A degree-approach account of multidimensional gradability

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The degree approach is one of the leading frameworks for the analysis of gradability in language, providing fully compositional accounts for constructions with gradable predicates of different categories. However, in this framework, the interpretation of a gradable predicate is almost always modeled in terms of a single scalar dimension (degree relation). This paper presents a compositional account which models multidimensional adjectives and nouns in terms of sets of degree relations, while keeping the standard assumptions and analyses of degree morphemes intact. Degree constructions are proposed to involve counting of or quantification on dimensions.

Based on cognitive psychological research, nouns are assumed to be associated with dimension sets, like adjectives do. The approach correlates the acceptability of a given noun in degree constructions and the default way in which its dimensions combine into a single interpretation. Nouns at which the dimensions can combine via counting operations or quantifiers are predicted to be more acceptable in many degree constructions than nouns at which the dimensions combine via other operations. The proposal is motivated by introspective data and experimental evidence, which is briefly reviewed. Its broad consequences are discussed and directions for future research are proposed.

Key words: Degree, Adjective, Noun, Comparison, Dimension, Similarity, Morphological gradability.

Acknowledgments: ….

1. Introduction: Morphological gradability in the presence of multidimensionality

The degree approach is a dominant and well-developed approach to the analysis of morphologically gradable predicates, namely predicates that can combine with gradability morphemes, as in *taller, very tall,* and *too tall*. Typically, however, the interpretation of these predicates is modeled in terms of single scalar dimensions. This paper studies the phenomenon of multidimensionality. It explains its relevance to accounts of morphological gradability, and how it can be formally added to the framework of the degree approach. It presents a fully compositional way of doing so, and studies its consequences. However, the paper also has programmatic goals. Hence, in various areas, it presents new questions and directions for future research into them, rather than final results. In particular, the present research has implications for the study of gradability in the nominal domain.

To this end, section 1.1 gives background on the degree approach. Section 1.2 and 1.3 present the questions that arise once multidimensionality is considered, and a proposed response, *the quantificational hypothesis*, according to which the interpretation of degree constructions involves quantification over dimensions. Section 2.1 and 2.2 review introspective data and experimental results that motivate the quantificational hypothesis, and section 2.3 presents in detail a formal, compositional account of the data in which degree constructions with

multidimensional predicates involve counting of or quantification on dimensions. Section 3 concludes with broader implications for the topics raised in the introduction.

1.1 The degree approach

Most adjectives, including, for example, *tall, expensive* and *healthy*, are *morphologically gradable*, meaning that they combine with degree morphemes, as in *taller, tallest, too tall, tall enough* and *very tall*. A popular approach to the analysis of gradable adjectives is the degree approach, and on a prevalent account within this approach, gradable adjectives denote relations between individuals and degrees, type <d, <e,t>> (Cresswell 1976; von Stechow 1984; Heim 2000; Fox and Hackl 2006; Beck 2011). For example, in each index of evaluation w, *tall* denotes the relation $\text{tall}_w = \lambda d \lambda x$: x's height in w $\geq$ d. This makes gradable adjectives like *tall* monotone in the sense that entities who are tall to a certain degree are tall to all lower degrees too:

(1) $\forall w, x, d, d_0$, s.t., $\text{tall}_w(x,d) \ \& \ d_0 < d$: $\text{tall}_w(x,d_0)$.

The monotonicity assumption is useful in various ways. For one, it helps capture the fact that sentences such as (2) are not contradictions. Assuming that *Jane is 1.5 meters tall* is true in w if and only if 1.5 meters is one of Jane's degrees in w, namely one of the degrees d such that Jane is at least d tall in w, makes this proposition consistent with 1.6 being one of those degrees too.

The monotonicity of gradable predicates has furthermore been exploited to explain the distribution of degree-modifier readings of propositional modifiers (Nouwen 2011). These readings characterize modifiers expressing markedness. For example, the objects that satisfy the predicates forming the modifiers *surprisingly, unbelievably,* and *unusually*, in some respect, stand out in their domain. In sentences such as those in (3a), these modifiers can be analyzed either as modifying propositions about classification as *tall* as in (3b), or propositions about tallness degrees as in (3c). The degree readings are not available for sentences such as those in (4), with modifiers like *believably* and *usually*, which do not express markedness.

(2) Jane is 1.5 meters tall, in fact she is 1.6 meters tall.
(3) a. Jasper is {surprisingly, unbelievably, unusually} tall.
    b. That Jasper is tall is {surprising, unbelievable, unusual}.
    c. Some degree to which Jasper is tall is {surprising, unbelievable, unusual}.
(4) a. Jasper is {believably, usually, expectedly} tall.
    b. That Jasper is tall is {believable, usual, expected}.

This distribution is explained in terms of inferences (Nouwen 2011). The sentence *Jasper is surprisingly tall* expresses the proposition that there is some degree d such that Jasper's having it as one of his degrees of tallness is surprising, as formally stated in (5). Degree readings of this sort can only occur with inference reversing modifiers. For example, (6a) entails (6b) (if (6a) holds true, then so does (6b)), and, similarly, (7a) entails (7b). By contrast, (8a) does not entail (8b). Rather, the reversed inference holds; e.g., if Jasper is unusually tall, then had he been taller, he would also be unusually tall.

(5) [[Jasper is surprisingly tall]] = $\lambda w \exists d$: tallw(j,d) & $\text{surprising}_w(\lambda w'$: $\text{tall}_{w'}(j,d))$
(6) a. Jasper is tall to degree d $\Rightarrow$

b. Jasper is tall to any degree lower than d.

(7) a. d is expected, usual, believeable. ⇒
b. any degree lower than d is expected, usual, believeable.

(8) a. d is unexpected, unusual, unbelieveable, surprising. ⇐
b. any degree lower than d is unusual, unbelieveable, surprising.

An adverb like *expectedly* cannot have a use as a degree modifier because it is not inference reversing. That Jasper is tall to an expected degree does not entail that had he been taller, he would also be tall to an expected degree. Rather, any degree d shorter than Jasper's height is expected. In fact, we expect any human being to be, e.g., 5 cms tall, and, so, being *expectedly tall* is a trivial property. Similarly, being *usually tall* means being tall to some degree which is usual. This, again, is trivial (Nouwen 2011).

In addition to the monotonicity of gradable adjectives, the degree relations they denote are assumed to form a basis for categorization; e.g., in each context, entities whose maximal height exceeds a contextual membership norm are classified as *tall*. If entities with height d are classified as tall, so do any entities with heights equal or higher than d. The selection of a contextually appropriate membership norm is based on the distribution of degrees in the local domain of discourse – the set of entities to which the degree relation applies (Kennedy 1999, 2007). On this approach, there is a null constituent in categorization forms, e.g., *pos* in *The chair is pos tall*, which introduces the contextual norm into the truth conditions (see section 2.3).

The degree-relation account of gradable adjectives has been successfully applied to give fully compositional semantics to a variety of degree constructions, including comparatives, equatives, superlatives, degree modifiers, exclamatives, and more (see section 2.3 for illustrations; von Stechow 1984, 2009; Kennedy 1999, 2007; Heim 1999, 2000, 2006; Hackl 2001; Kennedy and McNally 2005; Schwarzschild 2005; Rett 2008, 2015; Solt 2009; Beck 2011; Wellwood, Haquard and Pancheva 2012; a.o.).

