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Lexical Processing of Functionally Constrained Words

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A series of experiments examines lexical decision and naming times to single words which, when used in a sentence, are functionally constrained. Closed class words which cannot meaningfully stand alone (e.g., THAN, ELSE) took longer to respond to than open class words in a lexical decision task but not a naming task (with naming onset times adjusted for voice onset variations); whereas closed class words which can stand alone (e.g., NOW, THOSE) did not differ from open class words. It was further shown that open class words which cannot stand alone (e.g., RELY, DISPOSE) were associated with longer lexical decision times than those which can (e.g., RAIL, PERSIST), but not with longer naming times. Thus the effect of functional constraint was not restricted to closed class words and seemed to occur at a post-access decision stage of processing rather than influencing lexical access itself. Finally, it was demonstrated that not all functional constraints delay lexical decision times, since obligatorily transitive verbs (e.g., BORROW, UNDERGO) did not differ from unconstrained words. An explanation is given in terms of how meaningfulness might have an influence on lexical decision responses.

A study by Bradley (1978) purported to demonstrate a computational distinction between the recognition of closed class and open class words. Closed class words are those belonging to the minor grammatical categories (e.g., articles, prepositions, quantifiers) while open class words are those belonging to the major grammatical categories (nouns, verbs, adjectives). Bradley proposed that there is a special lexical store for closed class words which has a privileged status in recognition relative to the general lexicon which contains both closed and open class words.

The evidence that Bradley provided for her position is from two independent experimental paradigms using both normal and agrammatic subjects. When required to classify letter strings as words or nonwords (i.e., in a lexical decision task), normal subjects were delayed in their nonword responses when the letter string began with an open class word (e.g., SETITUDE), but not when it began with a closed class word (e.g., YETITUDE). Agrammatic aphasic subjects were delayed in both cases (relative to a nonword that had no word at its beginning, e.g., DITITUDE). In a second experiment, lexical decision times for normal subjects were found to correlate with open class word frequency, but not with closed class word frequency. Agrammatic aphasic subjects, on the other hand, showed frequency sensitivity to both types of word.

These findings strongly suggested that normal readers treat closed class and open class words differently while agrammatics do not make such a distinction, that is, agrammatics are unable to exploit a specialized closed class lexicon. Bradley's studies made a considerable impact, largely because the aphasics were actually producing a positive effect which the normals did not produce, rather than simply failing to perform as well as normals.

Further support has been obtained for the closed class–open class distinction using Bradley's nonword interference para-

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digm (e.g., Kolk & Blomert, 1985; Shapiro & Jensen, 1986, although see Petocz & Oliphant, 1988); letter cancellation experiments (Rosenberg, Zurif, Brownell, Garrett, & Bradley, 1985); and word monitoring tasks (Friederici, 1985; Swinney, Zurif, & Cutler, 1980). However, the frequency sensitivity paradigm used by Bradley has been less successful in adducing further support for the computational distinction between word classes. Studies in a variety of languages have failed to demonstrate any notable difference between the frequency sensitivity of open and closed class items (e.g., Gordon & Caramazza, 1982, 1983; Segui, Mehler, Frauenfelder, & Morton, 1982).

In 1985, Gordon and Caramazza reported a study of frequency sensitivity in the recognition of open and closed class words. In this study they presented data which they acknowledged as being consistent with Bradley's results, at least for all but the extremely high frequency words. That is, below a certain frequency value, reaction times to open class words correlated with frequency whereas reaction times to closed class words did not. Gordon and Caramazza concluded, however, that there were other variables, as yet unspecified, that were having an effect and which somehow led to the open class–closed class difference in Bradley's experiment as well as in their own. What these variables (or variable) might be was left open to speculation, though they were not "length" or "syllabicity" since these were controlled.

Before suggesting a variable here that may be relevant, it should be pointed out that Gordon and Caramazza also observed that closed class words were responded to more slowly than open class words. They made no attempt to explain this finding, but simply said that Bradley would have predicted the opposite result if closed class words did have a privileged status in the lexicon. The first experiment reported here looks at this difference in reaction times between open and closed class words to ascertain whether it is affected by a variable which may be an important one in determining lexical decision times.

Experiment 1

When one considers the words that fall into the closed class category, it becomes apparent that there are at least two types of closed class words. There are those which can be used on their own without reference to other words and those which cannot. Closed class words that can stand alone are readily usable as one-word sentences. For example, the word THOSE can be used as a one-word reply to WHICH SOCKS DO YOU WANT? On the other hand, a word like THAN or AM can only be defined in terms of its function in a sentence relative to other words in the sentence, and therefore cannot be used as a one-word sentence.

