The type of adjectives

Galit Weidman Sassoon
Bar Ilan University
galitadar@gmail.com

Abstract

A compositional analysis of a range of readings of comparison constructions, as well as the positive form is proposed, which, unlike previous accounts, is compatible with multidimensional adjectives and has the power to explain differences between them and nouns.

To this end, adjectives are represented as properties of dimensional quantifiers, namely of sets of gradable properties; e.g., healthy $\Leftrightarrow$ $\lambda GQ_{<et,t>}$. n-many(λF.F is a health dimension, λF.GQ(F)), where *many* denotes a cardinality function and n sets up a standard. Comparison morphemes either set the standard of *many* or of the dimensions. Consequences are discussed for our understanding of the adjective-noun distinction and for the analysis of gradable morphology.

1. The challenge

Scholars generally agree that natural languages provide evidence for a taxonomy of predicates consisting of word classes such as nouns, adjectives and verbs (Baker 2003: 1-16). Some semantic analyses distinguish between verbs and other predicate types, analyzing verbs as denoting event types (Landman 2000), but they do not say what distinguishes adjectives from nouns. Nouns tend to occur in argument position, where their main function is to refer to objects, whereas adjectives typically occur in predicate- or modifier-position, as in (1a-b) and (2a), respectively. However, nouns can freely occur in predicate and modifier positions, too, as in (1c) and (2b) (Baker 2003: chap. 4).

1) a. John is healthy.
   b. John is sick.
   c. Tweety is a duck.
2) a. The healthy boys came.
   b. This is an elephant turtle.

The compatibility of adjectives with so-called degree morphemes, as in, for instance, (3a)-(4b), calls for a more complicated type than that of a mere predicate or predicate modifier. A dominant response to this challenge is a degree-function analysis.

3) a. John is healthier than Mary (is).
   b. John is the healthiest.
4) a. The table is longer than the sofa is wide.
   b. The sofas are more similar than dissimilar.
   c. John is more a linguist than a philosopher.

Let a model M be a quadruple $< I, D_t, D_e, D_d>$ consisting of an interpretation function I and domains of truth values, entities and degrees, respectively, and let G be a set of variable assignments g. On a degree analysis, in every M and G, adjectives denote degree functions, f: $D_e \rightarrow D_d$, or corresponding relations, $R_f = \lambda x \in D_e \lambda d \in D_d. f(x) \geq d$ (von Stechow 1984; Kennedy 1999). Hence, the positive form, e.g., 'John is healthy', is translated to the form F(John)(c) ('John is c F'), which involves a null element c. This element sets up a categorization threshold such that for g(c) = d, $R_f(j)(d)$ is true iff the degree f(j) is equal to or bigger than d.

Alternative analyses to gradability and comparison exist, which similarly postulate a null parameter c for the assignment of truth value to the positive form, but do not postulate degrees. In particular, on a comparison-class analysis, dimensions, $F_{<et,et>}$, are functions from an entity set called comparison class, c, to a subset, the positive extension of F in c. Thus, assuming a comparison class variable c in the logical form (where $g(c_{et}) \subseteq D_e$), F(John)(c) is true iff John is in the positive extension of F in g(c).

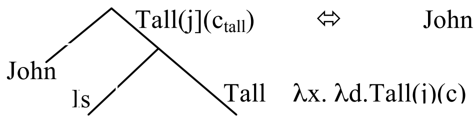
A traditional analysis of comparison, compatible with both approaches, translates (3a) to ∃c, F(John)(c) & ¬F(Mary)(c); i.e, John is healthier than Mary is true iff some degree exists, which John's health exceeds, but Mary's health does not (Schwarzschild 2008), or alternatively, some comparison class exists, relative to which John falls in the positive extension of *healthy*, but Mary does not (Klein 1980). Both approaches to gradability explain the noun-adjective distinction by postulating that nouns denote entity sets. This explains their incompatibility with most degree morphemes, illustrated by the oddness of, for example, #birder; #birdest; #very bird', and #too bird. However, a problem with this view of the noun-adjective distinction is that nouns can freely occur in between-predicate comparisons, as in (4c) above.

