Events Versus States: Empirical Correlates of Lexical Classes

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Abstract

Philosophers and linguists have claimed that verb meanings are divided into semantic types or superordinate categories that differ in internal conceptual structure. In particular, eventive verbs, which have internal causal structure are distinguished from stative verbs, which have no internal causal structure. In this paper, we explore the processing consequences of assuming that the lexical representations of verb meanings differ in the complexity of their internal representations. We conducted two experiments, a lexical decision task and a self-paced reading study, that investigated how verb types of different complexity are processed. We predicted that the conceptually more complex eventive verbs would take longer to process than stative verbs. In both experiments, this prediction was confirmed. This lends support to theories of verb concepts that propose classifications based on internal representations and shows that there are discrete and abstract conceptual categories in the domain of events.

Introduction

An important question in cognitive science concerns how word meanings (or lexical concepts) are internally represented. Although considerable progress has been made in the domain of nominal concepts since Rosch's studies, the nature and organization of verb concepts is less well understood. Early studies on verb meanings investigated whether verbs had internal semantic structure, as proposed in linguistic theories, but failed to find evidence supporting such a view (e.g., Fodor, Garrett, Walker, & Parkes 1980, Kintsch, 1974, Rayner & Duffy, 1986). For example, Rayner and Duffy (1986) measured the eye-fixation time on verbs during reading that were assumed to differ in internal complexity. They found no reading time differences corresponding to the semantic complexity of the verbs. This sort of finding, together with Fodor and colleagues' theoretical arguments (Fodor, 1975, Fodor, Fodor, & Garrett, 1975, Fodor & Lepore, 1998), was taken to support the view that verb meanings are atomic and lack internal structure. However, recent psycholinguistic studies challenge this view. Several sentence processing experiments have shown that lexical semantic properties such as selectional restrictions and verb-specific thematic roles (agent vs. patient) are quickly accessed by the processor when parsing syntactic ambiguities (e.g., Trueswell, Tanenhaus & Kello, 1993, Trueswell, Tanenhaus & Garnsey, 1994). More relevant to verb concepts per se, McRae, Ferretti & Amyote (1997) have shown that thematic roles have internal conceptual structure (as object categories do) and that their feature structure is quickly accessed by the parser when resolving syntactic ambiguities. Moreover, Ferretti, McRae & Hatherell (2001) have shown that verbs prime their typical agents, patients and instruments (e.g., *praying* primes *nun*). They argue that verbs activate event schemas or generalized situation based knowledge that facilitate accessing the meaning of their typical participants. Finally, McKoon & Macfarland (2000) have found processing correlates of two types of verb meanings, those that are conceptualized as either externally caused events (e.g., *break*) or internally caused ones (e.g., *grow*). These verb types are assumed to differ in internal lexical complexity, particularly in their causal components (see also Gentner 1981). Taken together, these findings suggest that there is some internal structure in verb meanings: thematic structure and event types.

The work presented here further investigates verb concepts, i.e., how verbs, which refer to events, are processed and internally represented. In particular, we ask whether there are verb-general concepts and structures beyond and above the idiosyncratic meanings of individual verbs. We follow numerous linguistic and philosophical studies (as in McKoon & Macfarland, 2000) in assuming common structural and causal properties across classes of verbs that define superordinate concepts. Thus, beyond the existence of typical agent-verb-relations (that between *nuns* and *praying*), there may be more abstract structural or conceptual properties that organize our knowledge of events stored in the lexicon.

The classification of verbs and their semantic properties has been the topic of numerous philosophical and linguistic studies (Vendler, 1967). Following traditional Aristotelian classes, these studies have argued that there is a typology of events underlying verb uses. Verb types appear to be universal (Smith, 1991) and are supposed to reflect the way speakers conceptualize the domain of events, i.e., the semantic/conceptual properties they assign to a particular actual occurrence. One general distinction typically made between verb meanings is, among others, that between states and events (Vendler 1967, Dowty, 1979, Taylor 1977, Bach, 1986, Verkuyl, 1993, Jackendoff, 1990, Rappaport-Hovav & Levin 1998). The distinction seems cognitively basic because it is grounded in causal properties: eventive verbs typically denote a cause and a change from an initial state to a resulting one (e.g. *write*, *destroy*), while stative verbs simply denote properties or stable relations between participants (e.g. *love*, *belong, contain*) (Dowty, 1979, Parsons 1990). The

distinction presupposes that verb lexical meanings have internal conceptual structures that differ in complexity: event lexical concepts have internal sub-components derived from their causal properties (e.g., the cause and the resulting state), while states lack any such components.