Perhaps, it is the inability of many closed class words to stand on their own that is a major variable affecting lexical decision times. It may be difficult for subjects to decide that a word of this type is a word, since its lexical entry would need to include more than just the word itself, being meaningless on its own. In other words, it may be the case that closed class words that cannot stand alone will take longer to recognize as words than open class words of the same frequency, while closed class words which can stand alone will be treated just like open class words. Experiment 1 tested this hypothesis.

Method

Materials. Two sets of 15 closed class words were constructed. In one set, each word was meaningful in its own right, being readily usable as a one-word sentence (e.g., THOSE, HERE, YES, SOON; mean log frequency = 2.772 according to Carroll, Davies, & Richman, 1971; mean length = 4.33 letters); while in the other set, they were not (e.g., ELSE, THAN, MUST, UPSIDE; mean log frequency = 2.311, mean length = 4 letters). Each of these closed class words was matched to an open class word of the same frequency and of the same length (e.g., LARGE, HOT, CARE, WORD). Thus there were two sets of matched closed class–open class pairs. These 60 word items were randomly intermixed with 40 nonwords of similar length and structure to the words (e.g., WHON, DAP, SNOLL, FIME). There were 10 practice items at the beginning. All of the word items are listed in the Appendix.

Procedure. Items were presented in upper-case letters on a visual display unit for 500 msec each. Subjects were instructed to respond as quickly but as accurately as possible in deciding whether the item was a word or not. The response was made by pressing a "yes" or a "no" button.

Twenty undergraduate psychology students participated as subjects.

Results and Discussion

The mean reaction times and error rates are presented in Table 1. Looking at reaction times, the main effect of word type (closed vs open class) was significant, $minF'(1,30) = 6.81$, $p < .02$, but more importantly this effect interacted with the ability of the closed class word to stand alone, $minF'(1,30) = 4.19$, $p < .05$. There was a difference between closed and open class words when the former could not stand alone, $minF'(1,25) = 9.64$, $p < .01$, but no difference between them when the closed class words could stand alone, both F_1 and $F_2 < 1$.

In the analysis of the errors, none of the item analyses were significant. The closed class words which could not stand alone significantly differed from the open class words on the subject analysis, $F_1(1,19) = 22.94$, $p < .001$; $F_2(1,14) = 3.13$, $.05 < p < .1$, while the closed class words which could stand alone did not, $F_1(1,19) = 1.88$, $p > .1$; $F_2(1,14) = 1.91$, $p > .1$.

TABLE 1
MEAN LEXICAL DECISION TIMES (msec) AND PERCENTAGE ERROR RATES FOR THE CLOSED AND OPEN CLASS WORDS OF EXPERIMENT 1

	Example	RT	Error
Closed class:			
cannot stand alone	ELSE	661	8.0%
Open class	CARE	580	1.0%
Closed Class:			
can stand alone	THOSE	597	0.3%
Open Class	LARGE	582	1.3%

It seems from these data that closed class words are only difficult to process when their function is linked to other words in a sentence, that is, when they cannot meaningfully stand alone. This can potentially explain the inconsistencies observed in experiments looking at the frequency sensitivity of closed class words. If a sufficient number of closed class words which cannot stand alone are used in a lexical decision experiment, particularly among the highest frequency words, the correlation between frequency and response time would be reduced. It should be noted, though, that only about one-third of Bradley's closed class items can be (unambiguously) classified as being unable to stand alone, and these do not seem to predominate amongst the higher frequency words. Thus this explanation is hard to sustain for Bradley's results, though it might account for the general inconsistencies observed using the frequency sensitivity paradigm.

The present experiment does, however, allow a direct examination of Bradley's claim that closed class words are not frequency sensitive while open class words are. In particular, the correlation between response times and word frequency can be calculated. Using the logarithmic transformation of frequencies provided by Carroll et al. (1971), there is no evidence in the data to suggest a difference in frequency sensitivity between closed class and open class items, even when the closed class words cannot stand alone. For the closed class words which cannot stand alone, $r(15) = -.75$, $p < .001$, and exactly the same value is obtained for their matched open class words. For the closed class words which can stand alone the correlation is $-.84$, $p <$

.001 (n = 15) and for their matched open class words $-.78, p < .001$. In other words, frequency and lexical decision times are highly correlated regardless of the functional status of the word, and thus Bradley's result is not replicated here. This, of course, does not rule out the idea that there is a specialized lexical store for closed class words (or at least for some closed class words), but suggests that if such a specialized store exists, it is just as frequency sensitive as the standard lexical store.

