DMASTER software (developed at Monash University and University of Arizona by K. I. Forster and J. C. Forster). The refresh rate of the PENTIUM monitor was 78 Hz making a refresh cycle equal to 12.9 ms.

Each trial consisted of a sequence of four visual events in the same location on the center of the screen: (1) a row of five hash marks for 490.2 ms; (2) a row of the mixed prime for 129 ms; (3) a row of ampersands for 154.8 ms; and (4) a lowercase word target for 1500 ms. The masks and words overlapped spatially with the pre- and post-prime masks, both of which contained the same number of symbols as the target. The duration of the prime (the prime-mask SOA) was set under 150ms in order to reflect a prelexical stage of word processing (Neely, 1991). Reaction time (RT) was measured by a voice-activated switch.

Results

Response latencies less than 100ms and more than 1900ms were discarded as outliers. These outliers were less than 0.4% of all responses (Ulrich & Miller, 1994). Responses with the naming errors were also discarded in the reaction time (RT) analysis. The mean latencies and their standard errors for each condition are summarized in Table 1.

Table 1

Naming Latencies (Milliseconds), Error Rate (%), and Standard Error for the "Related" and "Unrelated" Primes in Experiment 1

	"Related primes"		
Statistics	rETAKE-retake	reTAKE-retake	retAKE-retake
M	431	411	427
SE	11.3	12.8	12.7
ER	0.9	0.7	0.8

The ANOVA was a 2 X 3 within-subject design, Relatedness (related, unrelated) X Mixed Case type (case transition one letter before the boundary, at the boundary, one letter after the boundary). The analysis was conducted on reaction times of correct responses to targets, with subjects as the error term. The main effect of Relatedness was statistically significant, $F(1,41) = 59.43$, $p < .0001$, but not Mixed Case type, $F(1,41) = 1.46$, $p > .10$. Importantly, the two-way interaction between Relatedness and Mixed case type was statistically significant, $F(1, 41) = 3.18$, $p < .05$. Error analysis was not done because all error rates were below 1%. The pattern of two-way partial interactions between reTAKE – retake versus coSINE – retake (45ms) and retAKE – retake versus cosINE – retake (27ms) were similar to the one between reTAKE – retake versus coSINE – retake (45ms) and rETAKE – retake versus cOSINE – retake (22ms). The posthoc analyses generally confirmed these patterns of results: Each partial two-way interactions was statistically significant or marginally significant, $F(1,41) = 3.08$, $p < .06$, for the former, and $F(1,41) = 5.51$, $p < .05$, for the latter.

Discussion

Words with mixed case have been used as a way to investigate whether word recognition is based on word-shape, i.e., holistic or global processing (e.g., Allen, Wallace, & Weber, 1995; Allen & Emerson, 1991, Coltheart & Freeman, 1974; Haber, Haber, & Furlin, 1983), or letter-based analytic processing (e.g., Besner & Johnston, 1989; Mayall, Humphrey, & Olson, 1997; Mewhort & Johns, 1988; Paap, Newsome, & Noel, 1984). Studies supporting the holistic view showed that destroying the shape of a word slowed processing because case mixing affects the word-level code in word recognition system. Further, it affects words more than nonwords, and high frequency words more than low frequency words. In contrast, studies supporting the analytic view showed that case mixing led to masking of lowercase letters by neighboring uppercase letters, disruption of trans-letter features, or inappropriate letter grouping (e.g., T and A in the word ToAd may be grouped together). To use the term introduced by Katz, Lee, & Pugh (2000) and by Ziegler Perry, Jacobs & Braun (2001), word processing may proceed at either a small or large grain-size, with holistic processing involving large groups of letters (perhaps whole words) and small grain-size involving single letters or small letter clusters. Although the current study is not directly related with this debate, it suggests that the mixed case priming task may well be useful when applied to the study of processing grain-size. In sum, a mixed case prime that preserved the syllable-morpheme boundary facilitated naming of the target better than a mixed case prime that broke the boundary. This suggests that linguistic variables have an effect in an early stage of word recognition and that the manipulation of mixed case can reveal these effects.

Experiment 3 (Experiment 2 Omitted)

Using multi-morphemic words, Experiments 1 and 2 showed that the linguistic variables of syllable and morpheme might play a role in an early stage of word recognition. Experiments 3 and 4 were designed in order to shed some light on which of the two linguistic variables, syllable or morpheme, is responsible for the superior facilitation of an intact boundary mixed case prime.