Existing analyses of between-predicate comparisons (see Morzycki 2011 and references therein) yield wrong predictions regarding other gradable constructions. The problem is that postulating either semantic gradability, or even only ad-hoc, contextual, meta-linguistic, last resort gradable interpretations for nouns to capture the meaning of between-noun comparisons, such as (4c), results in wrong predictions for, e.g., within-noun comparisons. For example, infelicitous structures such as #'This bird is more a duck than that one' or #'This bird is the most duck of all' are then predicted to be equally felicitous.

An alternative approach to the adjective-noun distinction considers the nature of the concepts they denote. Intuitively, people suppose that nouns like 'bird' denote object categories, while adjectives like 'red' denote properties. Psycholinguists employ this division, but do not explicate what exactly it amounts to. A related common view is that categorization under adjectives is a matter of a single dimension, such as height for 'tall', whereas nouns are multidimensional, e.g., categorization under 'bird' depends on dimensions such as has a bird-genotype, bird descendant, can interbreed with birds, winged, feathered and small. However, categorization under many adjectives depends on multiple dimensions, too. For example, 'healthy' and 'sick' consider dimensions such as flu, chickenpox, cholesterol, and sugar intake. A person may be 'healthy' in some respects, but not in others (Kamp 1975).

As we saw above, formal semanticists typically ignore the complexity of multiple dimensions, modeling all adjectives after 'tall' and 'long', i.e., in terms of a unique scale and degree relation. To illustrate, the degree analysis assigns to adjectives a type of a degree function, <e,d>, or, as in derivation (5), a corresponding relation, <e,<d,t>. These types are obviously too thin to encompass multiple degree functions or relations which simultaneously affect the interpretation of an adjective.[1,2]

5)



⇔ John is c_{tall} tall.

In response to these challenges, this paper proposes a new approach to the semantic composition of sentences with adjectives, which captures multidimensional adjectives and the way they differ from nouns (consequences for modifier position fall outside the scope of this paper). The interpretation of statements with multidimensional adjectives, on the new approach, **necessitates quantification over dimensions**.

2. The proposed solution: Adjectives in the positive form

Let us assume that degree relations constitute dimensions and call their type, <e, dt>, type f. Multiple degree relations in the interpretation of an adjective can be accommodated into the representation by analyzing multidimensional adjectives as dimensional generalized quantifiers, type <ft,t> (sets of sets of degree relations). Like entity quantifiers such as 'every boy' (<et,t>), they have to move from their surface position to resolve type mismatch. They leave a trace of type f. Its value, F_f, combines with an entity and a degree argument, $F(j)(c_F)$, and is abstracted over at the clause level. The resulting clause interpretation is a set of relations. Thus, e.g., 'John is c_F F' denotes the set of degree relations F whose contextual norm John exceeds, $\lambda F.\ F(j)(c_F)$. For instance, this set includes the dimension cholesterol iff John's cholesterol level is sufficiently close to the ideal level in the context of evaluation. This clause interpretation, $\lambda F.\ F(j)(c_F)$, is of type (<f,t>), which is precisely the right one to combine with the raised adjective, which is of type <ft,t>).

The interpretation of a multidimensional adjective such as *healthy* as a dimensional quantifier makes use of a contextually determined **set of dimensions**. Thus, let λF.Dim(healthy,F) symbolize the set of contextually

[1] But see Kamp (1975) and Klein (1980) for discussions and proposed degree-less analyses.

[2] Analyses of positive forms 'X is F' often postulate a null morpheme to mediate the interpretation. The representation in (5) simplifies this aspect, assuming only a null variable c_F that can be read as either a comparison class or a degree parameter. When the variable remains free, the assignment function sets its value to the default comparison class or membership norm stored for F in the lexicon or calculated for it within context.

relevant health measurements or respects (cholesterol, fever, …). Dimensional adjectives such as *long* can also be associated with a dimension set, λF.Dim(long,F), the set of length measurements, assuming in each context this set is a singleton.