At this point, we should consider what it means to "not stand alone." How might this factor be represented lexically? It might be the case either that functional information stored in the lexicon is consulted as a guide to whether the letter string is a word or not, or else that functionally constrained words are stored in their own special lexicon which takes longer to access than the standard lexicon when words are presented in isolation. According to the first of these alternatives, access to the lexical entry is not influenced by the ability of the word to stand alone, but rather, it is the post-access decision stage that is affected. The experiment does not in fact elucidate what it is about the inability to stand alone that affects the lexical decision. However, two possibilities suggest themselves.

First, the decision that the entry actually is a word might be based on subcategorization rules (e.g., Chomsky, 1965; cf. Shapiro, Zurif, & Grimshaw, 1987) which specify the syntactic environment in which the word can be used. If there is no information that the word can be used on its own, this could delay the decision that the letter string, presented on its own, is classifiable as a word. The second possibility is that lexical decision takes meaning into account. If a word is not strongly associated with a meaning, then its status as a word is considered dubious. Words in the "cannot stand alone" condition of Experiment 1 were not associated with a meaning in two different ways. Words like THAN or NOR are nonmeaningful in the sense that their definition can only be given in syntactic rather than semantic terms, while words like ELSE or UPSIDE are nonmeaningful in the sense they are only part of a lexical item. It might be that OR ELSE and UPSIDE DOWN are associated with meaning, but their subcomponents ELSE and UPSIDE are not.

Whether it is subcategorization or semantic information that plays a role in lexical decision will be considered later in the light of further experiments. First though, we will turn to the alternative possibility that functionally constrained closed class words are delayed in their recognition because they are actually stored separately from all other words. This idea is similar to Bradley's proposal for closed class words as a whole.

If the effect observed in the first experiment arose because of a difficulty in accessing a specialized lexical store, rather than a delay at the post-access decision stage, then the same effect should be observed in a task where there is unlikely to be a decision component. One way of attempting to examine lexical access without the involvement of a decision stage has been to examine naming times (e.g., Balota and Chumbley, 1984; Forster & Chambers, 1973; Seidenberg, Waters, Sanders, & Langer, 1984; Taft, 1981). In this paradigm, subjects simply read the word and say it aloud, with response times being measured from the presentation of the word to the beginning of articulation. No decision is required regarding the lexical status of the letter string, unlike the lexical decision task. The words used in Experiment 1 were therefore presented for naming responses in Experiment 2. If the functional characteristics of a word affect access times, rather than the time taken to decide that the letter string is a word, then the inability of a word to stand on its own should delay naming times in the same way that it delayed lexical decision times.

Experiment 2

Method

Materials. The word items that were used in the first experiment were used in Experiment 2. The nonwords were omitted.

Procedure. Items were presented in the same manner as in the first experiment. The subjects responded by saying the word aloud into a microphone. Onset of vocalization triggered a voice switch which allowed the computer to record the latency from the presentation of the word to the vocalization of the response. Responses were monitored and response times were ignored if the subject mispronounced a word.

Since items were not matched across conditions on their initial phoneme, it was possible that one condition might have included words with initial phonemes that more readily triggered the voice switch than other conditions. For this reason the following naming control procedure was adopted (see Taft, 1981). After the naming experiment was completed, subjects were presented with the complete set of stimuli again. This time each word was presented for 1 s and then two lines appeared above and below the word. Subjects were required to name the word when the lines appeared. Response times were measured from the time the lines appeared. Since subjects had time to prepare their response before the lines appeared, naming latencies using this procedure should have solely reflected articulation times. These naming control times were therefore subtracted from the original naming times to gain an articulation-free measure of lexical access.

Twenty subjects participated in the experiment.

Results and Discussion

The results found in Table 2 are naming response times minus naming control times. Analysis of both reaction time and errors produced no significant difference between closed class and open class words and no significant interaction between this factor and the ability for closed class words to stand alone, with all F's < 1. The slightly inflated error rate (mispronunciation rate) for the closed class items that could not stand alone and for their open class controls, emanates almost entirely from the relatively high error rate for SHALL in the first condition and for SMALL in the second. It seems that subjects confused these two words.

