

NSF CAREER BCS-0094263: SCALAR REPRESENTATIONS IN NATURAL  
LANGUAGE SEMANTICS

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PROJECT SUMMARY

The ability to establish orderings among objects and make comparisons between them according to the amount or degree to which they possess some gradable property (such as height, brightness, beauty, etc.) is a basic component of human cognition. Natural languages reflect this fact: all languages have syntactic categories that express gradable concepts, and all languages have constructions that are used to make comparisons between objects. “Gradable” adjectives like *tall*, *bright*, *beautiful*, and so forth are canonical examples of such expressions, and have formed the central empirical domain for studies of grading in natural language.

A central conclusion of this body of work is that the semantics of grading must make reference to abstract representations of measurement, or “scales”. A question that has not been seriously addressed, however, is whether scalar representations underlie the semantic properties of categories other than gradable adjectives. This question is important because gradability is not just a property of adjectives, but of nouns, verbs, and prepositions as well. This point is made quite clearly in several important early studies of grading (in particular Sapir 1944 and Bolinger 1972), but it has not been investigated in depth or detail by contemporary work in semantics. Although some analyses of non-adjectival categories have incorporated elements of grading and scalar representations (in particular, work on verbal aspect and directional prepositions), there have been no systematic investigations of the deeper role of scalar representations in natural language.

The purpose of this study is to conduct just such an investigation, through a comprehensive examination of the role of scalar representations across categories. The primary focus will be on scalar representations in adjectives and verbs, both because the core semantic properties of these categories are best understood individually, and because preliminary research points towards a regular relation between scale structure in adjectives and event structure in verbs. The project will begin with a close examination of the role of scalar representations within each category, and will then investigate the relations between the two, focusing on derivational relations between verbs and adjectives. The study will conclude with a preliminary examination of the role of scalar representations in the prepositional and nominal domains.

The educational component of this project will involve course development, graduate and undergraduate mentorship, and direct access to research. The empirical domain of the project will support the development of an integrated three-quarter sequence in lexical se-

antics, formal semantics, and pragmatics. In addition, the topic of scalar representations in language provides a foundation for an exploration of linguistic, cognitive, and philosophical questions about meaning in a one-quarter seminar targeted specifically at freshmen and designed to emphasize discussion, intellectual challenge, and the development of critical thinking skills. The project will also support one graduate research assistant per year and two undergraduate researchers per summer, providing an opportunity for supervised independent research in an empirical domain that allows for a range of variation in research focus. Finally, the project will introduce students and colleagues directly to research in the field by bringing in two researchers each year to give guest lectures in class and present colloquia, and through a workshop on the role of scalar representations in natural language to be held at the end of the five year period.

## 1. OVERVIEW OF RESEARCH ACTIVITIES

The purpose of this study is to develop a comprehensive analysis of the role of scalar representations in natural language semantics through a systematic and detailed examination of the semantic effects of scale structure within lexical categories and the relations between scalar representations across categories. Scalar representations are independently justified, as they provide the basis for an account of a central component of human cognition: the ability to make measurements of degree, establish orderings among objects, and make comparisons between them based on the amount to which they possess some gradable property (see Bierwisch 1989 for relevant discussion). This project is therefore important because it will develop a framework for explaining scalar properties that hold across categories in terms of a general, formal, and cognitively grounded system of scalar representations.

That grading relations play a fundamental role in natural language semantics has been known for some time. In their early studies of grading and expressions of degree, both Sapir (1944) and Bolinger (1972) make the point that gradability is a property of members of every syntactic category. While “gradable” adjectives like *tall*, *bright* and *beautiful* are canonical examples of expressions that involve grading, it is also the case that the other grammatical categories — nouns, verbs, adverbs, as well as functional elements like prepositions and determiners — all contain words whose meanings establish orderings on objects based on the amount or degree to which some property holds.

Consider, for example, the adjective *sturdy*, the verb *build*, the nouns *wood* and *house*, and the preposition *from*. The adjective most clearly involves grading, as objects can be sturdy to different degrees, and so can be ordered accordingly. Similar remarks hold of the verb *build*, which describes a kind of “process of creation”, and therefore supports an ordering of objects according to how far along a scale of completion they are. Mass nouns like *wood* naturally set up scales of quantity, which can be quantified by amount phrases like *two cords (of)*. The scalar component associated with the meaning of a count noun like *house* is somewhat more complicated. Like the mass noun, it sets up a scale of quantity (*half a house*, *three houses*), but it also introduces a scale that measures the various properties associated with the concept ‘house’. As Sapir (1944, p. 94) observes, “Any two houses selected at random offer the contrast of ‘more’ or ‘less’ on hundreds of features which are constitutive of the concept ‘house’”. Thus house A is higher but house

B is roomier, while existent C is so much smaller than either A or B that it is ‘less of a house’ than they....” Finally, a preposition like *from* sets up a scale of (temporal, spatial, etc.) distance, ordering objects according to how far they are in a direction moving away from some reference point.