In this paper, we investigate how verbs denoting states and events are processed and represented. In particular, we ask whether eventive and stative verbs, which drastically differ in their semantic-conceptual complexity, are processed in ways consistent with their complexity. Two psycholinguistic experiments show that speakers' processing of verb meanings varies according to lexical semantic complexity, thus supporting the view that eventive and stative verbs are represented differently.

The Distinction between Verb Classes

Eventive and stative verbs are distinguished by semantic and syntactic properties. Syntactically, they differ in their ability to co-occur with certain adverbs and in certain constructions. These distributional restrictions are taken as tests that identify membership in one verb class or another. For example, stative verbs such as *deserve* are distinguished by their ability to occur with simple present in English but not present progressive, as in (1) and (2). Similarly, stative verbs cannot occur in nominalized constructions such as that in (3), cannot appear as complements of verbs like *force* as in (4), and cannot be modified by adverbial phrases as in (5). In contrast, eventive verbs such as *build* have the opposite distributions (for more tests, see Dowty 1979):

(1) Bill *is deserving** / *is building* something.
(2) Bill *deserves* / *builds** something.
(3) What Bill did was to *deserve** / *build* something.
(4) Bill forced Mary to *deserve** / *build* something.
(5) Bill *deserved** / *built* something in an hour.

The intuition behind (1)-(4) is that the participants of a stative eventuality are not causal or volitional agents. Rather, they are *experiencers*. The two classes thus involve different relations between their participants. The intuition behind (5) is that states persist in time while events have ending points or culminations. Examples of each verb type are given in Table 1.

Table 1: Verb examples

Events	States
enter	live
accuse	love
create	contain
give	know
build	despise
buy	constitute
betray	cherish

Semantically, the classes are distinguished by logical entailments. When each verb type occurs in sentences, they allow or disallow distinctive inference patterns. The entailments refer to causal and temporal properties of the construed eventuality as a whole. Stative sentences imply facts, i.e., they entail that they hold true for an indefinite period of time. In contrast, eventive verbs have the change-of-state entailment: they either entail a single change of state, as in (6) and (7) below (in Vendler's classification, achievement and accomplishment verbs), or sequence of changes as in (8) (activity verbs). These changes are caused by either an agent's single act or a series of actions that may be sustained for a while. But in contrast to states (which can persist on their own) events stop when their cause does so that they do not hold for indefinite periods.

(6) x killed y $\rightarrow$ x caused y to become dead
(7) x built y $\rightarrow$ x caused y to become existent
(8) x hammered y $\rightarrow$ x caused y to become hammered

The temporal entailments distinguishing each class are the counterpart of their causal properties. Because states have no internal (causal) structure, they are true at a given interval as well as at any subpart of this interval. More precisely, if a state is true at any interval i, it follows that it is true at all instants within i, as in (9).

(9) If Bill had a bike last week, he had a bike throughout the week.

This entailment is called temporal homogeneity. In contrast, events lack this property (Dowty 1979): if a change of state is true at any interval i, it follows that it is false at the initial part of i, (the initial state) and it is true at the final part of i (the final state) as in (10):

(10) If Bill wrote a letter in an hour, the letter was not written before the hour and was written right after it.

The entailment captures the fact that single-change events typically have sub-parts (the initial and resulting state) so that the event as a whole cannot be true until it is completed. This also holds for activity events at the level of each component change. It follows that events are not temporally homogeneous because their truth at a given interval does not hold at any sub-instant.

It is clear that whether one focuses on their temporal or causal properties, states are fundamentally different from events. While states lack internal causal structure and are temporally homogeneous, events have complex causal structures and are not temporally homogeneous.

The contrast between these verb classes has led linguists to propose conceptual lexical representations that capture their semantic properties and the relations between their participants. The representations are expressed via logical operators (Dowty 1979) or primitive

predicates (Rappart Hovav & Levin 1998, Jackendoff, 1990) such as CAUSE and BECOME, together with verb-specific lexical predicates that hold true of their arguments. Consider the representations of the following verbs:

write = x CAUSE(BECOME(*y be-written*))
break = x CAUSE(BECOME (*y be-broken*))
possess = x possess y
deserve = x deserve y

Because verbs of the same type have structurally similar representations, the distinction between events and states can be expressed in verb-general conceptual structures:

Events x CAUSE(BECOME(*y state*))
States x state y = state(x, y)

Eventive representations typically involve changes and causes, while stative representations simply involve a stative predicate that holds true of participants. In fact, stative predicates are component part of events, because changes include resultative states. This renders eventive verbs as semantically more complex than stative verbs.