English has words that look multi-morphemic but are not, in fact, composed of those morphemes. For example, the "re" in the word "repel" is not the common morpheme that a reader activates as "re" in "retake". Thus, when words like this (called pseudomorphemic words) are divided by an intact mixed case transition as in rePEL, only the linguistic boundary of the syllables is marked, not any morpheme. The comparison of the effects of mixed case primes, such as rEPEL, rePEL, repEL, with their appropriate controls, may provide information on whether the syllable is responsible for the better priming produced by a mixed case item with an intact boundary. If there is better priming by mixed case primes that delineate two intact syllables, one on either side of the case transition boundary, but not two intact morphemes, it would indicate clearly that syllable representations are involved at an early stage of word processing. With regard to morphemes, the experiment is inconclusive; morphemes may also be involved in addition to syllables but this experiment cannot address that question. On the other hand, if there were to be no benefit from a prime with an intact syllable boundary this would strongly suggest that the effects that we observed previously were due to morphemic information, not syllabic—unless, of course, there is a synergistic facilitative effect caused by coincident syllable and morpheme representations.

Experiment 3 used the same short duration of SOA as in Experiment 1.

Method

<u>Materials.</u> Twenty-four pseudomorphemic words were selected to construct the main stimuli. They were 4-6 letter words and the frequency were 376±58.09 according to the CELEX database (Baayen, Piepenbrock & van Rijn, 1993). These stimuli were used as the targets. The experimental conditions were differentiated by the types of primes. Six stimulus lists were created with different types of the primes and the same targets: List 1-3 were created in order to investigate the effect of the syllabic effects by making lower case to upper case transitions in a different position of the word prime; the primes of list 1 consisted of mixed case words with the case transition one letter before the boundary of the syllable (e.g., rEPEL -> repel); the primes of list 2 consisted of mixed case words in which the syllables were intact (e.g., rePEL -> repel); the primes of list 3 were mixed case words in which the case transition was one letter after the syllabic boundary (e.g., repEL -> repel); list 4-6 were created with unrelated word prime to be the baselines for list 1-3, as in the same manner as Experiments 1 and 2. An additional 15 prime-target pairs were used as practice trials. The stimuli for Experiment 3 are listed in the appendix.

<u>Design and Procedures.</u> There were six types of prime defined by List 1-6 (rEPEL, rePEL, repEL, dOMAIN, doMAIN, domAIN). Design and procedures were the same as in Experiment 1.

Results

Response latencies less than 100ms and more than 1800ms were discarded as outliers. These outliers composed of less than 0.5% of all responses (Ulrich & Miller, 1994). Response with naming errors were also discarded in the reaction time (RT) analysis. The mean latencies and their standard errors for each condition are summarized in Table 3. The ANOVA was a 2 X 3 (Relatedness X Mixed Case type) conducted on the correct reaction times to targets with subjects as the error term. Main effects of Relatedness and Mixed Case type were both statistically significant, $F(1,41) = 37.32$, $p < .001$, for Relatedness, and $F(1,41) = 4.18$, $p < .05$, for Mixed case type. Importantly, the two-way interaction between Relatedness and Mixed case type was statistically significant, $F(1, 41) = 3.28$, $p < .05$. The pattern of two-way partial interactions between rePEL – repel versus doMAIN – repel (56ms) and repEL – repel versus domAIN – repel (35ms) were similar to results of previous experiments as was the contrast between rePEL – repel versus doMAIN – repel (56ms) and rEPEL – repel versus dOMAIN – repel (21ms). The partial two-way interactions of the former was not statistically significant, $F(1,41) = 2.36$, $p > .10$, but the latter was, $F(1,41) = 8.22$, $p < .01$.