A question that follows naturally from these observations, but has yet to be investigated in a systematic and detailed manner, is whether all linguistic expressions that involve grading share core aspects of their lexical semantic representations, namely those that are responsible for encoding gradability. Although there has been a great deal of progress in analyses of gradability in specific domains — in particular the semantics of adjectives, but also the aspectual properties of verbs, the meaning of directional prepositions, and structural properties of noun denotations (e.g., the mass/count distinction) — there has not been a serious effort to develop a general theory of scalar representations in natural language, despite evidence pointing in this direction (which will be discussed below). The goal of this project is to investigate this issue, and to create a foundation of research and results that will support the long-term investigation of the role of scalar representations in natural language. The specific plan for the five year duration of the grant is to focus on scalar representations in two lexical categories: adjectives and verbs. There are two reasons for taking this approach.

First, adjectives and verbs are the two categories for which scalar analyses are at present best developed, although in both cases the full extent of the linguistic significance of scale structure remains to be determined. That scalar representations play a central role in the semantics of adjectives is well established; what remains to be fully determined is the linguistic significance of the *structure* of scalar representations. With respect to verbs, semantic analyses are typically not stated in terms of scale structure per se, but rather in terms of the structure of the event which the verb describes (its “aspectual structure”). Events can be assigned scalar representations, however, since they progress over time and can be so measured. Moreover, research on verbal aspect has clearly shown that structural properties of the temporal measure of an event have linguistic significance, affecting verbal behavior in a broad range of grammatical contexts.

The second reason for focusing on adjectives and verbs in this project is that initial results from two lines of research that I have been developing over the past two years point to a regular mapping between scale structure in adjectives and event structure in verbs. Specifically, in instances of word derivation between these two categories the scalar structure of the adjectival form is completely parallel to the event structure of the verbal form. A central aim of the project will be to fully explore and characterize the relation between event structure and scale structure, the linguistic significance of this relation, and its implications for a broader theory of scalar representations in language.

Although the project will focus on scalar representations in adjectives and verbs, the long-term goal of the project is to establish a theoretical and methodological foundation for the investigation of scale structure in other categories, in particular prepositions and nominals (through an examination of, for example, the semantics of directional prepositions and the count/mass distinction). Some resources over the next five years will therefore be devoted to preliminary work on these other categories, once a secure theoretical base has been established in the area of adjectives and verbs.

The remainder of this section provides a detailed description of the research component

of the proposal, and situates it in the context of related research.

**Scalar representations and adjective meaning** There is a long tradition in linguistics, as well as psychology, anthropology and philosophy, of assuming that when people predicate a gradable property of an object or make comparisons, they establish relations between abstract representations of measurement rather than relations between objects directly. Such abstract representations, or “scales”, are typically formalized as sets of “degrees” which are totally ordered along some dimension (*height, brightness, beauty, etc.*).<sup>1</sup> Degrees represent measures of the extent to which an object possesses a gradable property, and the semantic function of a gradable adjective such as *tall* or *short* is to map the objects in its domain to degrees on the appropriate scale (see e.g., Bartsch and Vennemann 1973; Cresswell 1977; Hellan 1981; von Stechow 1984a; Klein 1991; Kennedy 1999b). The truth conditions of sentences containing gradable adjectives are characterized in terms of relations between degrees, as illustrated by (1)-(3), where the (b) examples paraphrase the interpretations assigned to the (a) sentences.

- (1) a. Carmen is taller than Mike.  
       b. The degree of Carmen’s height exceeds the degree of Mike’s height.
- (2) a. Carmen is tall.  
       b. The degree of Carmen’s height is at least as great as some (contextually determined) “standard” degree of height.
- (3) a. Carmen is 6 feet tall.  
       b. The degree of Carmen’s height is at least as great as the degree denoted by ‘6 feet’.