Experimental Evidence

If the mental representations of verbs in fact differ due to their causal and temporal properties, this suggests that each verb type may involve differential processing cost depending on internal complexity. Representing the meaning of an eventive verb entails representing different alternative states of affairs such as the initial state and final state resulting from the agent's intervention. In contrast, representing the meaning of a stative verb implies representing a single state of affairs. If processing a verb implies accessing and processing its lexical meaning, more complex meanings should yield longer processing time. To test this empirical prediction, we conducted two psycholinguistic experiments. The first experiment was a visual lexical decision task. This task has been shown to be sensitive to top-down influences of meaning (see Balota, 1994, Balota, Ferraro & Connor, 1991) and several semantic effects such as abstract vs. concrete aspects of meaning have been reported (Blesdale, 1987, Eviatar, Menn & Zaidel, 1990, Paivio, 1991). The second experiment was a self-paced reading study, in which the reading time of verbs (occurring in sentences) was measured. Previous literature has shown that lexical complexity factors such as number of senses (Rayner & Duffy 1986) and type of verbs (McKoon & Macfarland 2000) have an effect on reading times.

Experiment 1: Visual Lexical Decision Task

In this experiment, we ask whether stative verbs are recognized faster than eventive verbs, given the hypothesized semantic complexity differences.

Materials 31 and 32 words were selected for each verb type (states and event) according to the semantic and syntactic criteria discussed in Dowty, 1979. The items were matched for word length, frequency (Associate Press Corpus, mean frequency for events = 2.40, and for states = 2.45), number of sense (WordNet database: events: 2.79; states: 2.59), number of orthographic neighbors (events: 2.23, states: 1.85) and argument structure. Verbs were transitive verbs (taking obligatory NP or PP complements), except for 6 intransitive verbs in each class, and were not ambiguous between noun and verb uses. Non-words (= 62) were possible words similar to real words. This favors deeper processing of words, because written form is not sufficient discriminator to perform the task (see Seidenberg, Petersen, MacDonald & Plaut, 1996).

In a pre-test study, imageability ratings (how easy is it to imagine/visualize the meaning of a word) were collected from another set of subjects to control for the possibility of this effect. We subsequently used the items' imageability ratings as a covariate in our analysis. The rationale for incorporating this factor derives from the observation that higher imageability ratings are associated with faster reaction times (James, 1975, Paivio, 1991, Strain, Patterson & Seidenberg, 1995). We used the instructions provided in Chiarello, Shears, & Lund's (1999) norming. Comparisons of these ratings across categories revealed that the categories differed, with eventive verbs being more imagaeble (mean for events = 4.21 in a scale from 1 to 7, mean for states = 3.25, p= .001).

Examples of test words are the following:

Events: betray, borrow, conquer, create, deduce, align, attract, devour.
States: adore, aspire, believe, belong, cherish, comprise, contain, deserve, detest.

Participants and Procedure 52 right-handed native speakers of English participated in this study, all students at the University of Maryland. For each word presented in the screen, participants decided whether it was a word of English. The experiment was carried out in G3 Macintosh computer running Psyscope. Words were presented at varying inter-trial time (500-1500 ms) on the center of the screen. Before each stimulus word or non-word, a fixation point was presented for 500 ms. The reaction time (RT) to each stimulus was automatically collected.

