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THE UNIQUENESS POINT EFFECT IN THE SHADOWING OF SPOKEN WORDS

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Abstract. Word shadowing was used in order to obtain evidence concerning the relevance of the uniqueness point (UP, i.e., the moment at which the acoustic-phonetic information already presented remains compatible with a single lexical entry) as a determinant of the point where spoken word recognition occurs. Taken as an average, response latencies showed a minimal but significant effect of the UP. However, there were important differences between items with early and late UPs. A multiple regression analysis, taking UP position, word length and word frequency into account, showed that UP position is the best predictor of the shadowing latencies of early-UP items, but that it does not contribute at all to the shadowing of words with late UP. We conclude that the UP strongly mediates the recognition of spoken words with early UP. In addition, the shadowing of late-UP items is best predicted by word length in slower, and by word frequency in faster subjects; this suggests the intervention of different mechanisms.

Zusammenfassung. Das Nachsprechen von Worten wurde benutzt um Beweise zu erbringen für die Bedeutung des Eindeutigkeitspunkts (UP d.h. der Zeitpunkt ab welchem die zugängliche akustische Information vereinbar ist mit einem einzigen Stichwort im Lexikon) als dem Punkt an dem die Erkennung von gesprochenen Worten stattfindet. Die Antwortlatenz zeigte, im Durchschnitt, eine schmale aber signifikante Auswirkung des UP auf. Es bestanden aber große Unterschiede zwischen Worten welche einen frühen gegenüber einem späten UP aufwiesen. Eine multiple Regressionsanalyse, welche die Position des Eindeutigkeitspunkts, die Wortfrequenz und die Wortlänge berücksichtigte, zeigte, daß die Position des Eindeutigkeitspunkts der bessere Prädiktor der Nachsprechlatenzen war im Falle von Eintragungen mit frühen Eindeutigkeitspunkten. Die Position beeinflußte in keiner Weise das Nachsprechen von Worten mit späten Eindeutigkeitspunkten. Es wird daraus geschlossen, daß der UP in die Erkennung von gesprochenen Worten mit frühen Eindeutigkeitspunkten eintritt. Das Nachsprechen von Eintragungen mit spätem UP wird, zudem, am besten durch die Wortlänge im Falle von langsamen Versuchspersonen und durch die Wortfrequenz im Falle von schnellen Versuchspersonen erklärt; dies läßt den Einfluß von verschiedenen Mechanismen erwarten.

Résumé. Une tâche de répétition de mots ("shadowing") a été utilisée pour étudier la contribution de la position du point d'unicité (PU, c'est-à-dire le moment auquel l'information acoustique déjà présentée n'est plus compatible qu'avec une seule représentation lexicale) au point de reconnaissance des mots parlés. La comparaison des temps de réponse à des mots à PU précoce et tardif a mis en évidence un effet significatif mais relativement faible du PU. Cependant, l'examen des résultats de chacune des deux séries de mots a fait apparaître des différences importantes entre elles. Une analyse de régression multiple prenant en considération la position du PU, ainsi que la durée et la fréquence des mots, a montré que la position du PU était le meilleur prédicteur du temps de réponse pour les mots de la série précoce mais qu'elle ne contribuait pas du tout au temps mis pour répéter ceux de la série tardive. Il semble donc que, pour une gamme relativement précoce de positions dans les mots, le PU soit un déterminant important du point de reconnaissance. Pour les mots de la série tardive, le meilleur prédicteur du temps de réponse était la durée des mots chez les sujets lents et leur fréquence chez les plus rapides, ce qui suggère l'intervention de mécanismes différents.

Keywords. Word uniqueness point, nonword deviation point, shadowing task.

1. Introduction

A basic hypothesis behind current speech perception models is that the process of word recognition begins on-line during reception of the speech signal (Cole and Jakimik, 1980; Frauenfelder and Tyler, 1987; Marslen-Wilson and Welsh, 1978). This notion, which was especially emphasized in the first version of Marslen-Wilson and Welsh's (1978) categorical "cohort model", also underlies more probabilistic accounts of the spoken word recognition process such as those proposed recently by Marcus (1984), Marcus and Frauenfelder (1985), Taft and Hambly (1986) and Marslen-Wilson (1987).