The interpretation of an adjective type <ft,t>, then, involves a relation between the set of contextually relevant dimensions, e.g., λF.Dim(healthy,F), and the set of dimensions which norms the entity argument exceeds, λF.F(John)(c_F). For example, intuitively, the positive forms of multidimensional adjectives such as 'healthy' and 'sick' involve quantification over dimensions; e.g., (1a) conveys that John is healthy in all relevant respects, and (1b) conveys that he is sick in some respect. By contrast, (1c) does not naturally lend itself to an interpretation equivalent to quantificational paraphrases such as Tweety is a duck in some/most/all respects (Wittgenstein 1953).

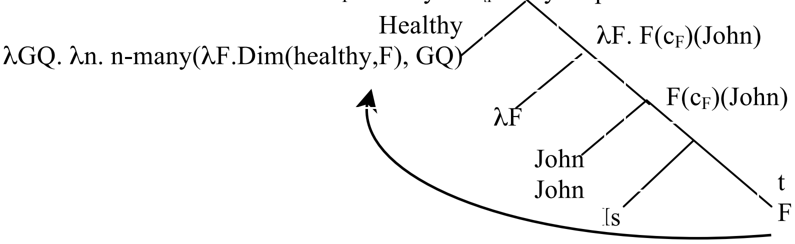
The above descriptions of the positive forms in (1) are motivated by empirical and experimental findings whereby grammatical operations can freely access the dimensions of adjectives and operate on them, whereas access to the dimensions of nouns is more restricted. Surveys of felicity judgments suggest that explicit dimensional quantifiers more naturally combine with adjectives than with nouns, as in *healthy/ safe/ clean in every respect* and *sick/ dangerous/ dirty in some respect(s),* vs. the odd combinations *#duck/tree in every/some respect*.

Moreover, the felicity of sentences of the form 'X is P' with adjectives, but not nouns, correlates with that of their quantified equivalents 'X is P in every/most/some respect(s)' (Sassoon 2014a). Furthermore, surveys and corpus studies suggest that exception phrases, which distribution is restricted to universally quantified propositions, combine with adjectives (as in '*healthy except for cholesterol*') and their negated antonyms (as in 'not sick except for cholesterol'), but they combine neither with nouns, nor negated nouns (#'(not) a duck except for size/the beak'; Sassoon 2012, 2013a,b). These findings suggest that the interpretation of adjectives, but not nouns, appears to be mediated by dimensional quantifiers.

Thus, on the emerging view, (1a) translates to 'John is healthy in every respect', or more formally, **Q(**λF.Dim(healthy,F)**,** λF.F(John)(c_F)**)**; e.g., if Q is a universal quantifier, this reads as 'for all the dimensions F of *healthy*, John is c_F F'. Recall, however, that 'every' itself, and determiners more generally, can also be represented in terms of a relation between the cardinality of a set and a membership norm n, as they do in generalized quantifier theory (Barwise & Cooper 1981). This leads us to a representation as in n-many**(**λF.Dim(healthy,F)**,** λF.F(John)(c_F)**)**, where n represents the number of adjectival dimensions whose norm John has to exceed for the sentence to count as true. Thus, *Healthy* translates to $\lambda GQ_{<<e,dt>,t>}$. λn. n-many(Dim(healthy), GQ). This reduces to $\lambda GQ_{<<e,dt>,t>}$. λn. |Dim(healthy) ∩ GQ| ≥ n. The type of adjectives is, therefore, <ft<d,t>>.

The value of n may range from the total cardinality of the dimension set (yielding universal force) to 1 (existential force). In analogy with c_F, a free variable c_n (representing the number of dimensions which norm the entity argument is required to exceed) surfaces in the positive form. The assignment function sets the value of this variable to a default value for n stored in the semantics of the adjective (e.g., *healthy* is universal*; sick* is existential), or else, to a contextually selected value (as with *clever*; for empirical support see Sassoon 2012-2013a,b).

6) [λn. n-many(λF.Dim(healthy,F), λF.F(c_F)(John))](c_n)
⇔ John is c_F healthy in c_n many respects F.