This approach to gradable adjective meaning has provided the formal basis for comprehensive and explanatory accounts of antonymy, the logical properties of comparative constructions, the semantics of measure phrases, and the distribution and interpretation of degree modifiers (Seuren 1978; von Stechow 1984a,b; Heim 1985, to appear; Kennedy and McNally 1999b; Kennedy to appear), and has been shown to be empirically superior to analyses of gradability that do not make reference to scalar representations (Kennedy 1999a,b). Once we introduce scalar representations into the semantics, however, we also raise a question: do these representations have linguistic significance, or are they just convenient formal tools for characterizing the meanings of grading expressions? If scalar representations are part of the semantic component of natural language, and not just notational devices, then we should expect them to have linguistic significance, just as, for example, properties of lexical representations affect aspects of argument expression.

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<sup>1</sup>The dimensional parameter differentiates one scale from another, and plays a role in explaining the anomaly of cross-scalar comparisons such as (i), which are sometimes referred to as instances of “incommensurability” (see Klein 1991; Kennedy 1999b).

(i) ? Alice is taller than she is clever.

Given the fact that scales have well-defined structural (set-theoretic) properties, the most natural way to determine the linguistic significance of scales is to ask whether differences in scale structure have empirical consequences. This question can be broken down into two subquestions. The first is concerned with the structure of degrees; the second with the structure of scales more generally. In Kennedy (to appear), I provide extensive empirical arguments that the structure of degrees is linguistically significant, showing that it explains the distribution and interpretation of antonymous adjectives in comparatives and provides the foundation for a comprehensive theory of antonymy. While this work does not address questions about the linguistic significance of scale structure more generally, the fact that degree structure underlies such a basic aspect of adjective meaning as antonymy strongly suggests that other structural properties of scalar representations will influence the grammatical behavior of expressions of grading.

One obvious structural property of scales, given their formal characterization as sets of points under a total ordering, is the “open” vs. “closed” distinction: if a scale has minimal and maximal elements, it is closed; if not, it is open. Evidence that this distinction is linguistically significant comes from the distribution of “proportional modifiers” like *completely*, *partially*, and *half*, which are acceptable with some gradable adjectives and unacceptable with others:

- (4) a. completely empty/full/open/closed
- b. partially empty/full/open/closed
- c. half empty/full/open/closed
- (5) a. ?? completely long/short/interesting/inexpensive
- b. ?? partially long/short/interesting/inexpensive
- c. ?? half long/short/interesting/inexpensive

Intuitively, the difference between the adjectives in (4) and those in (5) is that the former describe gradable properties that can have maximal and minimal values, but the latter do not: while it is possible for a container to be maximally or minimally full (or minimally or maximally empty), it is not possible for an object to be minimally or maximally long (or short). This can be explained in scalar terms: the adjectives in (4) map objects onto closed scales, while the adjectives in (5) map objects onto open scales. Assuming that proportional modifiers like *completely* and *half* denote functions on closed scales only — a natural assumption, given their meanings — the contrasts in (4)–(5) follow (see Lehrer 1985; Hay 1998).

In recent collaborative work with Louise McNally (Universitat Pompeu Fabra, Barcelona), I have identified further evidence that the open/closed scale distinction is linguistically significant. In particular, in Kennedy and McNally (1999a,b, to appear), we show that this distinction has consequences for a central semantic property of gradable adjectives: the nature of the “standard” with respect to which sentences involving adjectival predications are judged to be true. The role of the standard is illustrated by the informal interpretation assigned to (2a) above, in which a simple predication involving a gradable adjective is analyzed relationally.  $x$  is  $\alpha$  is true just in case the degree to which  $x$  is  $\alpha$  is at least as great

as a standard for  $\alpha$ . The value of the standard is determined with respect to a “comparison class” for  $x$ : a set of things that are similar to  $x$  in some relevant way (see McConnell-Ginet 1973; Kamp 1975; Klein 1980; Bierwisch 1989; Ludlow 1989; Kennedy 1999b).

The reason for introducing of context-dependent standard values relates directly to the problem of vagueness in gradable adjectives, which is illustrated by the sentences in (6).

- (6) a. The Mars Pathfinder mission was expensive.  
 b. The coffee at the airport is expensive.  
 c. The tea at the airport is expensive.

Assume that the airport coffee is more expensive than the airport tea. If a speaker judges (6c) to be true, then he is also committed to the truth of (6b). However, even though the cost of the Mars Pathfinder mission far exceeds the cost of airport coffee (or tea), the same speaker may judge (6b) true and (6a) false without contradiction. The crucial difference between (6a) on the one hand, and (6b)/(6c) on the other, is that the standard for the adjective *expensive* differs in the two cases. In (6a), the standard is based on a comparison class for the Mars Pathfinder; in (6b) and (6c) the standard is based on comparison classes for coffee and tea respectively, which are presumably the same. Once this information is taken into account, the interpretations assigned to (6a)–(6c) are as shown in (7).