A strong argument for such a sequential view is the demonstration that the position of the "uniqueness point" (UP) in a word (the moment in the phoneme string at which a word becomes the only candidate in the cohort of possible words) or the position of the "deviation point" (DP) in a non-word (the moment at which the input string is no longer compatible with any lexical candidate) are good predictors of the time necessary to identify a word or classify a non-word.

According to Marslen-Wilson and Welsh's (1978) categorical cohort model, which postulates optimal real-time information extraction, the time needed to identify a word or to classify a string as a non-word is constant from the critical phoneme, i.e., the UP and DP, respectively. The lexical decision task, or a version of it involving responses to non-words only, was used to test the second prediction. With the non-word detection task, Marslen-Wilson (1984) found that the reaction time measured from the offset of the last real word phoneme was unaffected both by the position of the DP (from the second to the fifth phoneme in the sequence) and by the length of the sequence (from one to three syllables). Moreover, the reaction time measured from the sequence onset increased linearly according to the position of the DP in the sequence, with the slope of this relationship being 0.90. These results suggest that the non-word decision is taken as soon as there are no more word candidates in the cohort.

However, these suggestions are undermined by severe contradictions in the literature. Marslen-Wilson's (1984) results have not been corroborated with either the same task (Goodman and Huttenlocher, 1988) or with the classical lexical decision task, i.e., with different responses to words and non-words (Taft and Hambly, 1986; Goodman and Huttenlocher, 1988). In fact, non-words with early DP yielded reaction times measured from the DP longer than non-words with late DP (Goodman and Huttenlocher, 1988); in addition, short non-words were responded to more slowly than long non-words that are identical up to the DP (Taft and Hambly, 1986). Furthermore, Taft and Hambly (1986) also found that reaction times to non-words with the DP in the same position were affected by similarities to real words, and that reaction times to words with the UP in the same position were affected by word frequency. All these results are inconsistent with the first version of the cohort model.

Obviously, showing that the UP and the DP are not the whole story should not lead to the conclusion that they play no role in spoken language processing and, a fortiori, that earlier segments of acoustic-phonetic information are not particularly important for word recognition. There is some evidence that word recognition occurs before the whole phoneme sequence has been presented. It would be difficult to interpret otherwise, for instance, the fact that the deletion of a consonant is more detrimental to word recognition when it occurs in initial rather than in final position (Bagley, 1900); that mispronunciations are detected more rapidly at the end than at the beginning of words (Cole and Jakimik, 1980); or that a listener will recognize a word more easily on the basis of its first half than its second, even when each part contains just enough information to specify the word (Nooteboom, 1981). Yet, whereas these findings support the notion of precocious word recognition, they do not imply that the UP plays a specific role in this recognition. What is meant by the specific role of the UP is its lexically-based discriminatory value, and not the perceptual weight associated with the position of the corresponding phoneme in a phoneme sequence.

On the other hand, the claim that the UP contributes specifically to word recognition by enabling a potential candidate to be isolated does not imply that recognition necessarily occurs at the UP. Indeed, the fixation of a perceptual belief about the word presented may require either some verification of the perceptual hypothesis formed at the UP, or an amount of redundant information. Thus, the processing of the acoustic-phonetic information that follows the UP would also contribute to determining the point at which recognition occurs. The advantages of this slightly delayed recognition are obvious. In particular, it would permit error recovery in cases of misperceived or mispronounced initial phonemes. Let us note that, in his new cohort model, Marslen-Wilson (1987) has incorporated a recognition mechanism that consists of selecting a word when its level of activation differs from all others by some criterion value rather than when the UP is given.

Recently, Radeau et al. (1989b) used a gender classification task to assess the contribution of the UP to spoken word recognition. This task was preferred to the lexical decision task because the latter is not appropriate for testing UP effects. Indeed, since a word can, in principle, become a non-word at any moment after the UP by the modification or addition of a phoneme, the subject is supposed to wait for the stimulus offset before deciding. In the study by Radeau et al. (1989b), the subjects were confronted auditorily with French nouns and had to decide by a key-press response whether each one was masculine or feminine. Gender decisions were faster for words with early UPs than for those with late ones, a result which suggests that the UP plays some role in spoken word recognition. Slopes of about 0.40 were found for the regression functions between RTs and UP positions measured from word onset. These slopes do not seem as steep as they should have been if the UPs had been the major source of variability of the recognition point. However, it might be argued that the gender classification task underestimates the UP effect. Since suffixes convey information about gender, subjects in some cases might have based their responses on the suffixes without consulting the lexicon (Desrochers et al., 1989).