TABLE 2
MEAN NAMING TIMES MINUS NAMING CONTROL TIMES (msec) AND PERCENTAGE NAMING ERRORS FOR THE CLOSED AND OPEN CLASS ITEMS OF EXPERIMENT 2

	Example	RT	Error
Closed class:			
cannot stand alone	ELSE	169	3.8%
Open class	CARE	167	2.8%
Closed class:			
can stand alone	THOSE	159	0.4%
Open class	LARGE	165	0.7%

The failure to find a difference between conditions in this naming experiment supports the view that the effect observed in the lexical decision task of Experiment 1 arose at the decision stage. It appears that words that cannot stand alone are accessed no differently than words that can stand alone. It is more difficult, though, to decide that the former is actually a word. The decision that an accessed lexical entry is a word seems to take the functional characteristics of the word into account.

Before accepting the conclusions drawn from the naming experiment, however, a methodological concern must be considered. It is assumed in the naming task that naming response times are a measure of the speed of lexical access plus the time it takes for the vocalization to trigger the voice switch. Naming control times are assumed to simply measure the time taken to trigger the voice switch. Therefore, subtraction of the control times from the naming times (giving what I will call "adjusted naming times") should provide a reasonably uncontaminated measure of lexical access. However, Balota and Chumbley (1985) have claimed that naming control responses are sensitive to word frequency, a factor that is typically thought to affect lexical access. One possible interpretation of their finding is that subjects re-process a stimulus before naming it under naming control conditions and therefore naming control times actually include a measure of lexical access. If this were the case, it would be inappropriate to subtract naming control times from naming times in order to obtain a pure measure of lexical access, since both times would be reflecting speed of access. The adjusted naming times might have shown no difference between experimental conditions simply because any effects of lexical access had been subtracted out.

To determine if this was what happened, one could see whether the words which cannot stand alone were indeed longer than the control words in both their unadjusted naming times and their naming control times. However, although it is encouraging to find that there was no such effect for either the naming times [$minF'(1,17) = 0.680$] or the naming control times [$minF'(1,25) = 1.336$], one cannot confidently conclude that this lack of difference means that the variable of being able to stand alone had no effect. It is possible that this factor did affect naming responses, but that it was washed out by an articulation difference between the conditions. It may have been the case that the words in the "cannot stand alone" condition took less time to trigger the voice switch than those in the control condition and that this difference counteracted a delay engendered by the inability of the words to stand alone, thus leading to a nonsignificant difference in both the naming and naming control responses. It seems then that another approach is needed to determine whether the use of adjusted naming times is valid.

To this end, a set of correlations was carried out. If lexical decision time is a measure of lexical access (plus a decision phase) then lexical decision time should correlate with other response time measures that supposedly reflect lexical access. In particular, lexical decision times should correlate with naming times and adjusted naming times, but not with naming control times. Naming control times, though, should correlate with naming times since they include a common component, namely the time taken for the vocalization to trigger the voice switch. This pattern of correlations is exactly what was obtained for the items used in the two experiments. With $N = 60$ in each case, the correlation between lexical decision and naming time is .41 ($p < .001$); between lexical decision and adjusted naming time is .53 ($p < .001$); between lexical decision and naming control time is .04 ($p > .05$); and between naming time and naming control time is .42 ($p < .001$). This analysis is therefore consistent with the idea that the naming control task was not leading to lexical access, but was simply a measure of the power of the vocalization to trigger the voice switch.

It can be seen that adjusted naming times were correlated with lexical decision times, even though the functional characteristics of the closed class words influenced the latter but not the former. The interpretation given for this is that the two response measures have a common component (namely speed of lexical access), but lexical decision times have an additional decision component which the adjusted naming times do not have. It is from this decision component that the effects of a word not being able to stand alone emerge.

One might conclude from the first two experiments then, that there is indeed something special about at least some closed class words, namely, those which cannot stand alone as meaningful units. However, there also exist open class words which do not stand alone and it might be the case that they are treated just like the equivalent closed class words. For example, the word RELY must necessarily be followed by ON, and DISPOSE by OF. BUDGE is typically accompanied by NOT, and BIDE is almost exclusively restricted to the phrase BIDE ONE'S TIME. It might be the case that open class words like these are associated with longer lexical decision times than open class words which do stand alone, like RAIL, PERSIST, and SPICE. If so, then the effects observed in Experiment 1 cannot be seen as being a special closed class effect. Experiment 3 is a test of this possibility.

Experiment 3

Method

Materials. Forty word pairs were generated such that the members of each pair were matched on frequency according to Carroll et al. (1971) and on approximate length. One member of each pair was a word which is exclusively (or most typically) accompanied by another word (or words) when used in a sentence (e.g., DISPOSE, BUDGE; mean log frequency = −0.304; mean length = 5.78) while the other member was a word which does not have such constraints (e.g., PERSIST, SPICE; mean log frequency = −0.303; mean length = 5.73). These 80 word items were randomly intermixed with 50 legal nonwords (e.g., SNATE, PRIB, REVOUNT) and preceded by 10 practice items. All experimental items are listed in the appendix.