In addition, it has triggered research that improved our understanding of morphological gradability in additional categories, including, verbs, prepositions, and nouns (Kamp & Partee 1995; Kennedy and Levin 2008; Morzycki 2009, 2011, 2012; Bochnak 2010; Constantinescu 2011; Wellwood, Hacquard and Pancheva 2012; Wellwood 2015, a.o.).

For example, the above test of monotonicity and thus morphological gradability (an interpretation type <d, <e,t>>), through the (in)availability of degree readings, has been applied to nouns, in attempt to distinguish between actual linguistic gradability (the property of having a degree argument d) and mere conceptual gradability (De Vries 2010). A class of nouns which behave like monotone predicates has been carved out, including, for example, *genius, idiot, nerd,* and *fan,* based on tests as in (9). For instance, the description *unbelievable genius* in (9a) has a degree reading; e.g., an unbelievable genius must have an unbelievably high degree of intelligence. By contrast, the examples in (9b) do not have a degree reading. This has been taken to form evidence that these nouns are linguistically gradable – they have a degree argument, as opposed to other nouns that fail the test. For example, neither the examples with *chair* and *duck* in (10a), nor in (10b) have a degree reading (Nouwen 2011; De Vries 2010).

(9) a. Vernon is an {unbelievable genius, incredible idiot}. [degree-modifier reading]
b. Vernon is a {believable genius, credible idiot}. [no degree-modifier reading]

(10) a. This is an {unbelievable chair, incredible duck}. [no degree-modifier reading]
b. This is a {believable chair, credible duck}. [no degree-modifier reading]

Thus, nouns like *chair* and *duck* are conventionally thought to denote, in each context of evaluation, sets of entities (type <e,t>), rather than a degree relation. Notice that these nouns do seem to occur in certain comparison constructions, as in (11a,b), but in line with the results of the monotonicity test, those are generally treated as metalinguistic comparisons, namely as having readings such as those in (11c-d), which can be made compatible with an <e,t> type for nouns (Giannakidou & Yoon 2011; Morzycki 2011). Nonetheless, the truth or falsity of such comparisons is often thought to stem from facts pertaining to degrees of prototypicality, as illustrated in (11e) (cf., De Vries 2010; Morzycki 2011; Sassoon 2013a). Prototypicality is intimately related to categorization in these nouns. Psychological studies of nouns that fail the monotonicity test in English and Dutch present almost perfect correlations between the prototypicality of an entity and its likelihood of categorization (Hampton 1998; Verheyen, Dewil and Storms 2015, and references therein; see also section 1.3).

(11) a. This is more a chair than a table.
b. This is more a duck than a goose.
c. It is more appropriate to call this a *duck* than to call this a *goose*.
d. The proposition *This is a duck* is closer to the truth than the proposition *This is a goose*.
e. This is closer to the prototype of a duck than to the prototype of a goose.

The distinction between conceptual and linguistic gradability, as in, e.g., *chair* vs. *genius*, respectively, is indicated by the distribution of additional modifiers. For instance, the modifiers in (12a,b) prefer predicates whose scale has end-points, like *invisible*, as opposed to the modifiers in (13a,b), which prefer predicates whose scales are open, like *intelligent* or *stupid* (Kennedy and McNally 2005; Kennedy 2007). Examples like (14) suggest that conceptually gradable nouns pattern with closed-scale adjectives, which is consistent with a scale based on similarity to a prototype, in which the prototype represents the scale maximum. By contrast, examples like (15) suggest that linguistically gradable nouns (e.g., *idiot, nerd, soccer fan, airhead, goat cheese enthusiast, simpleton, Barbie doll lover, loser, weirdo*) pattern with open-scale adjectives. This supports the view that nouns like *idiot* have an open scale, rather than a closed scale based on a prototype (De Vries 2010; see also an earlier discussion of a typology of gradable nouns in Kamp and Partee 1998).

(12) a. Maxwell's pet elephant is {almost, completely, virtually} invisible.
b. *Vernon is {almost, completely, virtually} stupid.
(13) a. *Maxwell's pet elephant is {unbelievably, hugely, terribly} invisible.
b. Vernon is {unbelievably, hugely, terribly} stupid.
(14) a. This is {almost, completely, virtually} a chair.
b. This is a(n) {unbelievable, huge, terrible} chair. [no degree-modifier reading]
(15) a. *Vernon is {almost, completely, virtually} an idiot.
b. Vernon is a(n) {unbelievable, huge, terrible} idiot. [degree-modifier reading]

Finally, De Vries (2010) observes that, when *complete* or *total* are used with monotone nouns, as in a *complete/total nerd*, they do not seem to refer to the endpoint of a scale; rather, they

convey having some property in every respect; e.g., a total nerd is someone who is nerdy with respect to his look, social skills, intelligence, hobbies, and any other dimension associated with nerdiness, but it is not the case that a total nerd could not possibly be nerdy-er. These nouns contrast with other ones, which are not multidimensional; e.g., according to de Vries, whether someone can reasonably be called a *goat cheese enthusiast* only depends on one dimension: their enthusiasm for goat's cheese. This analysis correctly predicts that monotone nouns that can occur with *completely* also allow modification by a *with respect to* phrase, as illustrated in (16).

(16) a. Maxwell is a nerd with respect to his computer skills.
b. Vernon is an idiot with respect to his political views.
c. #John is a goat cheese enthusiast in two respects.

To sum up, the degree approach provides powerful tools to account for a large body of challenging data. The emerging picture of the nominal domain suggests that some nouns do exist (e.g., *idiot, nerd, fan, psychopath, enthusiast*, and *weirdo*), which presumably lack a standard form of a prototype, but at the same time are linguistically gradable. They are subject to monotonicity-related phenomena. Moreover, some of these nouns seem to be multidimensional.

Notice, however, that despite the fact that the examples in (16) exploit the multidimensionality of certain nouns, the view of morphological gradability on which the big picture is based takes a one-dimensional perspective on the subject matter. All gradable predicates are generally represented in terms of a single degree relation, just like adjectives such as *long* or *expensive* should be. This paper proposes to enrich the degree account with the possibility of a multidimensional interpretation. This proposal sheds new light on the semantics of degree expressions, including the results of monotonicity tests, as explained in section 1.2.

Notice, in addition, that even nouns which fail the tests of morphological gradability can sometimes be modified by degree morphemes such as *more*, *almost*, and *complete(ly)* (cf., (11), and (14)-(16)). To explain these facts, more has to be said about the circumstances at which different degree morphemes can access the conceptual scales associated with such nouns. In other words, since 'non gradable' nouns can be degree modified, more has to be said about whether these nouns are or are not denoting degree relations based on their conceptual scales, as explained in section 1.3.