In order to gather more exact evidence about the real significance of the UP in its contribution to the word recognition point, the present study used a task that, unlike gender classification, was not open to the criticism that it encouraged a suffix-based strategy. We thus employed shadowing, where the subject was asked to repeat a word as soon as it was presented. Interestingly enough, shadowing was shown to be sensitive to lexical factors such as word frequency (Marslen-Wilson, 1985) and lexical status (Marslen-Wilson, 1985; Radeau et al., 1989a).

2. Method

2.1. Subjects

Twenty-two paid subjects, 6 female and 16 male, participated in the experiment. All were native French speakers and reported no hearing defects. Most of them were students at the Free University of Brussels.

2.2. Material

The material, presented in Table 1, was the same as described in Radeau et al. (1989b). It

Table 1
Words used in the experiments, with their phonetic transcriptions. The underlined positions correspond to the UP

Early Up words		Late Up words	
aptityd	aptitude	maʃinʀi	machinerie
pisɑ̃li	pissenlit	tuʀtəʀɛl	tourterelle
madmwazɛl	mademoiselle	ekyʀœj	écureuil
byɑ̃dʀi	buanderie	kɔlɔnad	colonnade
abɑ̃dɔ̃	abandon	agʀɛsjɔ̃	agression
nikɔtin	nicotine	pɔʀsəlɛ	porcelet
ʀituʀnɛl	ritournelle	balɑ̃sje	balancier
kautʃu	caoutchouc	ʀotisœʀ	rôtisseur
ʀikɔʃɛ	ricochet	anaʀʃi	anarchie
gaʀnəmɑ̃	garnement	ɛ̃vɑ̃tʀis	inventrice
stagnasjɔ̃	stagnation	ʃəmizje	chemisier
faʀɑ̃dɔl	farandole	tʀaʒedjɛ̃	tragédien
mɔnymɑ̃	monument	mekanizm	mécanisme
kʀystase	crustacé	akwaʀɛl	aquarelle
atəlje	atelier	diʀɛktwaʀ	directoire
topinjɛʀ	taupinière	kɔ̃fɛsjɔ̃	confession
ystɑ̃sil	ustensile	ʃapəlje	chapelier
kasulɛ	cassoulet	kʀeatyʀ	créature
ɔʀkide	orchidée	kɔʀdɔnɛ	cordonnet
maʒyskyl	majuscule	asistɑ̃s	assistance
kamɑ̃bɛʀ	camembert	vwajaʒøz	voyageuse
saʀabɑ̃d	sarabande	dinamizm	dynamisme
ʀapsɔdi	rhapsodie	savɔnɛt	savonnette
ɛsplanad	esplanade	ɛ̃pʀimʀi	imprimerie
adʒɛktif	adjectif	patinwaʀ	patinoire
ʃɛ̃pɑ̃ze	chimpanzé	alymaʒ	allumage
veʀɑ̃da	véranda	ekʀito	écriteau
skaʀlatin	scarlatine	tʀezɔʀje	trésorier
veikyl	véhicule	ʃɔvalʀi	chevalerie
spageti	spaghetti	ɛskalɔp	escalope
pɑ̃pləmus	pamplemousse	ʀamasi	ramassis
tʀaizɔ̃	trahison	tɑ̃tativ	tentative
dʀɔmadɛʀ	dromadaire	avɑ̃taʒ	avantage
iʀypsjɔ̃	irruption	baiɛjaʒ	balayage

consisted of two sets of 34 unprefixed, trisyllabic nouns with early or late UPs. These nouns were matched for mean numbers of phonemes (7.00 in the early set, range 5–9, and 7.08 in the late one, range 6–9) and mean frequency (256, range 0–1920, in the early one, and 291, range 0–1898, in the late set, according to *Trésor de la Langue Française*, 1971). Although the two sets of words had not been matched for initial phonemes, the distribution of these phonemes in terms of phonetic classes did not show any marked discrepancies between the two sets. The number of initial phonemes was distributed in the following way in the early and late sets respectively: 11–13 for vowels, semi-vowels and liquids; 8–10 for unvoiced and 3–4 for voiced oral stops; 5–4 for unvoiced and 3–1 for voiced fricatives; 4–2 for nasals.