Procedure. The procedure was the same as that followed in Experiment 1. There were 20 subjects.

Results and Discussion

Mean response times and error rates for the two types of open class words are presented in Table 3. As can be seen in the table, the words which were typically constrained in what other words they could combine with took longer to recognize than the words which were not so constrained, and this was significant *minF'*(1,24) = 9.21, $p < .01$. The former were also associated with more errors than the latter, *minF'* (1,25) = 5.80, $p < .05$.

TABLE 3
MEAN LEXICAL DECISION TIMES (msec) AND PERCENTAGE ERROR RATES FOR THE OPEN CLASS ITEMS OF EXPERIMENT 3

	Example	RT	Error
Cannot stand alone	DISPOSE	862	13.5%
Can stand alone	PERSIST	781	6.9%

The results obtained with the open class words of Experiment 3 seem to echo the results obtained with the closed class words of Experiment 1. When a word does not constitute a functional unit in its own right, it takes a relatively long time to recognize as a word whether it be a closed class word or an open class word. So the fact that DISPOSE is typically combined with OF has the same impact on recognition times as the fact that ELSE is typically preceded by OR and that THAN is only used in a particular syntactic framework. From this result it could be concluded that there is nothing special about closed class words. Instead, what seem to be special are any words which are functionally constrained.

From Experiment 2 it seems that this functional constraint does not affect access to the lexical entry for a word, but rather, makes it difficult to say that the accessed lexical entry represents a genuine word. To confirm this conclusion for the open class cases what is required is a naming experiment using the items of Experiment 3. This was undertaken in Experiment 4.

Experiment 4

Method

The materials were the word items used in Experiment 3, while the procedure was the same as that followed in Experiment 2. There were 20 subjects.

Results and Discussion

Table 4 presents the mean adjusted naming times (i.e., naming times minus naming control times) for the two experimental

TABLE 4
MEAN NAMING TIMES MINUS NAMING CONTROL TIMES (msec) AND PERCENTAGE ERROR RATES FOR THE OPEN CLASS WORDS OF EXPERIMENT 4

	Example	RT	Error
Cannot stand alone	DISPOSE	276	4.6%
Can stand alone	PERSIST	275	4.1%

conditions. There was no difference between the two conditions either for reaction times or error rates ($F < 1$ in all cases).

As was observed in the first two experiments, while the functional characteristics of the words had a strong impact on lexical decision times, there was no effect at all on naming times. Again, this suggests that there is not a special mechanism for accessing the lexical entries for words which cannot stand alone, but rather that it is difficult to decide that such lexical entries represent words in their own right.

The same correlations were carried out with the open class words as were previously carried out with the closed class words. This was to ensure that the lack of effect in the naming task was not simply a result of inadvertently subtracting out an effect when subtracting naming control times from naming times. (It should be noted that neither the unadjusted naming times nor the naming control times by themselves showed any effect of being able to stand alone, $minF' < 1$ in both cases.) As before, lexical decision times correlated significantly with both naming times [$r(80) = .57, p < .001$] and adjusted naming times [$r(80) = .59, p < .001$]; while naming control times correlated with naming times [$r(80) = .51, p < .001$], but not with lexical decision times [$r(80) = .20, p > .05$]. However, this last correlation approached significance and therefore suggests that there might have been some re-processing of the letter string in the naming control task. This is different than the first two experiments where there was no hint of a correlation.

The most likely source of this difference is the fact that the words in the third and fourth experiment took longer to access than those in the first two experiments, presumably because of their lower frequency, though why this should lead to a re-processing of the stimulus is unclear. Nevertheless, even if the naming control task did include an access component, there was no sign of a difference in the task between the constrained and unconstrained words (381 msec versus 380 msec). Thus these two types of words seem to be differentiated only at the decision stage of the lexical decision task.

It was suggested earlier that there are two alternative ways in which the manipulation of functional constraint could have its effects on lexical decision. On the one hand, the effects could arise from lexical information about subcategorization (i.e., information about the sentential environment in which the word can occur). That is, the effects might genuinely arise from constraints on the function of the word when used in a sentence. On the other hand, the effects might arise from a factor which has been confounded with functional constraint, namely, the meaningfulness of the word. To give an example, it might either be the case that DISPOSE is difficult to classify as a word because there is information stored within the lexical entry for DISPOSE which says that it must always combine with another word (namely, OF), or it might be the case that the lexical entry is actually represented as DISPOSE OF and it is this that is associated with meaning rather than the word DISPOSE on its own.