1.2 Failure of dimension accessibility, rather than of monotonicity

Classification under *long* is merely a matter of length, but classification under, e.g., *healthy* is a matter of degree in a variety of dimensions, such as blood-pressure, cholesterol and blood-sugar level. One can be healthy in some respects but not others (Kamp 1975; Klein 1980; Hoeksema 1995). Hence, in addition to the fact that, in each context, predicates denote degree relations and are associated with entity sets through membership norms (Kennedy 1999; Heim 2000; von Stechow 2009), the relation *dimension of* associates each predicate (e.g., *bird*, *healthy*, *similar*), in each context, with a set of one or more predicates – its contextual dimensions (e.g., *has a beak*, *healthy with respect to the flu*, *similar in shape*, respectively).[1]

[11] While degree relations and entity sets can be learnt independently of a specification of dimensions, speakers do seem to make pervasive use of dimensions in decisions about degrees and categorization. For example, as explained in section 2.2, the degree functions of nouns are often determined using the degree functions of their dimensions (to be functions from entities into the degree to which their values in the dimensions match certain

The naturalness of comparison constructions and other degree constructions with multidimensional adjectives, e.g., *healthier than Bill*, *more similar than dissimilar*, *very intelligent, too enthusiastic,* and *as optimistic as,* gives rise to an important question concerning semantic composition: **How do the different dimensions of a predicate and the operation denoted by a degree morpheme combine?** The following paraphrases of hypothesized readings of comparison constructions illustrate the potential relevance of dimensions and the way they combine to form a single interpretation. Examples (17a) and (17b) include a dimensional and a multidimensional adjective, respectively. Examples (17c) and (17d) include a pair of multidimensional adjectives and a pair of nouns, respectively.

(17) 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* or not, 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** contextually underlying entity classification as *healthy* or not, $f_{blood\ pressure}$, $f_{cholesterol}$, $f_{chickenpox,\ \ldots}$, exceeds zero.
c. *These two 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*.
d. *John is more (of) a linguist than a psychologist*: The number (or proportion) of dimensions of *a linguist* which membership norm John exceeds is higher than the number of dimensions of *a psychologist* which norm he exceeds.

These paraphrases suggest that comparison constructions involve *quantification over* or *counting of dimensions*; e.g., it follows from (17a,b) that a degree difference in at least SOME dimensions of an adjective should be present for within noun 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 (17c,d) that a larger NUMBER or PERCENTAGE of dimensions of a predicate in comparison to another predicate should be observed in an entity for the comparison to hold true. Without *of*, comparison (17d) appears ambiguous between such an interpretation, which seems especially accessible for American speakers, and an alternative one, whereby the relative similarity of John to the prototypes of *linguist* and *psychologist* compare. Intuitively, John may neither have any properties of linguists nor of psychologists, but still resemble their prototypes to different extents, if he is, for instance, a typical philosopher, or a child (Sassoon 2016a).

Another question relates to the circumstances at which comparisons and other degree morphemes can access the dimensions of nouns. Consider in particular, the monotonicity test, repeated below with some additional examples.

(18) a. Vernon is an {unbelievable genius, incredible idiot, huge football fan}.
b. Vernon is a {believable genius, credible idiot, small football fan}.
(19) a. This is an {unbelievable chair, incredible duck}.
b. This is a {believable chair, credible duck}.

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ideal values). Describing in detail a formal model with dimensions and the ways it addresses philosophical arguments against dimensions would demand more space than allocated for this paper, but see Sassoon (2013a) for extensive discussions.

Recall that the argument goes as follows. *Incredible* but not *credible* can access the scale of idiocy and denote a degree on this scale. Conclusion: *Idiot* is a monotonic predicate, which is evidence for having a degree argument. However, even if a prototypicality scale form the basis for classification under *bird* (through a membership norm), neither *incredible*, nor *credible* can access degrees on this scale to express (in)credibility of entities' birdhood degrees. Conclusion: This is not a monotonic predicate and therefore cannot be modeled via a degree argument.

This argument is very powerful. Notice, however, that it is based on a one dimensional conception of all grabable predicates, or at least, on the presupposition that all multidimentional predicates have accessible dimensions for degree modifiers to operate on. The only reason taken into account for the failure of *incredible* and other adnominal modifiers to access and operate on dimensions, is their non-monotonicity. However, additional reasons might exist. If the dimensions of some predicates are simply inaccessible, for example, because they are already bound by some dimension-binding operator, then failure of combination with degree modifiers cannot establish whether their dimensions are monotonic or not.

The following tests suggest that indeed the dimensions of multidimensional adjectives are more accessible than those of nouns for grammatical operations, and in particular, quantifiers, to operate on (Bartsch 1986; Landman 1989; Sassoon 2013a,b). Linguistic labels of operations on dimensions include prepositions, as in (20a), quantifiers, as in (20b), exception phrases, as in (20c), and quantifying adverbs, as in (20d), which on the relevant reading convey that their adjectival argument holds in all (or most) respects. The dimensions of nouns, by contrast, are not easily accessible, as the reduced acceptability of the nominal examples in (21) illustrates.

(20) a. healthy **with respect to** blood pressure; good **in** math.
b. healthy in {**some, most, every**} respect(s); different **in three** respects.
c. healthy **except for** high cholesterol; identical except in two respects, size and color.
d. **perfectly** healthy; {**mostly, completely, totally**} different.

(21) a. #bird with respect to size; #dog in movement.
b. #tiger in {**some, most, every**} respect(s); #table **in three** respects
c. #is a bird **except for** size; #is a snake except in two respects, length and color.
d. #**perfectly** (a) pine; #{**mostly, completely, totally**} a duck.

The exact reasons for which nominal dimensions are proposed to often be inaccessible for quantifiers and other grammatical operations to operate on, and the circumstances at which they become accessible, are explained in detail in sections 2. Generally, much data suggests that, as a default, in categorization, the degree functions associated with nominal dimensions combine to form a single similarity function through *averaging operations* such as weighted sums or products, as assumed in psychological *similarity theories* (cf., section 2.1). By contrast, as a default, the degree functions associated with adjectival dimensions appear to combine through *counting operations*, such as those that formal, logical theories assume for quantifying expressions like *all*, *most* or *some* (cf., section 2.2). This suggests that multidimensional adjectives, by default, can have a dimension argument, which quantifiers can bind, whereas the situation in nouns is slightly different.

Moreover, psychological studies present evidence suggesting that nouns divide into various types according to the way their dimensions integrate into a single classification criterion. The dimension-binding operations characterizing certain nouns, but not others, can shift, under

certain circumstances, into quantificational dimension-binding operations such as those characterizing multidimensional adjectives. These nouns turn out to be more acceptable in degree constructions than other nouns are, which do not resemble adjectives in the way their dimensions tend to be bound. Thus, the hypothesis in (22) emerges:

(22) a. **The Quantificational Hypothesis**: Degree constructions involve counting or quantifying operations over dimensions of multidimensional predicates.
b. **The reduced acceptability of nouns**: If the dimensions of a predicate are bound by averaging operations, it is impossible for a quantifier to access and bind them. As a result of the extra processing cost involved in attempts to override the similarity operations, acceptability reduces.

According to the quantificational hypothesis, the acceptability of degree constructions (e.g., (17a-d)) should correlate with the acceptability of constructions involving quantification over dimensions, such as those in (20)-(21), because it is hypothesized that the same problem underlies the reduced acceptability of nouns in all cases. The acceptability of these constructions is assumed to depend on the accessibility of the dimensions, namely, the possibility for a quantifying operation to bind them. This prediction too is borne out as the results of various studies suggest (for more details see section 2.1).

If this proposal is on the right track, the general moral is that, in testing whether predicates have a degree argument, we should first test whether they are multidimensional or not. And if they are, we should test whether their dimensions are accessible. Since nouns such as *bird* differ from nouns like *idiot* in the accessibility of their dimensions, the question whether or not they are different with respect to gradability and monotonicity remains open. All nouns may be morphologically gradable and monotonic, but some may fail the test only because their dimensions are inaccessible for binding by the quantifying operations mediating the interpretation of degree modifier constructions (for a detailed account along these lines see section 2.3).