To wrap up, positive forms such as (1a) break down to the following two parts, illustrated in (6): (i) a clause with a dimensional trace applied to an entity argument (e.g., *John*) and abstracted over to denote the set of the entity's gradable properties, e.g., λF.F(John)(c_F), and (ii) an adjective that denotes a function from such a set to truth, or more precisely, a relation between such a set and a norm n. The generalized quantifier interpretation λF.F(John)(c_F) saturates the generalized quantifier argument of the adjective to yield a truth value.[3]

[3] Adjective movement within nominal structures has been postulated in the past (e.g., Kayne 1994 and Alexiadou & Wilder 1998), but no explanation was provided for why the AP cannot remain in its base position. We provide motivation: Movement leaves a trace of a dimension variable, thus creating the right type of argument for adjectives. But this means that movement must be postulated across the board, even in predicate position. An alternative way to approach the problem without movement is via type shifting of the entity argument

3. Adjectives and gradability

The relevance of multiple dimensions to the interpretation of gradability morphemes can be seen in the fact that the interpretation of comparisons of various types can be given paraphrases relating to dimensions. Examples (7a-b) include paraphrases for within-adjective comparisons with a dimensional and a multidimensional adjective, respectively. Examples (8a-b) include paraphrases for between-predicate comparisons with multidimensional adjectives and nouns, respectively.

7) a. The sofa is 2 centimeters longer than the table (is) ⇔ The difference between the degree of the sofa and the table in the dimension underlying entity classification as long vs. not long, f_{length}, equals twice the degree of a centimeter.
   b. (Generally) John is healthier than Bill ⇔ (Generally), the difference between the degrees of John and Bill in the dimensions underlying entity classification as healthy vs. not healthy in the context, $f_{blood\ pressure}$, $f_{cholesterol}$, $f_{chickenpox}$, …, exceeds zero.
8) a. These sofas are more similar than different ⇔ The number of dimensions along which the two sofas classify as similar exceeds the number of dimensions along which they classify as different.
   b. John is more a linguist than a philosopher ⇔ The percentage of dimensions of a linguist along which John classifies positively exceeds the percentage of dimensions of a philosopher along which John classifies positively.

These paraphrases suggest that comparison morphemes involve quantification over or counting of dimensions; e.g., it follows from (7a,b) that a degree difference in at least SOME dimensions of an adjective should be present for within adjective comparisons to hold true. In positive multidimensional adjectives such as 'healthy', the requirement might be stronger such that a degree difference should generally be present in ALL or MOST of the dimensions. Furthermore, it follows from (8b) that a larger PERCENTAGE of dimensions of a noun in comparison to another noun should be observed for the between-noun comparison to hold true of an entity (see Sassoon 2014b for discussion).

The proposed account extends naturally to gradable constructions; e.g., (3a) breaks down to an adjective and the rest of the sentence, which in this case amounts to λF. John is more F than Mary. Assuming a traditional analysis of comparison, as in λF.∃c, F(John)(c) & ¬F(Mary)(c) (Klein 1980; Schwarzschild 2008), we get that (3a) translates to [n-many**(**λF.Dim(healthy,F), λF.∃c, F(John)(c) & ¬F(Mary)(c)**)**](c_n), i.e., |λF.Dim(healthy,F) ∩ λF.∃c, F(John)(c) & ¬F(Mary)(c)| ≥ c_n. In words, for n many (all) dimensions F of *healthy*, John is more F than Mary.

Preliminary corpus evidence suggests that the default force of quantifier over dimensions, modeled here through the value of c_n, is inherited from adjectives like *healthy* to their comparative form *healthier*. Evidence for such readings is formed by frequencies of occurrence of explicit quantifiers over comparative dimensions, as in, *John is healthier {in every/some respects; except w.r.t. cholesterol}* (Sassoon 2013a).

In terms of semantic composition, the comparison morpheme can either take two entity type arguments, or entity arguments type shifted to a set of relational properties. In the latter case, illustrated in (9a), the null parameter c of these properties is bound by the comparative morpheme.

But this is not the only reading derived. In (3a), *more* can either operate on each dimension F separately (as in (9a)) or on *many*, yielding that 'John is healthy in more respects than Mary', ∃n, such that n-Many**(**λF.Dim(healthy,F), λF.F(John)(c_F)**)** & ¬n-Many**(**λF.Dim(healthy,F), λF.F(Mary)(c_F)**)**. In words, there is a number n, such that John is c_F healthy in n many respects F, but Mary does not. As illustrated in (8b), this reading involves an unsaturated standard variable n in the interpretation of the adjective.