- (7) a. The degree to which the Mars Pathfinder mission was expensive is at least as great as a standard of expensiveness for missions to outer space.  
 b. The degree to which the coffee at the airport is expensive is at least as great as a standard of expensiveness for beverages.  
 c. The degree to which the tea at the airport is expensive is at least as great as a standard of expensiveness for beverages.

Clearly, (7a) could be false and (7b) (and (7c)) true even if the actual cost of the Mars Pathfinder mission is far greater than the actual cost of coffee at the airport.

Not all gradable adjectives have context sensitive standards or require reference to comparison classes, however. In particular, adjectives with closed scales appear to have *fixed* standards. Consider, for example, *empty* and *open*. Intuitively, whether a cup “counts as” empty does not depend on aspects of context or knowledge about cups; it depends only on whether or not the cup is completely devoid of contents. Likewise, we may truthfully say that a door is open just in case the door has some positive degree of openness, i.e., just in case it is not closed. The standards for these two adjectives are thus not arbitrary points on the scale fixed by reference to a comparison class, but are rather maximal (for *empty* — maximal emptiness equals minimal fullness) and minimal (for *open*) values. In other words, the standards for closed scale adjectives are *endpoints* of the respective scales.

This property of closed scale adjectives has important linguistic consequences. In particular, it affects the entailments of the sentences in which such adjectives appear. Since the truth conditions of an adjectival predication of the form  $x$  is  $\alpha$  are stated in terms of a partial ordering relation, the truth conditions for the corresponding negation involve a total ordering in the opposite direction:  $x$  is *not*  $\alpha$  is true just in case the degree to which  $x$  is

$\alpha$  is less than the standard. It follows that for an adjective  $\alpha$  with a fixed endpoint standard, if this standard corresponds to the lower end of the scale, a statement of the form  $x$  is not  $\alpha$  should entail that  $x$  has no amount of “ $\alpha$ -ness” at all.<sup>2</sup> If  $\alpha$ ’s standard corresponds to the upper end of the scale, however, then  $x$  is  $\alpha$  should entail that  $x$  has a maximal amount of “ $\alpha$ -ness”. Neither of these entailments should hold for gradable adjectives with non-endpoint standards, since the truth or falsity of  $x$  is  $\alpha$  tells us nothing about the actual degree to which  $x$  is  $\alpha$ .

The examples in (8) bear out these predictions. The closed scale adjectives *empty* (upper endpoint standard) and *open* (lower endpoint standard) trigger contradictions when inserted in sentences that violate the relevant entailments, but the open scale adjectives *expensive* and *tall* do not.

- (8) a. ? The cup is empty, but it could be emptier.  
 b. ? The door is not open, but it is more open than it was a few minutes ago.
- (9) a. The coffee at the airport is expensive, but it could be more expensive.  
 b. Benny is not tall, but he is taller than he was a year ago.

The fact that closed scale adjectives have endpoint oriented standards also affects their grammatical behavior. Since the standards for these adjectives are fixed, it is not necessary to make reference to a comparison class as part of the interpretation procedure. This affects the licensing properties of the adjective, as shown by the contrasts between the sentences in (10) and (11).

- (10) a. The coffee at the airport is expensive for coffee.  
 b. Benny is tall for a five-year-old.
- (11) a. ? That cup is empty for a cup.  
 b. ? That door is open for a screen door.

The *for*-phrase in (10) explicitly indicates the comparison class for the adjectives *expensive* and *tall*. As shown by (11), such phrases are unacceptable with closed scale adjectives like *empty* and *open*. Since the standards for these adjectives are already fixed, the *for*-phrases in these sentences serve no semantic function, and so are anomalous.

The conclusion of this initial research is that adjectives that map their arguments onto closed scales have fixed endpoint standards, and adjectives that map their arguments onto open scales have varying, context sensitive standards.<sup>3</sup> This connection between scale

<sup>2</sup>In a model in which degrees are formalized as intervals (contiguous sets of points) on a scale, as discussed above (see Seuren 1978; von Stechow 1984b; Kennedy to appear), “ $x$  has no amount of  $\alpha$ ” means that  $\alpha$  maps  $x$  onto an empty interval (see Kennedy and McNally 1999b).