One way of differentiating these two alternatives is to examine words which are clearly meaningful even though they are functionally constrained. If a verb always requires an object when used in a sentence, it is clearly functionally constrained. Yet such an obligatorily transitive verb must be associated with a meaning, since there is no larger lexical unit of which it could potentially be a subcomponent. For example, the word CONTAIN is functionally constrained in that it always requires an object when used in a sentence, yet, despite this, it has a clear meaning (namely, "include"). The same is true of BORROW and UNDERGO.

By looking at obligatorily transitive verbs, then, one can separate out the factors of meaningfulness and true functional constraint. The words THAN, DISPOSE, and CONTAIN are all functionally constrained in that they can only be used in a sentence with the support of other words of a specific type, but only the third of these examples is meaningful. THAN is not meaningful in the sense that it can only be defined in terms of its syntactic function, while DISPOSE is not meaningful in the sense that it can only be defined when combined with another word, namely the word OF. If meaningfulness is the important factor in slowing lexical decision responses, then obligatorily transitive verbs like CONTAIN should take no longer to respond to than unconstrained words like BELIEVE, since both are meaningful. If, however, it should turn out that functional constraint per se is the important factor, then lexical decision times should be longer for compulsorily transitive verbs than for unconstrained words. This is tested in Experiment 5.

EXPERIMENT 5

Method

Materials. Twenty pairs of words were used in the experiment. One member of each pair was a verb which requires an object when used in a sentence (e.g., BORROW, CONTAIN; mean log frequency = 0.997; mean length = 7.15) while the other member of the pair was an unconstrained word (verb, noun, or adjective) matched on frequency and approximate length (e.g., JUSTICE, BELIEVE). These 40 words were intermixed with 40 legal nonwords (e.g., LEGIME, IMPRECT) and preceded by 10 practice items.

Procedure. The procedure was the same as in the lexical decision tasks of Experiments 1 and 3. There were 20 subjects.

Results and Discussion

Mean lexical decision times and error rates are presented in Table 5. There was no difference observed between the obligatorily transitive verbs and their unconstrained controls either for reaction times or error rates, $F < 1$ in all cases.

It is not the case, therefore, that all forms of functional constraint affect the decision that an accessed lexical entry is a word. An obligatorily transitive verb, like BORROW, cannot stand alone in the sense that it needs to be accompanied by an object when used in a sentence. A word like DISPOSE cannot stand alone in a different sense, namely that it needs to be accompanied by a specific word. The important difference here has been suggested to be a difference in the semantic consequences of the different types of functional constraint. Obligatorily transitive verbs like CONTAIN are associated with a meaning, whereas words like DISPOSE are only associated with a meaning through the larger unit DISPOSE OF. It therefore seems that the factor that affects lexical decision responses is not functional constraint per se, but rather the meaningfulness of the word.

It should be noted that if a word like DISPOSE is represented in the lexicon as DISPOSE OF, one needs to further assume that access to this lexical entry can be gained on the basis of the subcomponent DISPOSE. If this were not possible, the letter string DISPOSE would not access any lexical entry and thus would not be classifiable as a word. There is, however, empirical support for the assumption that a lexical entry can be accessed on the basis of one of its subcomponents. For example, Taft and For-

TABLE 5
MEAN LEXICAL DECISION TIMES (msec) AND PERCENTAGE ERROR RATES FOR THE TWO CONDITIONS OF EXPERIMENT 5

	Example	RT	Error
Compulsorily transitive	BORROW	739	1.3%
Control	JUSTICE	743	2.0%

ster (1976) demonstrated that subjects experienced difficulty in making lexical decision responses to nonwords which were subcomponents of actual words, like the HENCH of HENCHMAN, suggesting that the lexical entry for the word was being accessed on the basis of the subcomponent.

General Discussion

Several different types of words have been examined in this study:

1. Closed class words which are functionally constrained in that they can only be defined in terms of their syntactic function, e.g., THAN, NOR, SHALL.
2. Closed class and open class words which are functionally constrained in that they are typically found in a sentence with other specific words, e.g., DISPOSE (*of*), (*or*) ELSE, VANTAGE (*point*), UPSIDE (*down*).
3. Open class words which are functionally constrained in that they are typically found in a sentence with a specific *type* of word, e.g., BORROW, CONTAIN, UNDERGO.
4. Closed class words which are not functionally constrained in that they do not require any reference to other words when being defined, e.g., THOSE, NOW, ME.
5. Open class words which are not functionally constrained in that there are several possible syntactic environments in which they can occur, e.g., BELIEVE, SPICE, CARE.