Whereas in the early set the UP was located on the first or second syllable and, on the average, coincided with the 3.85th phoneme (range 3–5), in the late set it was located on the last syllable and coincided with the 6.28th phoneme (range 5–8). These values were calculated by taking into account all the nouns listed in the 1986 Micro Robert.[1] Two additional sets of 16 items were used as practice items; these were selected according to the same criteria.

The words were recorded in a sound-proof room using a Neumann U87 microphone and a Studer A810 tape-recorder. They were spoken by a male native French speaker, in a neutral voice. There was a 5 s interval between two consecutive words.

The temporal distance of the UP from word onset was estimated through spectrographic analysis (0–7 kHz), as in Radeau et al. (1989b). Word onset was defined as the first mark of acoustic energy at any point of the frequency scale. The UP was considered to be situated in the middle of the prototypical segment of the particular phone under study. The criteria used to define these segments are given in Table 2. For words with the UP situated after the last phoneme (for instance, /akwarel/, since /akwarelist/ is also a French word), the position of the UP was considered to coincide with word offset. The average interval between the onset of a word and the UP was 398 ms (range 243–553) in the early set and 757 ms (range 467–1169) in the late one. Mean word length was estimated by means of the same analysis and averaged at 940 ms in the early set and 955 ms in the late one.

Table 2
Criteria used to define the prototypical segments

(1)	*Vowels:* stable portion of vocalic segment or time interval between beginning of initial transitions and end of final transitions.
(2)	*Semi-vowels:* time interval between beginning and end of transition.
(3)	/l/: segment characterized by a lowering of first formant (F_1) frequency.
(4)	/R/: segment characterized by an energy drop in second formant (F_2).
(5)	*Fricatives:* noise segment.
(6)	*Oral stop consonants:* time interval between beginning closure and end of burst.
(7)	*Nasal stops:* closure segment.

2.3. Procedure

The subjects were tested individually in a quiet room. The stimuli were presented at a comfortable level through Beyer DT 202 headphones.

The presentation of the items and the collection of the data were controlled by an Apple IIe computer connected to a Revox A77 tape recorder with the items being recorded on one channel. A voice key was employed to position a 50 ms square wave pulse, inaudible to the subjects, on the second channel near the beginning of each word. During testing, the pulses activated a voice key connected to a clock-card (Apple clock Mountain Hardware). The subjects were asked to repeat each word as quickly and accurately as possible. Their responses were detected via another voice key.

Items from the two sets were presented in random order, as in the mixed conditions of Radeau et al.'s (1989b) study. This mixed list of experimental items was divided into two blocks of 34 trials. Practice items were presented at the beginning of the session in one block of 32 trials.

[1] In Radeau et al. (1989b), the UP was also estimated by taking all the words of the dictionary into account. This method provided shallower slopes for the regression functions between the RT and the UP than those obtained by referring only to nouns.

3. Results

A response was considered to be erroneous if there was any hesitation or deviation from the target word by at least one phoneme. Shadowing latencies, which, for the sake of convenience, will be also called reaction times (RT), were estimated from stimulus onset to response onset. Errors and RTs longer than 2500 ms or shorter than 200 ms were discarded from the analyses.

The mean RTs and error rates for the two sets of words are presented in Table 3. On the average, words with early UP were responded to 30 ms faster than those with late UP. Mean RTs by subject and by item (calculated across the subjects) were analyzed in an ANOVA with UP position (early vs. late) as factor. The effect of the UP is significant in the analysis by subject ($F_1(1,21) = 10.61$, MSe = 927.5, $p < 0.005$) but not in the analysis by item (F_2 close to 1).

As can be seen from Table 3, very few errors were made: the percentage of errors was below 1 in both sets. Consequently, no analysis was carried out on error rates.

Another, more classic way of looking at the UP effect consists of considering the slope of the regression function that relates RTs to the temporal distance of the UP from word onset. For each subject, the regression functions between RTs and UP positions were calculated together for the words of the two sets and separately for the items of the early and late sets. This distinction was introduced because the significance of the UP effect in the analysis by subject (but not by item) suggests that inter-item variability may be important and may thus conceal an effect of the UP in one set. The data, based on mean RTs by item, for the three corresponding regression functions are presented in Fig. 1. It appears that the slopes are steeper in the early set than in the late one. The difference is significant in an ANOVA run on the individual slopes ($F(1,21)$ =

Table 3
Mean shadowing RTs (ms), intrasubject standard deviations and error rates (%)