Results Analysis of covariance across items with RTs as dependent variable and imageability ratings as covariate revealed a significant main effect of imageability (F(1,60)= 7.19, p= .009), a main effect of word type (F(1, 60)= 7.95, p= .006) and no interaction. The overall word effect is represented in Figure 1, with bars representing standard error. Mean difference was small but reliable, (about 20 ms), because not all state/event pairs show big

differences. We also conducted an analysis across subjects with similar result (F(51,1)= 40.21, p = .0001).
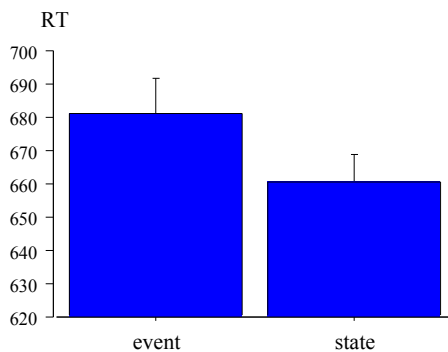
RT

Figure 1: RTs as a function of word type

We interpret these findings as indicating that both imageability and meaning complexity have an effect on RTs. The lack of an interaction between the two main effects indicates that the word type effect does not depend on imageability. Overall these results support the prediction that stative verbs are recognized faster than eventive verbs, consistent with an effect of representational complexity.

Experiment 2: Self-paced Reading study

In this experiment, we asked whether stative verbs are processed faster than eventive verbs when integrated into previous information in the process of sentence comprehension. For this, we measured the reading time to verbs of the sentence stimuli.

Materials 84 sentences containing 42 stative and 42 eventive verbs (plus fillers) were selected. Test verbs and sentences were carefully matched for a number of variables known to affect reading times in context. First, the verbs were pair-wise matched for frequency and word length. Mean log-frequency for both states and events was 3.96 and the mean word length was 6.11 characters for events and 5.82 for states (Collins Cobuild corpus). Comparisons of these variables were not significant.

Second, we pair-wise matched the verbs used in the sentences by their number of syntactic arguments and preferred (most frequent) syntactic frames. This is because Shapiro, Nagel & Levine (1993), Shapiro, Zuriff, & Grimshaw (1987), Rayner and Duffy (1986), McElree (1993) and others have shown that argument structure complexity as well as preferred argument structure can have behavioral consequences in reading times. We used Schulte im Walde's (1999) electronic corpus based on syntactic analysis of the Bank of English to compute number of syntactic arguments and the frequency of syntactic frames. Each selected verb pair had roughly the same number of syntactic frames in which they can occur and for the most frequent frame, the same number of arguments. For example, *love* was matched with *build*, which have similar log frequencies. Proportions of corpus occurrences in different syntactic frames is the following:

love		*build*	
subj:obj	0.67	subj:obj	0.76
subj:to-inf	0.10	subj:obj:obj	0.05
subj:v-ing	0.03	subj:obj:for	0.04

Both verbs occur very frequently in transitive uses, and both verbs have 3 possible argument structures. For verbs like *believe* (equi-biased verbs), which have two equally frequent argument structure (NP, sentence complement), the two most frequent frames were matched for number of arguments. So, *believe* was matched with *report*, which have roughly the same frequent syntactic frames.

Third, test sentences were exactly alike up to the point of the verb, and in some cases, the sentences were completely alike except for the verb. This eliminates the possibility that factors associated with preceding words affect the reading time of the verbs. Examples of matched verb and sentence stimuli are the following:

(11)   The young boy bullied his parents. (event)
       The young boy adored his parents. (state)
(12)   The retired musician built a house. (event)
       The retired musician loved his daughter. (state)

Finally, we control for the plausibility relation between the subject NP and the verb. Because certain types of subjects may be more likely to appear with one or the other verb type, we obtained individuals' judgments rating the typicality of the subject-verb relation. We asked 50 students to rate how typical it was for a given subject NP to perform the corresponding action denoted by the verb (Trueswell, et al. 1994). The ratings were compared across word types and did not differ significantly (t<1). The mean rating for events and states were 5.51 and 5.60 respectively in a scale of 1 to 7.

Procedure 30 students at University of Maryland read sentences on the computer screen. After each sentence, participants answered a comprehension question. The words of the sentences were presented one-by-one and the participants pressed a key on the keyboard to see each word. Reading time for each word was recorded, though our interest was in the reading time of verbs.

Results comparison of reading times at the verb position revealed a word type effect both across subjects (F(1, 29)=10.66, p=.003) and items (F(1,43)=8.9 p=.004). Eventive verbs took longer to process than state verb (about 25 ms. difference). Figure 2 represents the mean reading times (and standard errors) for the nouns preceding the verb, the verb position and the next word.