It was found in the experiments that lexical decision times to words falling into categories 3, 4, and 5 were equivalent, while lexical decision times (though not naming times) were relatively slower for words of categories 1 and 2. The explanation for this has been given in terms of a difference in meaningfulness between the first two conditions and the rest. This difference can be characterized in the following way.

The lexical entry for a word belonging to category 3, 4, or 5 can be represented as a lexical unit which is associated with a meaning and to which is attached information about the word's syntactic function, for example, something along the lines of: **BORROW** [verb, -NP] = "temporarily take"; **THOSE** [pronoun, -VP, -PP, -#; adjective, -NP] = "the things over there"; **BELIEVE** [verb, -NP, -S, -#] = "accept as true." A word belonging to category 2 is only one subcomponent of such a lexical unit, e.g., **DISPOSE OF** [verb, -NP] = "get rid of"; **UPSIDE DOWN** [adverb, -#] = "having the bottom at the top." For words of category 1 there is no associated meaning, e.g., THAN [comparative conjunction, -NP].

If we assume that at least part of the decision stage of the lexical decision response is based on the meaning associated with the lexical unit, words of category 2 (like DISPOSE) will be delayed because the word itself is not directly associated with the meaning, while words of category 1 (like THAN) will be delayed because the lexical unit is not associated with any meaning at all.

The importance of semantic factors in lexical decision performance has been demonstrated previously, for example by the existence of semantic priming effects (e.g., Meyer & Schvaneveldt, 1971), by differences between concrete and abstract words (e.g., James, 1975; Kroll & Merves, 1986; Schwanenflugel and Shoben, 1983), and between words of many and few meanings (e.g., Jastrzembski, 1981; Rubenstein, Garfield, & Millikan, 1970). Thus the decision that an accessed lexical entry represents a word in its own right does appear to be at least partly based on how meaningful the word is, a conclusion also drawn by Whaley (1978) on the basis of a multiple regression analysis of lexical decision times, and by Chumbley and Balota (1984) who found an effect of meaningfulness on lexical decision but not on naming responses.

There is a possible problem with this argument, however, that some semantic effects have been shown to occur in the naming task as well as the lexical decision task.

Seidenberg et al. (1984) observed a semantic priming effect on naming times, and Bleasdale (1987) found that abstract words took longer to name than concrete words. Thus it might be supposed that if the effects of not being able to stand alone have a semantic basis, such effects should have been observed in the naming task. However, all one can really conclude is that the loci of the semantic priming effect and the concreteness effect appear to be different than the locus of the effects of meaning being proposed here. The semantic factors being considered in relation to the present study have nothing to do with the nature of the representation of a word's meaning or the associations between words of related meaning, but rather, the nature of the link between the orthographic form of the lexical entry and its meaning. If an incomplete version of the orthographic form of the lexical entry has no meaning (e.g., DISPOSE) or if the lexical entry has no meaning (e.g., THAN) then the decision that the item is a word in its own right appears to be hampered, though access itself remains unaffected.

CONCLUSION

The experiments reported in this paper have attempted to provide some understanding of how the functional characteristics of words might be lexically represented. A word presented in isolation can be difficult to respond to as a word when it is functionally constrained if used in a sentence. However, it was shown that this does not generalize to all functional constraints, in particular, obligatory transitivity. For this reason, it is difficult to point to general syntactic factors that might influence the decision stage of the lexical classification response. Instead, a semantic explanation was offered whereby lexical decision is influenced by the nature of the orthographic-semantic link in the lexicon.

While these conclusions must remain highly speculative, the data presented here are not supportive of Bradley's idea of a special lexical store for closed class items. First, those closed class words which can stand alone do not seem to be processed any differently than open class words, and second, the naming of words seems to be totally unaffected by their functional status, suggesting that functional effects are post-access effects. However, it must be noted that no attempt has been made here to account for findings of open class–closed class differences using other paradigms (e.g., Bradley's nonword interference paradigm) and therefore these need further exploration.

APPENDIX

The following are the items used in Experiments 1 and 2 along with their lexical decisions times (LDT: Experiment 1) and adjusted naming times (ANT:Experiment 2).