	Early UP	Late UP	Difference
RT	836	866	30
S	132	162	
Error	0.67	0.80	

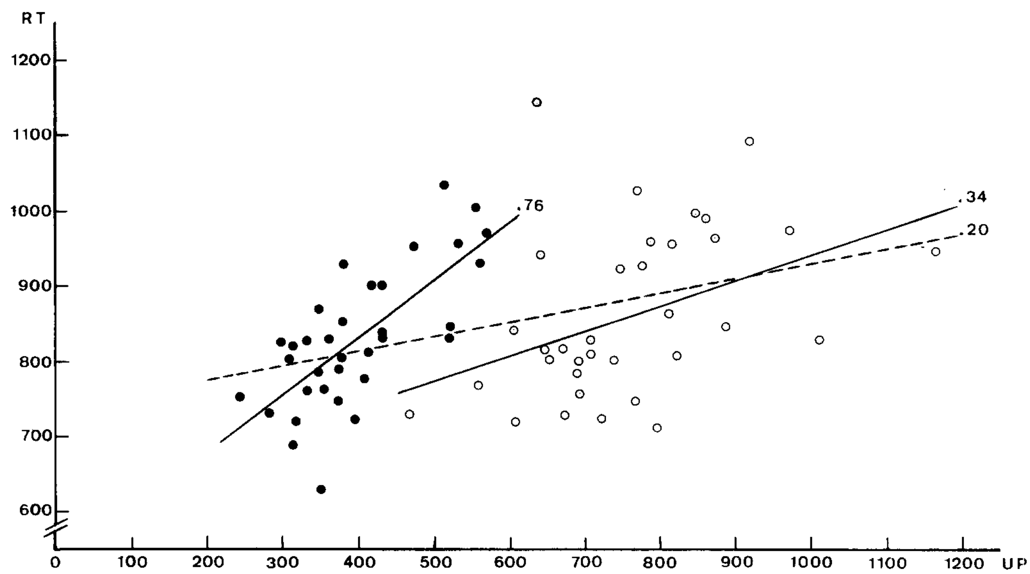

Fig. 1. Mean reaction times for nouns with early (●) and late (○) UPs as a function of the UP position from word onset (in ms). The regression lines are shown separately for each set of nouns as well as for both sets (broken line).

12.91, MSe = 0.14, $p < 0.005$). The correlations associated with the slopes are significantly different from zero by t-tests (early set: slope = 0.76, $r = 0.72$, $p < 0.0005$; late set: slope = 0.34, $r = 0.42$, $p < 0.01$; both sets: slope = 0.20, $r = 0.41$, $p < 0.0005$).

A possible interpretation of the shallower slope obtained for the late set is that some of the subjects often initiated their responses before the sensory information corresponding to the last syllable, thus to the UP of the words with late UP, had been presented. This was especially liable to occur in the fastest shadowers. In order to test this interpretation, we separated the subjects into two subgroups – fast and slow. The cut-off criterion took into account the mean time from word onset to UP in the late set (757 ms) corrected for the time needed for response preparation and execution. We do not know how much time is devoted exclusively to these processes. On the assumptions, first, that Marslen-Wilson and Welsh (1978) were right in attributing 75 to 100 ms to response processes in continuous speech shadowing and, second, that this period also holds for single word shadowing, the cut-off criterion was fixed at a mean RT of between 832 and 857 ms. On the basis of this criterion, the fast subgroup included eight subjects, three females and five males, who repeated the late set of nouns with a mean delay ranging from 572 to 809 ms: the slow subgroup included fourteen subjects, three females and eleven males, whose mean RTs for the same set ranged from 900 to 1056 ms.

The data for the regression functions between RT per item and UP position are presented in Figs. 2 and 3 for the slow and fast shadowers, respectively. In both subgroups, the slopes are steeper for the early set than for the late one. On the whole, the slopes also seem steeper for the slow shadowers than for the fast ones. Using UP position (2 levels) and Group (2 levels) as factors, an ANOVA run on the individual slopes showed the two main effects to be significant. The slopes are steeper in the set with an early UP than in the set with a late one ($F(1,20) = 30.50$, MSe = 0.06, $p < 0.005$); they are also steeper for slow shadowers than for fast ones ($F(1,20) = 8.97$, MSe = 0.03, $p < 0.01$). The UP Position × Group interaction is not significant (F close to 0).