In (4b), illustrated in (10), *more* analyzed as the comparative of *many* yields that for some n, the sofas are similar in n-many respects, but not dissimilar in n-many respects, meaning that they are more similar than dissimilar.

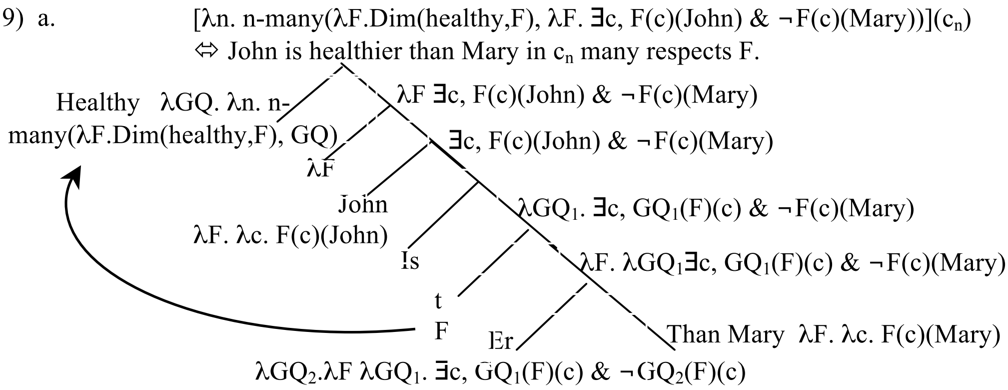
On the emerging view, *more* is a cross categorical morpheme, just like negation and conjunction. It combines with any set of arguments of any types that can combine to the form ∃a, $R_1(a,b_1)$ & ¬$R_2(a,b_2)$ and be interpreted consistently. To this end, the arguments can comprise of one relation R and two entities b_1 and b_2, or to one argument b and two relations R_1 and R_2. R can be an adjective type <d, <ft,t>> whose degree argument would be bound existentially and then it would be fed by two dimensional quantifier type <f,t>, as in (9b). Alternatively, R can be of a dimension type f whose degree argument is bound and then it applies to two entity arguments, or two entity quantifiers apply to it, as in (9a). R can also be a relation over noun meanings as in 'more boys than girls arrived', which can be similarly represented as ∃n, n-many(boys, arrived) & ¬n-many(girls, arrived).

(e.g., *John*) to a set of dimensions, λF.F(John)(c_F), which can then combine directly with an adjective interpretation insitu. Grammar may, therefore, allow both options.

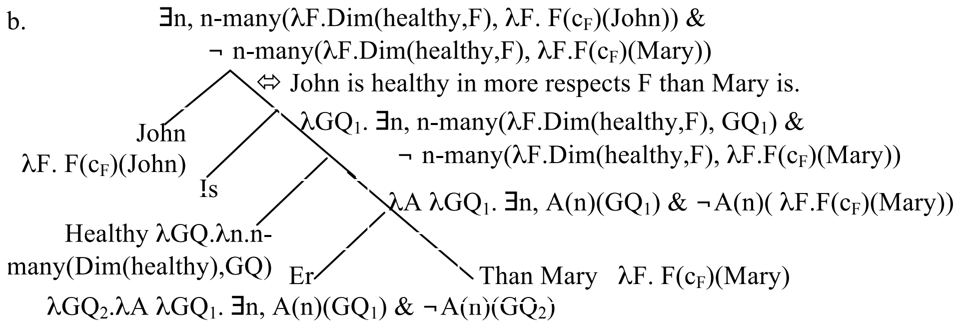
Replacing *longer* with *more long* in (4a) yields that the sofa is c_F long in more respects F than the table is c_F wide, i.e., ∃n, n-many(λF.Dim(long,F), λF. F(c_F)(the sofa)) & ¬n-many(λF.Dim(wide,F), λF.F(c_F)(the table)). Since the two adjectives in this example are one dimensional, this reduces to the requirement that the sofa be c_{long} long, and the table not be c_{wide} wide. But precisely this message is conveyed by the simpler positive forms: *The table is long and the sofa is not wide*. Thus, decrease in felicity is correctly predicted.[4]

The ban on comparison of number of dimensions which norm an entity exceeds given two dimensional adjectives (as in, e.g., *more long than wide*) can also be formulated as a more general restriction on the distribution of 'more' to scales comprising more than two degrees (Frank Veltman, p.c.). The scale from which the value of n is drawn in the case of a dimensional adjective comprises of only two values, 0 and 1, unlike the case of a multidimensional adjective, in which it normally comprises of many more values. This ban explains unavailability of the first reading of *more* (as in 9a) with predicates whose dimensions are not gradable (*prime, triangle*).