Cannot Stand Alone	LTD	ANT	Control	LDT	ANT
AM	652	157	BOX	546	158
NOR	879	186	AGE	624	185
THUS	678	132	SEEM	539	183
MUST	627	144	WORD	554	168
SHALL	755	152	WATCH	541	153
THAN	619	194	MAKE	549	148
AMONG	642	178	READY	540	175
TOO	560	154	MAN	592	154
EVERY	547	151	SMALL	606	165
UPSIDE	704	186	CONCEPT	639	201
WHILE	594	150	SOUND	541	117
OUR	662	163	NEW	563	175
UPON	612	178	BODY	575	159
ELSE	631	152	CARE	587	166
VIA	896	258	DINE	698	190
Can Stand Alone			Control		
NOW	538	132	WAY	556	187
AGAIN	589	167	GREAT	617	186
OFTEN	632	161	HOUSE	551	146
THOSE	553	151	LARGE	562	132
OFF	530	182	OLD	544	159
WHERE	598	149	KNOW	551	182
YES	546	144	HOT	537	190
MORE	561	138	TIME	586	188
BOTH	546	155	SHOW	587	170
SOON	577	157	HARD	628	129
VERY	545	137	LONG	546	148
ME	564	131	GO	564	168
DOWN	553	167	FIND	573	162
HERE	561	201	TAKE	564	141
UNDERNEATH	927	213	ADVANTAGE	772	188

The following are the items used in Experiments 3 and 4 along with their LDT (Experiment 3) and ANT (Experiment 4).

Cannot Stand Alone	LDT	ANT	Can Stand Alone	LDT	ANT
SEMBLANCE	1390	462	COMMUNION	996	366
RIFE	898	271	LOBE	904	267

BARRAGE	1038	346	THERMOS	910	327
PENT	901	246	PROD	919	379
PLY	840	254	ALE	783	268
CRUX	856	331	LURK	993	196
SUFFICE	748	278	GRUMBLE	986	408
STAUNCH	953	287	SLEUTH	931	274
VANTAGE	975	316	BOYCOTT	735	286
FRAUGHT	841	284	CORDIAL	690	329
SPATE	938	255	SNICK	783	250
BIDE	1120	293	RAVE	733	314
WAFT	956	300	SLUR	733	256
VERGE	821	253	CRAMP	622	196
ASUNDER	1078	383	APPAREL	871	207
PLIGHT	799	324	FRIGID	827	295
FLUX	798	251	WELD	740	280
SCANT	791	256	PUTTY	755	284
BRUNT	854	274	EQUIP	1037	305
FOND	756	201	RAIL	627	181
BUDGE	967	333	SPICE	665	184
RID	753	192	LID	732	252
SCOPE	654	223	SLANG	719	212
CAPITALIZE	765	345	SLAUGHTER	706	242
JOT	896	289	KEG	840	295
EXPERT	656	200	PRESENT	617	236
RELY	705	234	DELAY	616	213
CONSIST	703	227	PRECISE	687	254
DEPEND	676	247	COMPLEX	644	169
REFER	713	305	AFFECT	658	233
INTEND	779	178	DEBATE	653	288
DEVOTE	722	231	DIGEST	657	247
DEVOID	778	206	RECEDE	899	358
ABJECT	1302	267	ACCRUE	883	420
RECOURSE	890	288	PRETEXT	859	344
INDULGE	781	237	INVERT	751	248
ASPIRE	779	289	ERODE	881	266
IMPINGE	938	355	IMMERSE	752	284
DISPOSE	767	252	PERSIST	753	326
ACCUS-TOMED	904	281	CONDUCTED	708	296

The following are the items used in Experiment 5 along with their lexical decision times.

Constrained		Unconstrained	
ADMIT	660	REMOTE	631
CONTEMPLATE	933	ANTICIPATE	746
CONTAIN	709	BELIEVE	620
EXPECT	686	DEVELOP	683
DISCUSS	642	DESIGN	650
INTRODUCE	661	NONSENSE	722
INCLUDE	636	PRODUCT	640
PROMOTE	779	ASCENT	861
REPRODUCE	781	CONTRIBUTE	848
REQUIRE	712	CONTEST	695
SUBTRACT	740	DEMAND	684
UNDERGO	922	DISGRACE	841
WITHSTAND	784	AWESOME	959
ALLOW	607	OCCUR	622
CREATE	746	MIRROR	641
CLASSIFY	651	SUPERIOR	798
BETRAY	830	BEWARE	660
BORROW	689	JUSTICE	686
STIMULATE	760	PORRIDGE	967
SLAY	849	THAW	904

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