A semantic analysis in terms of degrees may have theoretical benefits for the analysis of modification of nouns by degree morphemes such as *more, almost,* and *complete(ly),* as in, e.g., (11) and (14)-(16). The next section concludes the introduction by briefly discussing this point, focusing on nominal comparisons.

1.3. Nouns and degree morphology

We have seen that nouns occur in metalinguistic comparison constructions. For example, (23a) directly express a proposition about speakers preferences regarding which predicate to use as a label for Rubinstein, entailing, roughly, that the speaker finds it more appropriate to call Rubinstein *a pianist* than *a conductor* (Giannakidou & Yoon 2011), or that the proposition *Rubinstein is a pianist* is closer to the truth than the proposition *Rubinstein is a conductor* in the sense of Lasershon's (1999) analysis of imprecision (Morzycki 2011).

Comparisons such as (23b), which are more relevant to our present interests, also seem to have such implications, but, arguably, they follow more indirectly. [2] For example, (23b) seems to express a proposition about the relative degree to which Rubinstein exemplifies the concepts associated with *pianist* and *conductor*. A proposition about the relative appropriateness of these

[2] For a detailed account of *rather* type of comparisons in various languages see Giannakidou & Yoon (2011).

predicates as labels of Rubinstein seems to follow. If this intuition is on the right track, it suggests that, indeed, scales in the basis of categorization under nouns are directly involved in the interpretation of (23b).

(23) a. Rubinstein is a pianist rather than a conductor
b. Rubinstein is more a pianist than a conductor.
c. This creature is more a crab than a lobster.

Moreover, both of the propositions *Rubinstein is a pianist* and *Rubinstein is a conductor* are plainly true, thus to capture examples like (23b), Morzycki's imprecision scale has to include various degrees of plain truth. The basis for the distinction between these degrees seems to lie in the prototypicality structures underlying categorization under *pianist* and *conductor* (if an entity is closer to the prototype of one noun than of another, this affects the position of that entity in the halo of the relevant nouns), but the details of this intuition have yet to be explicated (Morzycki 2011, 2012).

In addition, (23c) is judged to be more natural than (24b) despite the fact that the propositions *This is a crab* and *That is a crab* may differ in terms of their distance from the truth just as much as the propositions *This is a crab* and *This is a lobster* may. More generally, within-noun comparisons such as (24a,b) are not as natural as between-noun comparisons such as those in (23b,c), and similarly, other degree morphemes that classically combine with gradable adjectives such as *very* and *too* cannot easily combine with nouns to relate to scales of prototypicality, appropriateness or imprecision, as the infelicitous forms in (25a) illustrate. A similar problem is raised by Morzicki (2012) concerning gradable nouns. If we assume that *fan* can denote a degree relation in the context of *big fan*, then we have to explain why it can't do so in other contexts, such as those illustrated in (25d).

(24) a. #Rubinstein is more a pianist than my son
b. #This creature is more a crab than that one is.
(25) a. #The most duck; #duck enough; #too duck; #very duck.
b. #The most fan; #fan enough; #too fan; #very fan.
(26) #The table is {longer, more long} than heavy.

Let us recapitulate. We have seen that within-noun comparisons (namely, comparisons of two entities along the dimensions of a single noun, e.g., *pianist* in (24a) and *crab* in (24b) are less natural than most within-adjective constructions, and so are other degree constructions with a single noun such as those in (25) (see Baker 2003 for cross linguistic evidence to this effect). By contrast, between-noun comparisons (namely comparisons of single entities along the dimensions of two different predicates such as *pianist* and *conductor* in (23b) and *crab* and *lobster* in (23c) are as natural as between-adjective comparisons are, and they are even more natural than most comparisons between one-dimensional adjectives, as example (26) illustrates (Kennedy 1999).[3]

A simple postulation of a syntactic-category constraint, whereby comparison morphemes only select adjectives, and/or a postulation of a semantic-type difference, whereby most adjectives but only very few nouns denote a degree relation, would fail to explain these facts. Nor will a resort

[3] These generalizations are confirmed by various studies of acceptability judgments of nouns and adjectives in comparisons constructions (Sassoon 2016b; Sassoon and Fadalon in progress; Fadalon and Sassoon in progress).

to metalinguistic scales suffice. An additional account has to be provided for the different acceptability levels of the different degree constructions. The emerging picture is consistent with a morphologically gradable account of both nouns and adjectives, which posits constraints on the interpretation of the various degree expressions to capture their selection preferences.[4]

A morphologically gradable account of nouns has the advantage that it makes a connection between the semantic representations of nouns and their psycholinguistic representations, which are designed to capture facts about their processing. Sections 2.1-2.2 aim to exploit these connections to uncover predictors of acceptability of predicates in degree constructions. For one, if metalinguistic scales are affected by the scalar mechanisms in the basis of categorization under nouns, as Morcycki (2011, 2012) suggests, considering the latter in greater detail can potentially help explain the restricted distribution of metalinguistic interpretations of nouns, i.e., **why nouns denoting prototypicality scales can occur in some degree constructions, but not others**.

However, section 2 to which we now turn, largely sets this important issue aside (see a short discussion and references at the end of section 2.3). Rather, it focuses on the proposal that, **in explaining the status of nouns in degree constructions more generally, i.e., across different constructions, an important factor is the role of their multiple dimensions in categorization**. To better understand the motivation for the quantifying hypothesis and the determinants of dimension accessibility, the following two sections review studies of the role of dimensions and dimension-binding operations in categorization. We start by discussing the role of similarity and averaging operations in categorization under nouns.

2. A multidimensional perspective within the degree approach

2.1 Similarity-based categorization

Extensive work within cognitive psychology (for a review see Murphy 2002) has shown that speakers associate concepts with sets of dimensions, and they systematically consider entities that score highly in these dimensions better examples than others of the concepts in question. For example, the dimension set of *bird* often includes dimensions like *having feathers, wings, beak, small size, egg-laying, flying, singing* and *perching*. Robins score highly in these dimensions and thus are considered better (more prototypical) examples of *bird* than, e.g., ostriches do (Rosch 1973). Furthermore, exemplariness (also called prototypicality) is a strong predictor of categorization probability (Hampton 1998) and speed (Rosch 1973); e.g., the verification of sentences like *a robin is a bird* is faster than of sentences like *an ostrich is a bird*. But in a context such as *the bird walked across the barnyard*, at which a chicken is regarded as a typical bird, categorization is faster for *chicken* than for *robin* (Roth and Shoben 1983).

These results motivated **the prototype theory,** which models conceptual structure via a set of weighed dimensions and selected dimensional values. The latter indicate what the best example p of a concept is like, whether such an object actually exists or not. Each dimension F has a *weight* W_F (e.g., W_{flying} tells us how important flying is in classification) and a *selected value*, $f_F(p)$ (e.g., $f_{size}(p_{bird})$ represents the ideal size for birds). The typicality of an item is modeled by d's similarity to the prototype; e.g., the similarity of a robin to a bird is indicated by its averaged degree in the bird dimensions: How well its values match the prototypical values in the dimensions.

[4] Additional arguments for morphological gradability in nouns based on scope ambiguities and incompatability with argument position can be found in Sassoon (2016a).