<sup>3</sup>Some closed scale adjectives have senses that involve open scales and context-sensitive standards; in such uses, they behave just like other open scale adjectives. For example, *open* has an open scale and a context sensitive standard when it describes a personality trait, as in (i), as shown by the fact that it does not accept modification by proportional modifiers, and does allow a *for*-phrase.

- (i) a. ? He’s half open to new ideas.  
 b. He’s very open to new ideas for someone with such a conservative upbringing.

structure and the standard value — a central aspect of gradable adjective meaning — has implications not just for semantics, but also for philosophy (in particular, studies of vagueness), first and second language acquisition (see McNally and Kennedy 1998) and natural language processing (see Kennedy and McNally 1999a).

Four items fill the agenda for the next phase of research in this area. First and foremost, the robustness of the correlation between closed scales and endpoint oriented, context insensitive standards needs to be firmly established. While preliminary research has not uncovered systematic exceptions, a large scale investigation making use of natural language corpora and other empirical tools must be undertaken. Second, the principles underlying the “orientation” of endpoint standards need to be identified: what determines whether the standard for a closed scale adjectives is a maximal value (as for *empty*) or a minimal value (as for *open*)? Third, other types of scale structure must be examined. The preceding discussion considered only totally open and totally closed scales, but there are two other logically possible structures: upper closed/lower open and upper open/lower closed. It must therefore be determined whether all four possibilities are manifested, and if they are all linguistically significant. Finally, in order to fully explain the relation between scale structure and standards, the principles underlying the relation must be determined. Closed scale adjectives are perfectly compatible with variable, context sensitive standards; the fact that they make use of fixed endpoint standards instead therefore suggests the influence of some deeper principles of linguistic/cognitive organization.<sup>4</sup>

**Scalar representations and verb meaning** Theories of verb meaning are typically not stated in terms of scale structure per se, but many make reference to the structure of the event that the verb describes — its “aspectual structure”. Two characteristics of this aspect of verb meaning suggest that properties of scalar representations play a role in verbal behavior, just as we saw for adjectives. First, event structure involves a kind of scalar representation, since events are structurally distinguished according to the way in which they map onto a temporal measure (Vendler 1957; Dowty 1979). Second, a wide variety of work on aspect and argument expression has shown that the aspectual properties of a large set of verbs (in particular, those that describe gradual changes of state) are not inherent to the verb, but are rather determined based on the structure of the event the verbal predicate describes (Verkuyl 1972, 1993; Declerck 1979; Krifka 1989, 1992; Dowty 1991; Tenny 1995; Jackendoff 1996; Ramchand 1997).

A classic example of this relation between event structure and aspect involves the effect of the mass/count distinction in direct objects on verbs of creation or destruction, such as *eat*, *write* and so forth. As shown by the examples in (12), a verb phrase headed by *eat* accepts modification by a temporal modifier headed by *in* when its direct object is a count noun, but not when its direct object is a mass noun (or bare plural).

- (12) a. Kim ate a sandwich for an hour/in an hour.  
 b. Kim ate rice for an hour/?in an hour.

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<sup>4</sup>One possible explanation for this correlation, which serves as an effective starting point for an investigation into this issue, is a functional one: speakers take advantage of the availability of endpoints to reduce the level of processing complexity associated with context-dependent uses of gradable adjectives.



Licensing of a temporal modifier headed by *in*-PP is a classic diagnostic of a basic aspectual property: telicity.<sup>5</sup> Roughly, telic predicates are those that describe events with natural culmination points, such as *build a house*, and atelic predicates are those that describe events that do not have inherent endpoints, such as *sleep*. The contrast in (12) demonstrates that a verb phrase headed by *eat* may have differing telicity depending on the nature of its direct object. If the object describes a bounded quantity of stuff, like a (quantified) count noun, an endpoint to the described event can be identified (in (12a), the point at which all of the sandwich is eaten). This gives rise to a telic interpretation. In contrast, if the object denotes a potentially unbounded quantity of stuff, as with mass nouns (or bare plurals), there is no way to identify an endpoint to the event, and the predicate is atelic.

Contrasts like those in (12) provide evidence that the structure of a described event may determine the aspectual properties of the verbal predicate that describes it; this is not surprising, given that aspect is a theory of the relation between verb meaning and event structure. The deeper questions that have driven research on this topic involve how and why a particular predicate describes the sort of event it does. In the case of contrasts like (12), for example, how exactly does the mass/count difference in the nominal arguments correlate with the endpoint/no endpoint difference in the described events (and by extension, the telic/atelic distinction in the verbal predicates)? While the details of these correlations are not yet completely understood, it is clear that structural properties analogous to the open/closed scale distinction discussed in the previous section — in particular, the bounded/unbounded distinction — play a fundamental role in verb meaning. A question that must be addressed, then, is whether scalar representations themselves are a basic component of verb meaning.