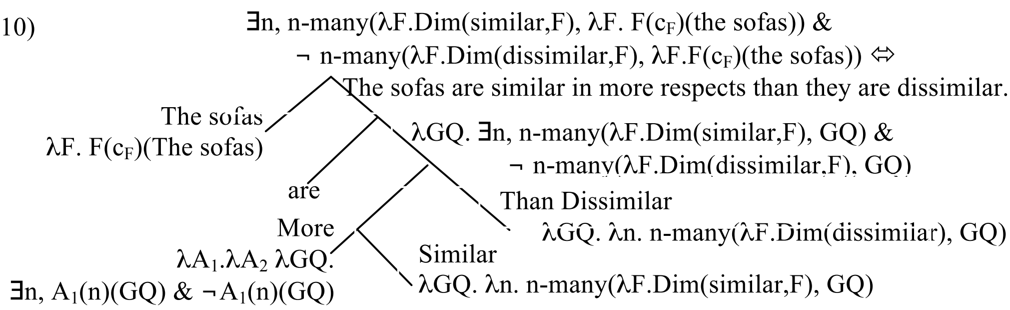
9) a.



b.



10)



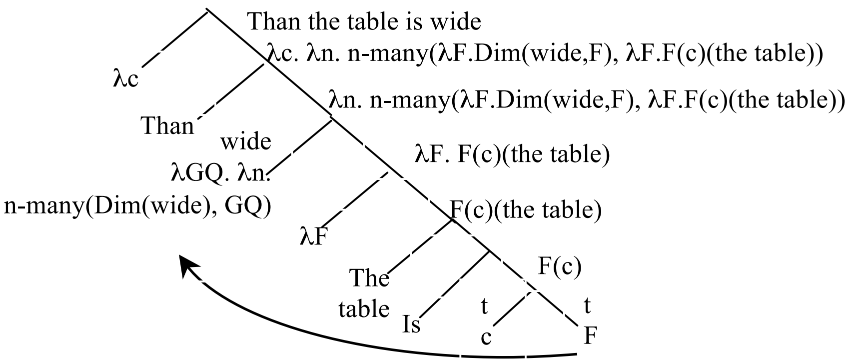
The comparison morphemes in the examples we considered so far either bind the standard of the dimension counter *many* (like *more* in (9b-10) or the dimensional standards c_F (like *–er* in (9a)). However, direct-comparison morphemes like *-er* in (4a), which surface a measure phrase argument, appear to bind both standard variables. An extension of the traditional account of comparison is required to capture their meaning. Comparison can be viewed as involving a set λa, $R_1(a,b_1)$ & $\neg R_2(a,b_2)$, which is not necessarily bound existentially (Schwarzschild 2008).

[4] To discern the interpretation from that of the conjunction of positive forms, it is inferred that the latter is false. To accommodate this, a degree lower than c_{long} must be used as the value of the contextual standard, for the sofa to only be close to being long, yet longer than the table is wide.