Categorization, on this view, is a process in which it is decided whether an entity is similar enough to a concept's prototype. Thus, the tight coupling between similarity and membership is captured (Hampton 1998). Moreover, newly encountered entities which average better than known members are correctly predicted to be automatically regarded as category members. Thus, this account captures the fact that we are able to categorize infinitely many new instances under the concepts we are familiar with, based on a finite set of encoded dimensions and members. Classification of atypical instances is slower because they have lower degrees in the dimensions. Thus, more dimensions have to be considered to determine membership.

Two main types of similarity functions, additive and multiplicative, are relevant to us, because nouns associated with them are predicted to exhibit different levels of dimension accessibility, as explained shortly. *Additive Similarity* can be modeled as the weighted sum of x's dimensional degrees, as in (27) (Rosch and Mervis 1975) [5], while *multiplicative similarity* can be modeled by the weighted product of x's dimensional degrees, as in (28) (Medin and Schaffer 1978).

(27) **Additive similarity**: $f_p(x) = w_{F1}f_{F1}(x) + \ldots + w_{Fn}f_{Fn}(x)$.

(28) **Multiplicative similarity**: $f_p(x) = f_{F1}(x)^{WF1} \times \ldots \times f_{Fn}(x)^{WFn}$

Multiplication models cases in which the most radical decrease in similarity is between entities which perfectly match the ideal in all the dimensions and entities with a mismatch in just one or very few dimensions. For instance, assuming, for simplicity, equal dimensional weights and dimensional degrees between 0 and 1, then even instances which match in all of the dimensions except for a 0.5 score in one dimension, have a low mean similarity, 0.5, because multiplication yields $0.5 \times 1 \times \ldots \times 1 = 0.5$ (Murphy 2002). Two 0.5 scores yield a mean similarity of 0.25, and so on. The decrease predicted by additive similarity is by far less drastic.

To illustrate, all robins resemble prototypical robins in being small, eating seeds and fruit, and communicating by singing, whereas all eagles resemble prototypical eagles in being big, eating animals, and communicating with calls. An entity which is somewhat a robin and somewhat an eagle does not classify as either; instead, it classifies as a new species. By contrast, a scholar with some properties of a linguist and some properties of a philosopher may well count as both. Multiplicative similarity models the tendency for interrelated dimensions and gaps between categories in the case of *robin* and *eagle*, whereas additive similarity models the tendency for independent dimensions and category overlaps in the case of *philosopher* and *linguist*.

To study dimension integration in different noun domains, Hampton, Storms, Simmons and Heussen (2009) have invented scenarios with borderline cases. On one scenario, a historical nuclear accident nearby a remote island resulted in the evolution of hybrid creatures, e.g., a subkind with some features of lobsters and some features of crabs. In a second scenario, a secluded community in a remote area had the habit of using artifacts in ambiguous ways; for instance, some pieces of clothing had features of both a scarf and a tie. Participants were asked to help scientists classify the entities. In line with multiplicative-similarity, hybrids of two natural kinds were often classified in neither one of the kinds. By contrast, in line with additive similarity, hybrids of social categories were often classified in both categories.

In an additional study, categorization under labels of artifacts and human traits, unlike animals and plants, appeared to often be based on a simple counting strategy, i.e., on whether entities

[5] With binary dimensions (dimensions denoting functions from entities to 0 or 1), and weights indicated by the number of category members satisfying them (W_F = | [[bird]] $\cap$ [[F]] |), similarity reduces to x's family-resemblance score – the number of dimensions all -members share with x (cf., Tversky 1977).

were within the norm in *some* (or *most*) of the concept's dimensions (Wattenmaker 1995). This was modeled with additive similarity, assuming binary dimensions (functions from entities to 1 or 0) with equal weights. This case is unique in that the effect of averaging can be represented via quantifiers. A social noun N is interpreted as denoting the property that an entity x has if and only if x is within the membership norm ($f_F(x) = 1$) in SOME (or MOST) of N's dimensions.

Importantly, this property discerns social nouns from natural-kind nouns, in which categorization is based on multiplicative similarity (a weighted *product*, rather than *sum*, as in (27)), so that even a representation of their dimensions as binary and of equal weights does not yield classification based on dimension counting. Thus, social nouns are predicted to be more compatible than natural-kind nouns with quantificational dimension-binding operations such as those in (20)-(21) or (31) below. Moreover, given the quantificational hypothesis in (22), also degree constructions involve quantification over dimensions. Hence, social nouns are predicted to be more compatible than natural-kind nouns also with degree morphemes such as those in (24)-(25) or (29)-(30) below. These predictions were confirmed in a number of studies (Sassoon 2016b; Sassoon and Fadalon in progress; Fadalon and Sassoon in progress).

In these studies, participants judged the naturalness of constructions such as those in (29)-(31) on a scale ranging from 1 (perfectly unnatural) to 7 (perfectly natural). The results suggest that adjectives (as in (29e)-(31e)) are more natural than nouns in these structures (as in b-d of (29)-(31)). But they also strongly suggest that additive social nouns (as in (29c,d)-(31c,d)) are more acceptable than multiplicative natural-kind nouns (as in (29a,b)-(31a,b)).[6] Moreover, in support of the view that comparisons indeed involve quantification on dimensions, the acceptability of a predicate in comparisons such as in (29)-(30) correlated with its acceptability in constructions with explicit quantifiers on dimensions and exception phrases that weaken generalizations on dimensions, as in (31). Correlations were moderate to strong (in most of the cases, their coefficients ranged between 0.5 and 0.9).

(29) Within-predicate comparisons: "X is more NP than that Y"
  a. #This piece of fruit is more an orange than that one.
  b. #This farm animal is more a cow than that that one.
  c. ?This booklet is more a diary than that one.
  d. ?This artist is more a composer than that one.
  e. This {piece of fruit, farm animal, booklet, artist} is more attractive than that one.

(30) Between-noun comparisons: "X is more NP_1 than (Y is) NP_2"
  a. ?This piece of fruit is more an orange than an apple
  b. ?This farm animal is more a cow than that one is a horse
  c. This booklet is more a diary than a sketchbook
  d. This artist is more a composer than that one is a poet
  e. This {piece of fruit, farm animal, booklet, artist} is more exciting than boring.

(31) Dimensional quantifiers/exception phrases: "X is NP, {in, except in} n respects"
  a. #This vegetable is (not) a potato in {some, most, all} respects.
  b. #This predator is (not) a tiger except for its teeth number.

[6] Metalinguistic comparisons also exhibit this acceptability difference (cf., (30c) vs. (30a)). This supports the availability of a reading involving comparison of the number of dimensions of each compared predicate, whose norm an entity exceeds, as in (17d). This is predicated by the quantificational hypothesis in (22), but is not expected assuming their only reading is based on degrees of any type of averaged similarity of entities to nominal prototypes (cf., (27)-(28)) or on metalinguistic scales of appropriateness or imprecision.

c. ?This place is (not) a church in {some, most, all} respects.
d. ?This girl is (not) a genius except with respect to literature.
e. This {piece of fruit, farm animal, booklet, artist} is exciting in {some, most, all} respects/ except in one respect.