Table 3

Naming Latencies (Milliseconds), Error Rate (%), and Standard Error for the "Related" and "Unrelated" Primes in Experiment 3

	"Related primes"		
Statistics	rEPEL-repel	rePEL-repel	repEL-repel
M	471	436	465
SE	23.3	22.6	23.1
ER	0.6	0.8	0.9

Discussion

The effects of a mixed case prime that maintained an intact syllable boundary produced more facilitation against its baseline than any other condition, eliciting a statistically significant two-way interaction. However, a follow-up analysis showed that the difference in facilitation was mainly due to the difference between the intact syllable prime and the broken syllable boundary in which the transition came before the syllable boundary (rePEL versus rEPEL). The similarity between rePEL and repEL can be explained, at least in part, as due to the ambiguity of spoken syllable boundaries in English (in contrast to many other languages). In English, a single consonant between vowels may "share" itself with both, making, in effect, a geminate of the consonant. Thus, for example, repEL may become, when spoken, "rep" + "pel"; nearly all English speakers will find that pronunciation quite acceptable as an utterance of the printed word REPEL.

Syllabic effects have not always demonstrated their effects in previous studies that used one-word (i.e., non-priming) presentation as compared to the present priming study. (e.g., Frederiksen & Kroll, 1976; Forster & Chambers, 1973). Thus, it seems like that the manifestation of syllabic effects may be restricted according to the experimental manipulation. Booth and Perfetti (2002) make a similar point when they suggest that syllable effects seem to be observed more easily in naming paradigms. We suggest that the paradigm/task used needs to focus on the early stage of word processing. However, we have no strong argument why the naming paradigm should be the best candidate for studying early processing. One piece of evidence in its favor is that it is well known that naming reaction times are faster than, say, response times in lexical decision, a task that requires a decision process.

General Discussion

How early in the process of recognizing a printed word can we find evidence of phonologic (specifically, syllabic) representations? How early is there evidence of morphologic representation? These questions were investigated by preceding target stimuli with primes that were mixed case words partitioned either appropriately or inappropriately by the relevant representation. Experiment 1 used a short interval between prime and target and showed that a mixed case prime whose case transition was at either a syllabic or morphological boundary (i.e., reTAKE) facilitated naming of the target (e.g., retake) compared to a mixed case prime whose case transition broke the syllable-morpheme boundary (e.g., rETAKE or retAKE). This suggested that syllabic or morphological information plays a role in early stage of word recognition. Experiment 3 showed that a mixed case prime that preserved the syllable boundary (without respect to the morphology) also facilitated target performance. This suggested that facilitation of target naming in Experiment 1, in which the syllable-morpheme representations were confounded, might be attributable, at least, to the syllable information. Experiments 2 and 4, employing a longer SOA than Experiments 1 and 3, showed a smaller and weaker effect of mixed case priming, suggesting that the early effects of syllable priming either dissipated quickly in the word identification process or were conflated later in that process with other effects.

A significant limitation of this study is, of course, that there was no experiment in which the mixed case prime was partitioned at a morphological (but not syllabic) boundary (e.g., FASTer → faster, for suffix). This would have provided an opportunity to compare the relative role of syllable and morpheme in word processing. The realization of this condition, however, has a collateral limitation in comparing it with the role of the syllable. This is because most of the possible mixed case primes that are partitioned only at a morphological boundary (but not at a syllable boundary) are words with suffixes, not prefixes as the word in Experiment 1-4. Thus, the direct comparison itself would be confounded. In addition, the ambiguity of English syllable boundaries becomes more critical for these stimuli.

The facilitation of the target by a syllabic prime in the Experiment 3 and no facilitation in Experiment 4 are results that are compatible with previous studies showing the strong role of phonology in early word processing stage (e.g., Lukatela, Eaton, Lee, & Turvey, 2001; Lukatela & Turvey, 1994, 2000; Luo, 1996). Although the syllable is a larger phonological unit than the phoneme which was addressed in these studies, the idea of syllable representations being instrumental in the word identification process receives support from the same theoretical approach. The phonological recoding hypothesis of Van Orden, Pennington, and Stone (1990) argues that the resolution for the network of orthography and phonology is much faster than the one for the network of orthography and semantics because of the much higher self consistency between orthography and phonology. If we add an assumption that the network of orthography and phonology is evolving to determine syllabic units following the identification of the phoneme units, the early role of syllable information extracted from the orthographic information can be understood.

This successful use of mixed case priming suggests that this paradigm may be useful for studying other aspects of printed word recognition. As the manipulation of the prime in current experiment was proven to be effective in differentiating the processing of the target, this type of manipulation can be used as a new method to investigate the early stages of word processing. As compared to a single word presentation (such as a standard naming task) the manipulation of primes in the fast time scale can reveal how the early stages of word recognition may involve linguistic representations.

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