In recent collaborative work with Beth Levin (Stanford University), I have been exploring precisely this question. Our research focuses on verbs that show varying telicity in different contexts, like *eat*. A shared property of these verbs is that they describe events in which one participant (canonically the one introduced by the direct object) undergoes a gradual change of state, which can be characterized as a change in the degree to which it possesses some gradable property. This degree of change can be assigned a scalar representation which we hypothesize to be the crucial determinant of event structure and aspect. Specifically, if the degree to which the affected argument changes has a maximal value, the corresponding event has an endpoint, and the predicate is telic. In contrast, if the degree of change has no natural maximum, then an endpoint for the corresponding event cannot be determined, and the predicate is atelic.

Initial support for this hypothesis comes from the class of “degree achievements”, many of which are derived from adjectives by the *-en/∅* morpheme (examples include *lengthen*, *widen*, *shorten*, *open*, *close* and so forth). Degree achievements have long presented problems for theories of aspect, because many verbs in this class appear to have ambiguous telicity. This is illustrated by the two uses of *lengthen* in (13), which differ in the acceptability of an *in*-PP.

- (13) a. The tailor lengthened my pants in an hour.

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<sup>5</sup>The telicity of a predicate also affects (among other things) the inferences it supports and the adverbial modifiers it accepts (see Dowty 1979). Thus like scale structure in adjectives, this property has a number of clear linguistic consequences.

- b. ? The water dripping off the roof lengthened the icicle in an hour.

The crucial difference between (13a) and (13b) is that in the former, real world knowledge about tailors identifies a bound for the degree to which the affected argument (my pants) changes in length as a result of the event (whatever measure was agreed upon by me and the tailor). In contrast, no such bound can be identified in (13b), since icicles can in principle get longer and longer. (13a) is therefore assigned a telic interpretation, while (13b) is atelic.

Degree achievements provide the clearest illustration of the hypothesis that scalar representations of degree of change map onto event structures because the property with respect to which the argument affected by the action of the verb changes is “transparent”: it is the property associated with the source adjective. The next stage of research is to extend this scalar analysis to other predicates that describe gradual changes and show similar telicity properties, such as verbs of directed motion and verbs of creation and destruction. Like degree achievements, the argument affected by the action that these verbs describe undergoes a change in the degree to which it possesses some gradable property: the property of location along a graded path in verbs of directed motion and the property of (some generalized notion of) volume or extent in the case of verbs of creation and destruction. Clearly, if this analysis of telicity generalizes to these other verbs, as our initial research suggests (Hay, Kennedy, and Levin 1999), we will have a clear example of scalar representations in verb semantics.

This view of scalar representations in verb meaning, if correct, also suggests a new understanding of the notion “incremental theme”. This term is introduced by Dowty (1991) to name the argument of a verb whose properties determine the verb’s telicity through a homomorphic relation between the argument and the temporal progress of the event described by the verb (see Krifka 1989, 1992). For instance, in a predicate such as *mow the lawn*, *the lawn* is the incremental theme since the progress of the entire event can be determined by looking at the state of the lawn. The problem with this approach is that it does not easily generalize to the full class of verbs that describe gradual changes of state, since distinct types of homomorphisms appear to be necessary for each type. For example, with canonical verbs of change of state, the homomorphism is between a gradable property corresponding to the state associated with the verb; with verbs of motion, the homomorphism is defined by the path traversed by one of its arguments.

A scalar analysis of telicity supports a more unified analysis, however. Within this framework, the semantic object that best corresponds to Dowty’s incremental theme is in fact the scalar representation of the degree to which the affected argument changes along a path of motion, in spatial extent, or in some other scalar property. On this view, the homomorphism crucial to determining a verb’s telicity is a relation between the scalar representation of the degree of change and the temporal progress of the event. The “incremental theme” is thus construed as a measure of a property of an argument of a verb, not an actual argument (although it may be expressed by an argument-like expression, as in the case of extent objects of some verbs of motion, such as *swim the Channel*).<sup>6</sup> If this is correct, then it provides still more support for the conclusion that scalar representations

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<sup>6</sup>In fact, Dowty (1991, p. 659) recognizes that with verbs of motion the term “incremental theme” is most appropriately applied to the path of motion, even if it is often left unexpressed, rather than to the argument corresponding to the moving object or themes.

play a fundamental role in verbal semantics. A central goal of the current project will be to provide a fully explicit, formal characterization of the relation between scale structure and telicity.