In sum, social additive nouns accept readings based on dimension counting more easily than natural-kind multiplicative nouns, and accordingly, we see differences in their acceptability in degree constructions. All in all, these results support the quantificational hypothesis in (22), as well as the view that nouns can denote at the type of degrees, as opposed to the view that nouns are odd in most degree constructions merely because they cannot denote at this type. In particular, between-noun comparisons such as (30a,c) seem to have readings involving fully fledged morphological gradability of the noun (a degree relation based on an averaged similarity scale or on direct counting of dimensions, as discussed in more detail in 2.3), as opposed to mere metalinguistic readings generated from nominal denotations of type <e,t>.

One may object to such an analysis on the grounds that such comparisons often seem to involve nominal dimensions with minor effects on categorization, dimensions that are only remotely connected to the true meaning of a noun. However, this fact may actually stem for the process of accommodation, which has to take place for nouns to occur in degree constructions. In this process, the dimensional weights are locally changed, such that important and unimportant dimensions are temporarily weighed equally. For instance, when natural kind nouns are interpreted additively and with equal dimensional weights, such that, e.g., having a certain number of duck properties of any sort suffices for membership in *duck*, we get an extended interpretation in which the noun may apply to non ducks, which bear superficial resemblance to ducks (e.g., duck toys or drawings). Upon such an interpretation shift, it becomes possible to use degree constructions with *duck,* which cannot be used to rank real ducks, such as *This is more a duck than that,* and *This is the most duck*. The word *duck* merely conveys *duck-like* (has n many duck properties), and this has consequences for the appropriateness or distance from the truth of the propositions expressed by *{This, That} is a duck*.

A similar shift occurs more easily in nouns such as *girl*, which are additive in the first place, but their dimensions don't all weigh equally in normal circumstances. Gradable traits which are associated with girls, but are relatively poor indicators of categorization, such as, e.g., loving pink, may gain influence on interpretation, such that *girl* is interpreted as equivalent to *girlish* ('has respects typical of girls'), thereby licensing degree morphology, as in the Hebrew combination *meod yalada* (‘very girl’, ‘very girlish/ immature’), the Spanish *Es muy hombre* (‘is very man’, ‘He is very much a man’; Espinal 2013) and the Mandarin Chinese *hen xuesheng* ('very student', 'very student-ish'; Li 2015). Social nouns are more often reported to co-occur with degree morphology in the languages of the world than natural kind nouns. On the present proposal this stems from their additivity.

Notice, however, that the adjective-noun distinction confounded the results of Wattanmaker's (1995) study. Many of the social concepts in many of his experiments were adjectives applicable to humans, and most of the natural kind concepts were nouns. Thus, the reported findings indirectly support the view that adjectives and social nouns tend to be interpreted by means of quantification or dimension counting significantly more often than natural-kind nouns. The next section reviews linguistic data suggesting that quantification on dimensions is indeed prevalent in categorization under adjectives.

2.2 **Quantification on dimensions in adjective categorization**

Native speakers intuitively judge entities as *identical* if and only if they are identical in *all* (or *most*) of the respects that count as relevant in the context. By contrast, they intuitively judge entities to be *different* if and only if they are different in *some* (at least *one*) respect. Objects are considered *clean* if and only if dirt of *no sort* (dust, stains, etc.) is attested on them, while they are considered *dirty* if and only if dirt of *some* sort is attested. Individuals with a slight cold are *not* strictly speaking *healthy*, since they are not *all* healthy, while one type of sickness suffices to count as *sick*.

Considering these, among many other examples, the following hypotheses emerge. First, the dimensions of adjectives seem to be integrated using quantification or counting operations. Second, the dimensions of positive adjectives (like, e.g., *identical*, *healthy* and *clean*) appear, as a default, to be integrated by means of *universal quantifiers* (ALL, NO). By contrast, those of their negative antonyms appear to be integrated by *existential quantifiers* (SOME); e.g., intuitively, to count as healthy, one cannot have any serious disease, whereas to count as sick, one must have some disease or other. Hence, *healthy* seems to mean healthy in ALL respects, and *sick* – sick in SOME respects. We may consider one to be healthy (or not to be sick) despite, say, high cholesterol only when this dimension is considered irrelevant. When using expressions like *all* or *everybody*, the standard practice is to ignore irrelevant entities (von Fintel 1994), but not to allow any other exceptions. Moreover, the discourse in a given context may revolve around, e.g., cholesterol problems, such that *healthy* and *sick* would associate uniquely with this dimension. Thus, positive adjectives also have weak interpretations.

Several corpus and judgment studies (Sassoon 2012, 2013b; Shamir 2013) explored these hypotheses. They suggest that, indeed, universal and existential quantification on dimensions is general among positive and negative adjectives, but rare in concrete nouns. The methodology exploited the fact that exception phrases indicate universal generalizations, which can have exceptions, unlike existence statements. This fact is illustrated by the higher acceptability of (32a,b) than of (32c,d) (von Fintel 1994; Hoeksema 1995; Moltmann 1995; Fox and Hackle 2006). Notice that, as logical theories predict, negated existential quantifiers are universal (cf., (32b)), and negated universal quantifiers are existential (cf., (32d)).

(32) a. Everyone is happy except for Dan
b. No one is happy except for Dan
c. #Someone is happy except for Dan
d. #Not everyone is happy except for Dan

In accordance, speakers tend to accept exception phrases with adjectives whose dimensions combine via an implicit universal quantifier ALL, but not with their negative antonyms, whose dimensions combine via an existential quantifier SOME, cf. the acceptability contrast in (33a,c) (Hoeksema 1995). And since negated existential quantifiers are universal and vice versa, the effect is reversed in the presence of negation. Hence, exception phrases tend to be accepted with negated existential adjectives, but not universal ones, as illustrated in (33b,d).

(33) a. I am **healthy** except for high blood pressure (bp) ($\forall F \neq bp$, I'm healthy in F).
b. He is **not sick** except for the flu ($\neg\exists F \neq flu$, He's sick in F/$\forall F \neq flu$, He's healthy in F).
c.#I am **sick** except for normative blood pressure (#$\exists F \neq bp$, $\neg$(I'm healthy in F)).

d.#I am **not healthy** except for (normal) cholesterol (#∃F≠ch, ¬(I'm healthy in F)).

These judgments are supported by distributional patterns, as revealed in a study of 1300 naturally occurring examples of the form 'Adj. except' with 8 antonym pairs in positive vs. negated contexts (Sassoon 2013b). Frequency of co-occurrence of an adjective with dimensional exception phrases depended both on adjective polarity (positive vs. negative) and context polarity (existence or absence of negation), which interacted significantly.

Universality, i.e., frequency of implicit universal quantification on dimensions, as measured by the frequency of exception phrase modification of an adjective in contexts without negation, was higher in positive adjectives (cf., (33a)) than in their negative antonyms (cf., (33c)), whereas **existentiality**, i.e. frequency of implicit existential quantification on dimensions, as measured by frequency of exception phrase modification of an adjective when negated, was higher in negative adjectives (cf. (33b)) than in positive ones (cf. (33d)). Moreover, in positive adjectives, universality was higher than existentiality, but in negative ones, it was lower.

These patterns were also reflected in results of surveys of acceptability judgments (e.g., Sassoon 2012). They support the view that negative antonymy systematically affects the force of quantifier on dimensions. The dimensions of positive adjectives tend to be bound by a universal quantifier, ALL or NO, while those of negative antonyms tend to be bound by an existential quantifier, SOME. In other words, by default, multidimensional adjectives are used to convey generalizations on dimensions, while multidimensional antonyms relate to counterexamples to such generalizations. Moreover, Shamir (2013) directly compared adjectival antonyms to concrete nouns, showing that these nouns are less acceptable with dimensional exception phrases than either positive or negative adjectives, in both negated and non-negated contexts ($p < .000$; cf. *#bird/not a bird, except for flying*/ *size*/ *wings*), in line with dimension binding via similarity operations, instead of quantification, as assumed in section 2.1.