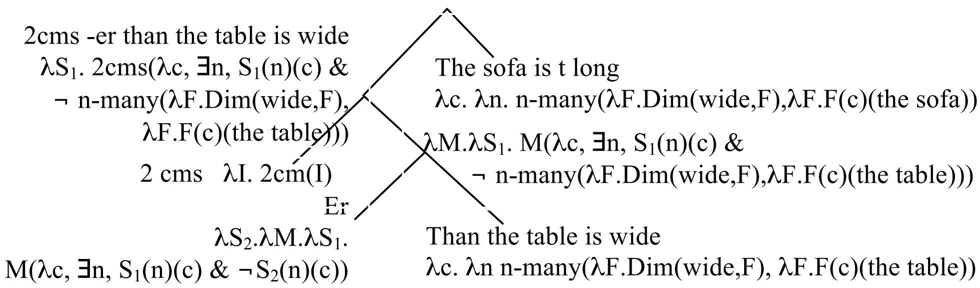
For example, (4a) may translate to $2CM(\lambda c, \exists F \in DIM(long), F(the\ sofa)(c)\ \&\ \neg\exists F \in \{DIM(wide), F(the\ table)(c))$, i.e., the property of being 2 centimeters long holds of the interval comprising of the set of degrees c such that for some dimension F of ‘long’ the sofa is c long, but for no dimension F of wide the sofa is c wide. Thus, we get for (4a) that the set of degrees c—such that the sofa is c long, but the table is not c wide—stretches along an interval of 2 centimeters, as desired (Kennedy 1999).

The compositional semantics for the than-clause in (11a) and matrix clause in (11b) is compatible with a standard analyses of *er* as a determiner over degree predicates, whereby a silent WH operator moves up within the than-clause leaving a degree trace to be bound by a lambda operator as in (11a). The matrix clause is analyzed as a degree predicate based on the assumption that the whole *er*-phrase moves at LF, leaving a degree trace to be bound by a lambda operator.

11) a.



b. $2cms(\lambda c, \exists n, n\text{-}many(\lambda F.Dim(wide,F), \lambda F.F(c)(the\ sofa))\ \&$
$\neg\ n\text{-}many(\lambda F.Dim(wide,F), \lambda F.F(c)(the\ table)))$



4. Nouns and gradability

Nouns denote sets of entities. Yet, the role dimensions play in categorization under nouns is a main predictor of their (in)felicity in gradable constructions, as follows.

On psychological similarity analyses, entities classify under nouns iff their values on multiple dimensions sufficiently match the ideal values for the noun. The degree of an entity in a given noun is built by addition or multiplication of its degrees in multiple dimensions. The resulting weighted sum or product should exceed a membership standard. Interestingly, additive classification characterizes mostly social concepts (artifacts and human traits), whose dimensions are relatively independent (Hampton et al. 2009). For instance, typically, a ‘linguist’ works in linguistics departments, investigates languages, and reads Chomsky’s work, but a person violating some of these features may still count as a linguist. By contrast, multiplicative classification characterizes natural kind concepts (plants and animals), where the dimensional values always go together (Hampton et al. 2009); e.g., an entity halfway between a zebra and a donkey classifies as neither. Only small deviations from the ideal are allowed.

To appreciate this distinction, consider a set of binary dimensions with equal weights. For entities that match the ideal in all of them, 1 … 1, except for one mismatch, 0, addition gives $0 + 1 + \ldots + 1 \gg 0$, while multiplication gives $0 \times 1 \times \ldots \times 1 = 0$. Thus, with binary dimensions of equal weights, additive, but not multiplicative classification is rendered equivalent to quantification (mere counting of dimensions). Entities are required to have sufficiently many (all/ most/ some) of the dimensions.

Since adjectives favor quantification, additive nouns are predicted to be judged more felicitous than multiplicative ones in adjective-selecting linguistic constructions. This prediction is borne out (Sassoon 2014a). Findings suggest that domain (additive vs. multiplicative) is a main predictor of noun felicity in various constructions, including within and between predicate comparisons. Hence, grammar is sensitive to conceptual structure. In particular, comparison morphemes are acceptable with a noun to the extent to which its interpretation can approximate that of an adjective, namely be modeled by means of quantification over dimensions.

The general moral with regard to the noun-adjective distinction is that the interpretation of the former, but not the latter involves quantification over dimensions. Thus, most gradability morphemes, whose interpretations involve quantification over dimensions as well, freely select adjectives, but not nouns.[5]

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[5] Quantifying modifiers, such as *perfectly, slightly,* and *in {every, some} respects*, may bind n or c as well; e.g., x may be *perfectly healthy* if x is c_F F in every respect F, or if in c_n respects F, x is F to every degree c. This gives additional motivation for the richer adjectival structure proposed, to be studied in the future.