The results are thus similar to those of the lexical decision task and strongly support our hypothesis of a semantic complexity difference between verb meanings. Semantic complexity in this experiment is clearly independent of syntactic behavior and argument structure complexity.
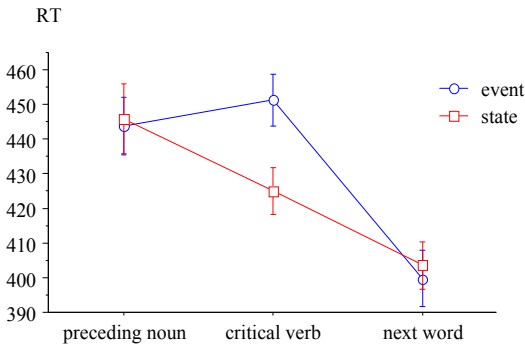

Figure 2: Reading times as function of word type and position

Discussion

The results of these experiments show that eventive verbs take longer to process than stative ones, thus supporting the view that the mental representations associated with them differ in semantic complexity. Computing the verbs' meanings involves differential processing cost, as suggested by the hypothesized complexity of conceptual representations. The distinction between these verb classes is rather abstract and is based on whether the verbs involve a change of states. To our knowledge, this is the first time that these verb classes are shown to have empirical correlates.

Note that the results cannot be attributed to syntactic differences among verbs (frames or number of arguments), as this factor was kept constant. Nor can they be explained as a consequence of expectations generated by the type of arguments with which verbs occur, a factor that has been often manipulated in studies of syntactic ambiguity resolution. In our sentence comprehension experiment, the same subject-arguments were used for both eventive and stative verbs and the plausibility relations between subject-argument and verb were equalized. Also, no such factor was present in the lexical decision task. Thus, the alternative interpretation of the results in which there is a processing difference but not a representational one does not seem plausible, as there is no apparent reason to expect a purely processing difference. We are inclined to conclude, then, that difference in processing cost are due to representational complexity differences between states and events and that such differences may rely on the causal vs. non-causal relations they establish between their participants.

However, the results are neutral as to whether representations such as *x CAUSE(BECOME(y state))* are

accurate expressions of the internal representation of the verb meaning. These results only suggest that the representation of eventive verbs is more complex than that of stative ones, regardless of how the complexity is spelled out. Yet if the internal mental representation of verbs includes the type of relations that they establish between participants, it is possible that the complexity difference is due to causal features. In one case, the eventualities denoted involve changes and cause-effect relations (and therefore, agentive participants), while in the other case, they involve mere descriptions of facts. These are important cognitive differences that may somehow be abstracted over verb-specific meaning.

Our results have some important implications for theories of word meanings. As McKoon & Macfarland's (2000) findings, our results challenge the view that verb meanings are atomic and unstructured. On such a view, there is no principled reason to expect these differences in processing unless the lexical entry is allowed to have some sort of internal structure. In this respect, the failure of previous attempts to find lexical complexity effects could be due to the fact that indirect measures of complexity were used (e.g., Fodor et. al 1980) or very small (perhaps undetectable) differences between verb classes were investigated (e.g., Rayner & Duffy, 1986).

Our results also suggest that part of the information encoded in the verb is semantic/conceptual, and somewhat independent from number of participants and syntactic frames. Several psycholinguistic studies have shown that these syntactic variables do influence behavioral measures (e.g., Shapiro et al. 1993). Similarly, Fodor & Lepore (1998) claim that syntactic combinatorial rules can be part of lexical entries, thus increasing their complexity. Our results indicate however, that such syntactic information is not the only relevant factor for complexity effects. Purely semantic properties can also yield processing time differences.

Finally, our results have implication about the exact source of the semantic complexity effects and the overall organization of verb concepts in the lexicon. McRae et al. (1997) and Ferretti et al. (2001) have suggested that events in memory are organized in event schemas and that such schemas arise from the knowledge of their typical agents and patients acquired during learning, i.e., thematic feature knowledge. Thus, it is in principle possible that the verb classes studied here can be distinguished by such thematic features (e.g. features defining agent/patient vs. experiencer/entity structures). However, it is unclear how these features would explain the complexity effects. More importantly, it is unclear whether such features can in fact be distinguished from other aspects of the verb meaning such as the relation between participants established by the verb. Both types of information are inherently related. Our results suggest a level of abstraction or generalization of verb schemas that goes beyond verb-specific knowledge of typical participants and typical situations. Rather, as is the case for nominal concepts, verb concepts

seem to be organized in major event types, in this case distinguished by general causal properties. These types provide the domain of events with a hierarchical organizational structure from verb-specific concepts to abstract verb-general concepts.

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