At the same time, context can override the tendency for similarity-based dimension binding; e.g., in a scientific context at which birdhood is defined by means of n genes, it is acceptable to state that a certain exemplar *is a bird except with respect to 3 genes.* Similarly, Sassoon's (2013b) corpus results illustrate that context can override the tendency for universal and existential quantification in positive and negative adjectives, respectively. This is also evident from certain intuitive judgments; e.g., both the combination of *smart* and of *stupid* with *except in math* are natural, and so is *The ipad is a bigger iphone except you can't make calls*. In addition, the likelihood of multiplicative vs. additive dimension-binding in Wattanmaker's (1995) study was affected by the order of presentation (the number of preceding additive vs. multiplicative predicates). Other contextual factors await future research (see a pilot study in Sassoon 2012).

Returning to default contexts, we have seen that dimension-binding in nouns is mostly based on averaging functions (weighted-sums or -products), rather than quantifiers. This is in accord with the fact that the noun dimensions are normally neither necessary nor sufficient conditions for categorization (Hampton 1995). Noun dimensions are often binary (e.g., 'wings' and 'beak' for *birds*) and many. In contrast to adjectives, conceptual gradability in nouns emerges due to averaging on many of them, not due to counting or to a choice of a single scalar dimension.

The next section presents an analysis that aims to capture the data reviewed so far, including compositional derivations of interpretations for constructions with multidimensional predicates. It proposes that multidimensional adjectives denote a *dimension counting relation* R_A, namely a relation between entities and the number of dimensions which norm they exceed. In degree constructions, such interpretations generate propositions about the number of dimensions of a

predicate (all, many, some, more), which norm entities exceed; e.g., (17c), *The sofas are more similar than dissimilar*, can express the proposition that the sofas are similar to each other in more respects than they are dissimilar, and *The sofas are very similar* can express the proposition that the sofas are similar in many respects.

Moreover, it is proposed that *with respect to* PPs can adjoin to multidimensional predicates in order to introduce a dimension argument, and it is explained why they can do so only if the predicates they adjoin to denote dimension counting relations.

Once introduced, the dimension argument can be saturated, as in *clever in doing math*, which denotes the property of having higher than normal ability to do math, assuming math to be a dimension of *clever*. Or, alternatively, the dimension argument can be bound by an explicit or implicit quantifying expression as in *atypical in two respects, optimistic in some respects,* or *vital in every respect*. In degree constructions, such interpretations generate propositions about the degrees of entities in each one of a certain number of dimensions, e.g., two, some, or all of them. For example, in *X is more expensive than Y*, the comparison is of degrees on the scale of the unique member of the dimension-set of *expensive* (a function from entities to their cost). The proposition expressed is that for SOME dimension F of *expensive*, x is F-er than y (cf., (17a)). With the multidimensional adjective *healthy*, comparison can be along more dimensions; e.g., *X is healthier than Y* can express the proposition that for ALL or MOST health dimensions F, x is F-er than y (cf., (17b)).

2.3 Compositional derivations

The formal account developed in this section adopts the main tenets of the degree approach. Controversial matters (e.g., the hierarchical relations between AP and DegP) are orthogonal to the proposal, but certain views are adopted for concreteness sake, as follows:

(i) Syntax and semantics for the language as defined in Heim and Kratzer (1998).

(ii) A null degree morpheme *pos* in the projection DegP at the AP specifier of gradable adjectives in positive forms, analyzed as in von Stechow (2009), where the membership norm is an interval; e.g., *This chair is pos tall* is true iff for every degree d in *tall's* standard interval, $I_{tall,w}$, the chair is at least d tall: $\forall d \in I_{tall,w}$, $tall_w(x,d)$.

(iii) All the standard analyses of degree constructions. Degree morphemes (e.g., *pos(I_c), 2 meters, –er than Sue*) denote degree quantifiers (type <<d,t>,t>), which move from their original position DegP to resolve type mismatch, leaving behind a trace of type d. A raised degree morpheme applies to the degree predicate created by abstraction over its trace (Heim 2000).[7]

For example, the LF of the positive form *John is pos A* is: *pos(I_c)(λd.A(John,d))*. The degree predicate *λd.A(John,d)* denotes the set of degrees d such that John is A to at least degree d, $\lambda d.R_A(j,d)$. I_c is a free variable which within each context of use is assigned as a value the interval I_R that functions as the contextual standard interval of the adjective A. *Pos* denotes the determiner $\lambda D_c \lambda D. \forall d \in D_c$, D(d). Thus, *pos($I_c$)($\lambda$d.A(John,d))* is true iff $[\lambda D. \forall d \in I_R, D(d)](\lambda d.R_A(j,d))$ is true, namely iff $\forall d \in I_R, R_A(j,d))$, i.e., for every degree d in A's standard interval, John is A to at least degree d.[8]

[7] In *than*-clauses, it is commonly assumed that a silent WH operator moves, leaving a trace in DegP to be bound by a lambda operator at the embedded CP level (Bersnan 1973; Creswell 1976).

[8] Worlds and other indices (e.g., for time or assignment function) are omitted for simplicity.

The new part of the proposal concerns multidimensional interpretations of adjectives. An analysis analogous to that of one-dimensional interpretations is developed as follows. First, let us assume that adjectives A can be ambiguous between two readings. On their first reading they denote a degree relation which is based on some measurement or other, $\lambda d{\in}S_F\lambda x.R_F(d,x)$, where F is some dimension or other of A. We will return to discuss how this reading is generated toward the end of this section.

The second reading, $\lambda d{\in}S_{A\text{-respects}}\lambda x.R_A(d,x)$, is based on multiple dimensions. Recall that we treated the dimensions associated with multidimensional adjectives as predicates on their own right. Let Dim_A be the set of degree relations denoted by the dimensions of the adjective A, such that R_A is the relation between entities and the number of degree relations in Dim_A which norm they exceed, $\lambda n{\in}S_{A\text{-respects}}\lambda x.|\lambda R{\in}Dim_A.\forall d{\in}I_R,\ R(d,x)| \geq n$ (where for each possible degree relation R, I_R is its standard interval.) This relation holds between a degree (natural number n) and an entity x iff the intersection between the set Dim_A (of degree relations denoted by predicates that count as dimensions of A in the context of evaluation) and the set of degree relations that x exceeds every degree in their standard-interval, is of at least size n. The possible values of n are degrees on a scale $S_{A\text{-respects}}$ of cardinalities of sets of A dimensions (subsets of Dim_A), ranging from the cardinality of the entire dimension set $|Dim_A|$ to the cardinality 0.