**Scale structure and the adjective/verb interface** Once it is established that scale structure plays a role in both adjective and verb meaning, the next research question is whether there is a relation between the scalar representations used by the two categories. Hay et al. (1999) show that the aspectual properties of degree achievements provide one piece of evidence for such a relation. Specifically, the scalar structure of the source adjective determines the aspectual properties of a derived verb: when the adjectival form uses a closed scale, the default interpretation of the verbal form is telic; when the adjectival form uses an open scale, the default interpretation of the verbal form is atelic.

A second piece of evidence for a mapping between scale structure in adjectives and verbs comes from data involving the opposite derivational relation: deverbal gradable adjectives. As shown by the examples in (14), even though the degree modifiers *very* and *well* can modify adjectives derived from verbs, and are moreover very similar in meaning (both have the effect of “boosting” the degree to which a gradable property holds of an object), they differ in their distribution.<sup>7</sup>

- (14) a. a well/??very protected harbor  
 b. a well/??very built house
- (15) a. a very/??well surprised child  
 b. very/??well worried parents

These acceptability judgments are mirrored by distributional asymmetries in corpora, as shown by the numbers in Table 1.

Table 1: Distribution of degree modifiers in the British National Corpus

	<i>well</i>	<i>very</i>
protected	62	2
educated	78	3
defined	146	2
surprised	0	154
worried	0	192
frightened	0	92

In Kennedy and McNally (1999b), we show that these distributional differences relate both to scale structure and to the nature of the standard value. Using evidence from proportional modifiers and entailment patterns, we show that *well* requires the adjective it

<sup>7</sup>Kennedy and McNally (1999b) present corpus data which show that these participles pass the usual tests for gradable adjective status (they appear as complements of copular verbs and in comparative constructions), so the pattern of data cannot be explained in terms of morphosyntactic restrictions.

modifies to be associated with a closed scale, while *very* requires the adjective it modifies to have a context dependent standard (and an open scale, given the relation between scale structure and standard discussed above). What is relevant to the current discussion is that the data discussed in Kennedy and McNally 1999b indicate that the structure of the derived adjective's scale is a function of the aspectual properties of the source verb: when the verb is telic (when it describes a bounded event), the derived adjective has a closed scale; when the verb is atelic (when it describes an unbounded event), the corresponding scale is open. The results of this work thus mirror the results of the research on deadjectival verbs.

The next stage of research on the relation between scale structure in adjectives and verbs should begin by looking at a larger corpus of data to solidify the statistical patterns of modifier distribution, by extending the study to other degree modifiers and classes of adjectives, and by expanding the study to degree modification in other categories (in particular, verbs). Most importantly, we need to look for the effects of scale structure in adjective/verb derivational relations in languages other than English, particularly because a number of recent papers on other languages suggest that the principles at work in English (the open/closed distinction; the context dependence of the standard value) play a role in other languages. For example, work by Tsujimura (to appear) shows that the distribution of the Japanese modifier *totemo* ('very') is parallel to its counterpart in English: it only modifies gradable predicates (a category that includes both adjectives and verbs in Japanese) with context dependent standards. Similarly, Barbiers (1995) argues that the open/closed scale distinction is the crucial factor determining whether an adjective can appear as the complement of a modal verb in Dutch: only adjectives that have closed scales appear in this environment.<sup>8</sup> These findings strongly reinforce the hypothesis that scale structure plays a broad role in natural language semantics.

**Summary of the Research Program** Viewed as a whole, the research described in the preceding pages indicates that the grammatical properties of both adjectives and verbs are sensitive to aspects of scale structure, in particular, the whether scalar representations have endpoints or not. Moreover, there is suggestive evidence that the scalar representations used by adjectives and verbs are similar in very fundamental ways, and that there are well-defined and regular mappings between the two. The deeper question that needs to be addressed is whether it is the case that the scalar representations used by adjectives and verbs (and other categories) are the actually same. That is, we need to determine if there a single, general system of scalar representation that manifests itself (possibly in different ways) in adjectives and verbs (and other categories). Answering this question is the ultimate goal of the research program that this project will begin.

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<sup>8</sup>Barbiers also observes that comparatives may occur as complements of modal verbs, regardless of the scale structure associated with the comparative adjective. This suggests that the crucial feature is actually the nature of the standard value, since the property shared by comparatives and closed-scale adjectives is that neither has a context dependent standard.