The fact that there is no interaction between

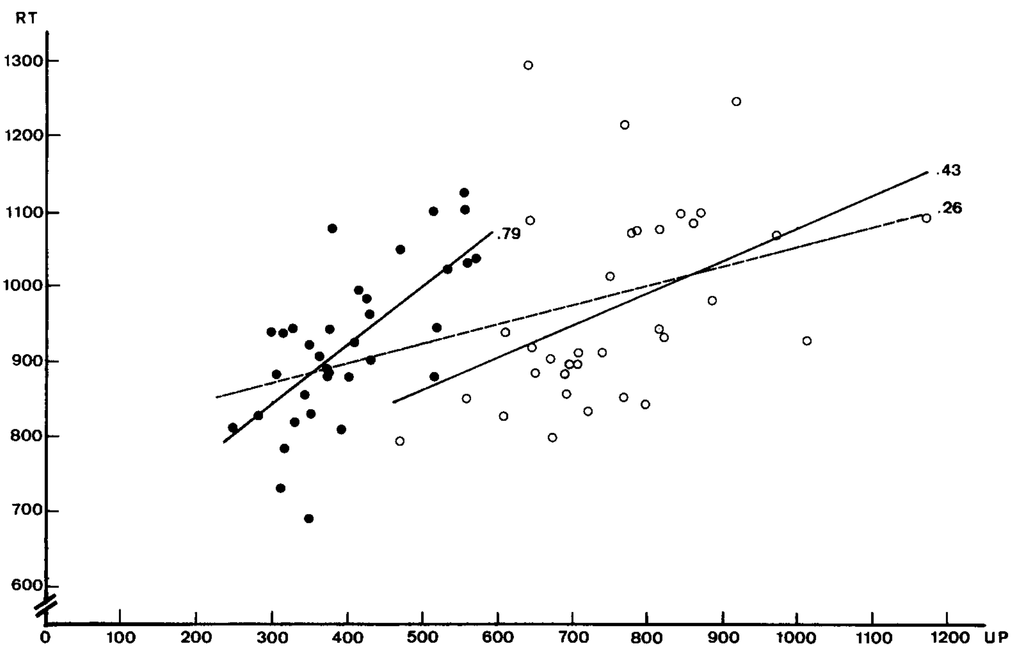

Fig. 2. Mean reaction times for nouns with early (●) and late (○) UPs as a function of the UP position from word onset (in ms) in slow shadowers. The regression lines are shown separately for each set of nouns as well as for both sets (broken line).

subgroup and set does not suggest that the shallower slopes observed for the late set are exclusively due to the fast subjects responding before the UP. The slow subjects display the same pattern of results. Thus, it is worthwhile examining whether material-bound variables, rather than the subjects or, indeed, in addition to them, can explain the difference observed between the early and the late items. The possible role of word frequency and length, which correlate significantly with the RT over all the subjects and items ($r = -0.24$, $p < 0.025$ and $r = 0.56$, $p < 0.005$ for frequency and length, respectively, is considered separately for the two sets of words in the following analyses. Let us note that, whereas the two sets were matched for these variables in terms of means, the corresponding distributions might differ in other respects.

We ran a multiple regression analysis in order to assess the relative contribution of UP position, word length and word frequency (in logarithmic value) to the RT. Note that UP position and word length correlated significantly ($r = 0.29$, $p < 0.01$), but that neither of them correlated with word frequency. We used a stepwise procedure in which the independent variable with the largest partial correlation was considered first for entry into the equation, the other variables being examined in the following steps. Table 4 gives the partial slopes and the partial correlations of the variables entering the equation, separately for the two subgroups and the two sets of words. In the early set, the independent variable that mostly predicts the word recognition point is UP position; frequency has no effect at all and word length is significant only for the slow subjects. In the late set, on the other hand UP position has no effect in either subgroup, and the variable with the highest correlation with the RT is word length, especially for the slow subjects. Besides word length, frequency also correlates significantly with the RT but only in the fast subjects.

4. Discussion

If the analysis of the present experiment had only compared the early- and the late-UP sets of items, it would have been tempting to say that spoken word recognition makes little use of the

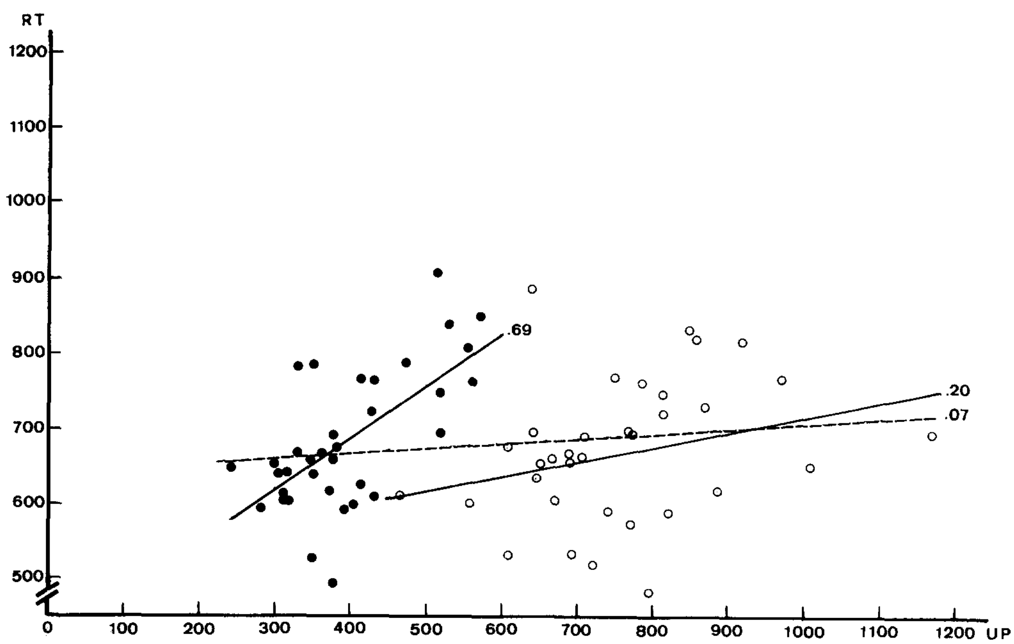

Fig. 3. Mean reaction times for nouns with early (●) and late (○) UPs as a function of the UP position from word onset (in ms) in fast shadowers. The regression lines are shown separately for each set of nouns as well as for both sets (broken line).

Table 4
Partial slopes (*B*) and correlations (*R*) between RT and UP position, length (LG) and (Freq) for the variables entering the equation in a stepwise regression analysis for each set of words and each group of subjects

	Early UP			Late UP		
	UP	LG	Freq	UP	LG	Freq
Fast subjects						
B	0.69	–	–	–	0.27	–40.57
R	0.63	–	–	–	0.41	–0.35
Slow subjects						
B	0.60	0.26	–	–	0.57	–
R	0.47	0.36	–	–	0.61	–

UP. Indeed, in the overall analysis, the effect of UP position on the latencies of spoken word shadowing is small and unreliable; it is significant in the analysis by subject, but not by item. However, such a conclusion is undermined when a more detailed examination of the differences between the items is carried out. Indeed, such an examination leads to the conclusion that, in certain circumstances, the UP may contribute powerfully to word recognition. As a matter of fact, the effect of the UP is much more dramatic in the set of words with early UPs than in the set with late ones. Furthermore, whereas for the early set the contribution of the UP reaches a very high significance level, for the late set no significant contribution of the UP to the RT emerges when correlations with word frequency and word length are taken into account.

The finding of a UP effect on the shadowing of early-UP words can be accounted for in two non-exclusive ways. Both suppose that the UP is crucial in determining spoken word recognition. According to the first interpretation, a response obtained from the lexicon in shadowing is much more likely to occur when the UP is situated relatively early in a word (on the first or second syllable) than when it is situated relatively late (on the third syllable). Since the UP can only have an effect when a response is obtained from the lexicon, the fact that the early set is much more sensitive to UP effects than the late set is hardly surprising. However, this interpretation is somewhat undermined by the fact that, in each set, the UP effect does not depend on whether the subjects are slow or fast shadowers, even though responses initiated before lexical access are more likely to occur in the fast subgroup.