## 2. OVERVIEW OF EDUCATION ACTIVITIES

The research component of this project will support the training of graduate and undergraduate students in the study of meaning in natural language, through integrated classes in meaning (lexical semantics, formal semantics, pragmatics), independent research projects, and direct access to contemporary research. These components are described in more detail below.

**Year long course sequence in the study of meaning** The empirical domain of the project provides excellent material for an integrated and coherent three-quarter sequence in the study of meaning (designed for graduate and undergraduate students), because it covers issues in lexical semantics (such as word derivation, markedness, and aspect), formal semantics (such as ordering relations, compositional interpretation, and formal representations of meaning), and pragmatics (such as context-dependent aspects of adjective meaning). The topic of scalar representations will provide a common theme running through an integrated sequence in the study of meaning, giving students an empirical and conceptual focus that effectively illustrates the complex interaction of word meaning, compositional meaning, and contextual meaning in the construction of full semantic representations.

**Freshman seminar in meaning** The core elements of the year-long curriculum can also be distilled into a one-quarter “freshman seminar” on meaning. Such seminars are designed to introduce freshmen to the intellectual challenges of research and discovery by emphasizing discussion of ideas, exposition and argumentation, and the development of critical thinking skills. For the same reason that it provides the basis for an integrated year-long sequence in the study of meaning, the topic of scalar representations in semantics also supports the development of a coherent and focused freshman seminar that will address questions in word meaning, formal analysis of natural language, and the role of context and world knowledge in assigning complete meanings to utterances.

**Independent research opportunities** The project will promote the development of independent research skills in both graduate students and undergraduates through research assistantships and work study. Specifically, the project will include an academic year research assistantship for one graduate student, academic year work study support for one undergraduate, and two summer research assistantships for two undergraduates. The latter positions in particular will provide excellent research opportunities for two undergraduates (one of whom will be selected from the freshman seminar; the other from the larger pool of Linguistics or Cognitive Science majors).

An important aspect of the empirical domain of the project is that it allows for a range of individual variation in student research topics. This is important because students should be given the freedom to pursue their own research agendas and to develop their skills as independent researchers within the framework of mentorship provided by the project. Possible topics of investigation for student research within the larger context of the grant proposal include (but are not limited to): issues in the semantics of gradable adjectives; degree modification across categories; proportional modification across categories; scalar properties

of modifier clauses (such as comparatives, relative clauses and temporal modifiers); issues in the syntax, semantics or morphology of adjectives and verbs cross-linguistically; the mass/count distinction; and the semantics of directional and spatial prepositions.

**Exposure to current research** The project will introduce students and colleagues to current research on scalar representations in language by bringing in two speakers per year to give guest lectures in the graduate and undergraduate classes, and to give colloquia to the larger Linguistics/Cognitive Science community. In addition, at the end of the five-year period of the project, I will organize a workshop on scalar representations in natural language that will bring outside researchers together with Northwestern graduate and undergraduate students who have developed research topics within the project to discuss and further develop the current state of understanding of the topic.

### 3. SCHEDULE

In terms of research, the first two years will be devoted to a comprehensive analysis of the role of scale structure in adjectives and verbs, following the working agendas described in Section 1. This will involve in-depth work on English, making use of natural language corpora to investigate the distributional properties of closed vs. open scale adjectives and the argument structure of verbs of change. The research will also be extended to other languages, through linguistic fieldwork in the Chicago area and evaluation of grammars and corpora, where available. The third and fourth years of the project will shift attention to the relations between scalar representations in adjectives and verbs, focusing on questions involving degree modification and other cross-categorical phenomena in English and other languages. Again, natural language corpora will play a crucial role in the research. The third and fourth years will also see the beginning of work on a unified theory of scalar representations that holds for both adjectives and verbs; fully developing this theory will be the primary focus of the fifth year of the project. In conjunction with this effort, the investigation of scalar effects in language will also be extended to other grammatical categories, in particular nouns and prepositions.

The educational component of the project will begin in earnest during the summer of the first year, which will be devoted to simultaneous development of the materials for the year-long sequence in meaning and the freshman seminar, both of which should begin during the 2001-2 academic year. Subsequent summers will be devoted to updating and improving the courses based on new research findings and on student evaluations from the previous year, and to advising the two undergraduate researchers. The educational component has a built-in evaluation metric, as Northwestern requires all students to complete detailed evaluations of every class.

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