The second interpretation is that, irrespective of the task, the UP may well be much more efficient when it occurs early. One way to verify this interpretation is to compare the present results with those obtained from the gender classification task. The data of the mixed conditions of Radeau et al.'s (1989b) study were re-analysed separately for the early and late sets. The pattern of results is the same as in the present experiment. The slopes are steeper in the early set than in the late one (0.65 versus 0.42 in condition 2, and 0.83 versus 0.46 in condition 3). ANOVAs run on the individual slopes with UP position as factors show that this effect is significant in both conditions (condition 2: $F(1,23) = 11.02$, MSe = 0.06, $p < 0.005$; condition 3: $F(1,15) = 20.75$, MSe = 0.05, $p < 0.005$). The different slopes observed by Radeau et al. (1989b) for the two sets of words can be accounted for if the subjects used a suffix strategy when the lexical strategy has seized up, i.e., in late UP words. However, the results of a calibration experiment run by Radeau et al. (1989b) provides arguments against such an interpretation. Moreover, in the present experiment, where the use of a suffix strategy served no purpose, we obtained slopes (0.76 and 0.34 in the early and the late set, respectively) that are very similar to those of Radeau et al. (1989b). The results of both tasks thus converge on the suggestion that the contribution of the UP to the word recognition process might be more important in the initial than in the final segments of words.

The method which we have used to estimate the UP and which consisted of locating the UP in the middle of the prototypical segment of the particular phoneme under study, might not reflect the true position of this point. We therefore checked to see whether any of a number of other methods of locating the UP yielded steeper slopes than the method mentioned above. In one of these attempts, two judges (the present authors) located the UP in a position corresponding to the minimal amount of acoustic information necessary for the critical phoneme to be unambiguously heard. For these new UP values, the slope of the regression function between the RT and the UP in the early set is 0.69. Thus, there is good agreement between this slope and the one obtained using the former method of estimating UP position. However, this new slope is not steeper but somewhat shallower than the previous one. The same tendency was obtained when the UP was situated at the end of the prototypical segment of the critical phoneme; the slope was now 0.68. Finally, when the UP was situated in the middle of the relevant syllable this resulted in a somewhat weaker slope, 0.55. We thus found no better alternative to the method of locating the UP in the middle of the prototypical segment of the critical phoneme.

In the present study, we distinguished between fast and slow subjects. Subjects were considered to be fast or slow depending on whether they repeated the late-UP items before or after a mean time incorporating the mean interval between word onset and the UP in this set, and a constant interval supposed to reflect response processes. The contribution of the UP to the RT in either the early or the late set does not seem to depend very much on whether the subjects were fast or slow. (Note, however, that the slow subjects displayed a somewhat smaller correlation between early-UP and the RT than the fast ones.) In contrast, the contributions of word length and frequency differed clearly according to the set of items and the group of subjects. In the early set, only the slow subjects showed a contribution of word length to RT. With respect to the late set, whereas the slow subjects displayed a more important contribution of word length to RT than the fast subjects, only the fast subjects made use of word frequency. The fact that the role played by word length was more important in the slow shadowers is quite natural; unless an early UP was detected and provided them with unambiguous information about the word, they seemed to have waited for the offset of the stimulus.

Let us now turn to the word frequency effect. If we assume that the role of word frequency in shadowing is mainly to facilitate the recognition process, then there seems to be no reason why the slow subjects should have shown a word frequency effect since these subjects apparently initiated most of their responses to the late set items only after they had heard the whole stimulus and thus, presumably, after they had recognized the word. On the contrary, a word frequency effect could be expected to occur in the fast subjects, since these subjects probably initiated most of their responses during the recognition process. It is also interesting to note that, in the fast subjects, the relation between UP and RT as a function of the set of items is completely reversed when word frequency is substituted for the UP. This may mean that UP and word frequency contribute to word recognition at different stages of the recognition process. Whenever an early UP allows a single candidate to be determined, the corresponding response becomes available; before an early UP is reached, there may still be too many candidates consistent with the information presented, so that producing a response on the basis of the most frequent word would be hazardous. This difficulty is probably avoided when the UP comes late in a word.

To sum up, both the word length and the word frequency effects observed in the present study seem to reflect optional, though presumably unconscious and involuntary, mechanisms. Thus, while word length triggered off a "wait-and-recognize" mechanism, word frequency triggered off an anticipatory mechanism which can only be efficient in the later stages of the recognition process.

5. Conclusions

In conclusion, the 0.76 slope obtained here between RTs and early UPs indicates strong UP influence in the determination of the spoken word recognition point. However, this may be true for only part of the lexical entries with early UP. It is important to bear in mind that our results were obtained with trisyllabic words, and that words of two, three or four phonemes rarely have their UP before the last phoneme, at least in English (Luce, 1986).

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