For example, the adjective in *Ann is pos I_c optimistic* can be interpreted multidimensionally. This interpretation involves the setting of a standard I_n for $R_{Optimistic}$, namely one or more values n on the scale of cardinalities of dimensions of optimism, $S_{Optimistic\text{-respects}}$, such that, in order to count as optimistic in the context of evaluation, one has to exceed the norm of at least n many dimensions (degree relations R_F in $Dim_{Optimistic}$). A default value for I_n may be stored in the semantics of an adjective; e.g., by default, *healthy* is interpreted in terms of universal quantification over its respects (to be healthy one must have no disease), thus $|Dim_{healthy}|$ is by default its standard (meaning that its standard interval includes the maximum of the scale $S_{healthy\text{-respects}}$), whereas *sick* is interpreted existentially (to be sick, one must have one disease or other), thus 1 is its default standard (meaning that its standard interval only consists of the lower end of the scale: $\{1\} \subset S_{sick\text{-respets}}$). In other cases, as a default, the standard value is determined by context, as in the case of *clever* and *stupid* and presumably also *optimistic* and *pessimistic*. However, the data discussed in section 2.2 suggests that positive adjectives tend to be interpreted universally more frequently than existentially, whereas negative adjectives less so.

One advantage for a representation of the quantification introduced by adjectives using cardinality scales is that the quantification over respects introduced by adjectives such as, e.g., *healthy* and *sick,* cannot take scope over explicit quantifiers of type <<e,t>,t>. For example, *Some boy is healthy* cannot mean that for all or most health dimensions, there is some boy which is healthy with respect to them.[9,10]

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[9] I am indebted to Barbara Partee, who raised this issue.

[10] Recall that, within generalized quantifier theory, the interpretation of determiners like *every* has been recast in terms of conditions on the cardinalities of sets of entities (Barwise & Cooper 1981), such that the interpretation of determiners involved two numerical parameters, as follows. Det(A,B) is true iff the conditions Det poses on the cardinality n of the intersection $|A\cap B|$ and the cardinality m of the difference $|A-B|$ are met. For example, the restrictions posed by *some, every* and *most* are $n > 1$, $m = 0$, and $n > m$, respectively, and the restriction posed by *many* is $n > I_{many}$, where I_{many} is a context dependent value. The proposed interpretation of multidimensional adjectives only uses the n parameter, similarly to the interpretation assumed for *many* in recent theories (Hackl 2001; Solt 2009; Wellwood, Hacquard and Pancheva 2012; and Wellwood 2015).

Another advantage is that the multidimensional interpretation proposed introduces a variable over dimension counts, and thus allows degree modifiers to relate to dimension counts. For example, in some contexts, no single measurement of optimism is particularly salient. Rather, entities are ranked by the number of aspects at which they are optimistic in the context. Imagine, for example, a situation at which Ann is 100% certain about finding love, and Bill is only 85% certain about this, which is not as much as Ann is optimistic in this respect, but is enough in the context for him to count as optimistic with respect to love. By contrast, imagine that Bill is not only optimistic with respect to finding love, building a family, succeeding at work, and having good friends, but also about the world's prospects with regard to economy, pollution, and global piece, and about the weather conditions at any particular moment, whereas Ann is only optimistic with respect to personal issues, but not general ones. In this context, (34a) is true if *optimistic* denotes the single respect of optimism with regard to love, R_{love}, and false if *optimistic* denotes the multidimensional relation $R_{optimistic}$.

Assuming the standard LF in (34b) and denotation of *more*, λDλD'.Max(D') > Max(D) (Heim 2000), with the multidimensional interpretation of *optimistic*, (34a) is true iff the condition in (34c-d) holds, which is not the case in the given context as stated in (34e).

(34) a. Ann is more optimistic than Bill.
b. More(λd. Ann is d optimistic, λd. Bill is d optimistic).
c. $[\lambda D \lambda D'.Max(D') > Max(D)](\lambda n.|\ \lambda R \in Dim_{Optimistic}.\forall d \in I_R,\ R(d,bill)| \geq n)$
$(\lambda n.|\lambda R \in Dim_{Optimistic}.\forall d \in I_R,\ R(d,ann)| \geq n)$.
d. $Max(\lambda n.|\ \lambda R \in Dim_{Optimistic}.\forall d \in I_R,\ R(d,ann)| \geq n) >$
$Max(\lambda n.|\ \lambda R \in Dim_{Optimistic}.\forall d \in I_R,\ R(d,bill)| \geq n)$.
e. False because $|\{R_{love}, R_{family}, R_{work}, R_{friends}\}| < |\{R_{love}, R_{family}, R_{work}, R_{friends}, R_{economy}, R_{pollution}, R_{global\ piece}, R_{weather}\}|$.

(35) a. Bill is more optimistic than pessimistic.
b. More(λd. Bill is d optimistic, λd. Bill is d pessimistic).
c. $Max(\lambda n.|\lambda R \in Dim_{Optimistic}.\forall d \in I_R,\ R(d,bill)| \geq n) >$
$Max(\lambda n.|\ \lambda R \in Dim_{Pessimistic}).\forall d \in I_R,\ R(d,bill)| \geq n)$.

Similarly, the between-adjective comparison in (35a) can be interpreted along a single dimension such as R_{love}, or along the multidimensional relations, $R_{Optimistic}$ and $R_{Pessimistic}$, in which case the LF in (35b) is true iff the condition in (35c) is met, namely there are more dimensions at which Bill is optimistic than there are dimensions at which he is pessimistic. Antonym pairs are quite good in such comparisons, because it is easy to think of them in terms of a single set of dimensions, such that entities at one side of the standard interval of each dimensional scale are, e.g., *pessimistic* and entities at the other side are *optimistic*. Thus, fewer parameters have to be estimated than with pairs of adjectives with different dimension sets (e.g., *healthy* and *clever*).

The dimension counting readings are not always available. In particular, they are not licensed in contexts at which the dimensions cannot be regarded as equally important; e.g., in certain contexts both optimism about the world and optimism about oneself may count as relevant, but not equally much. It is particularly difficult to get a reading based on dimension counts in (36a) because one individual might have a life risking disease such as cancer, but be healthy otherwise, whereas the other individual may have several light diseases (e.g., flu, ear infection, and diabetes). Obviously, one life risking disease counts more than any number of diseases which are

not life risking. Thus, a reading based on comparison of dimension cardinalities can only occur in contexts at which no individual has a serious disease or both have (e.g., considering the lists of results of two patients with an equally dangerous cancer, or of two healthy adults, in a series of general medical tests, it is possible to call the one who is within the norm in more tests *healthier*). Comparisons of dimension cardinalities appear more naturally in other cases, as for example in (36b,c). They appear to be more dominant in more abstract domains, at which actual precise measurement is not quite possible, as for instance in (36d-h).

(36) a. Ann is healthier than Bill.
b. Ann's policy is healthier than Bill's
c. Ann's food is healthier than Bill's
d. This alien is more human than that one.
e. This robot is more human than that one.
f. This artist is {better, more exciting, more tolerant, more liberal, more conservative, more typical, more atypical of this area of Italy} than that one.
g. Ann is more tolerant than conservative.
h. The sofas are more similar than different.

For example, (36d,e) may compare the number of human traits each alien or robot has; e.g., in the case of (36d) one may consider for each alien whether it has human legs, human hands, human eyes, human voice, human thinking, etc., or for each robot, whether it has human laugh, human smile, human facial expressions, human behavior in different situations, whether it can dance or sing, make moral judgments, etc. In addition, (36g), may count as true based on a comparison of the number of respects in which Ann is liberal to the number of respects in which she is not, e.g., whether she is racist or antiracist, whether she is chauvinist or feminist, or whether she is open minded or not about matters such as abortion.[11]

In *#The sofa is more long than the table is wide*, we get that the sofa is long in more respects F than the table is wide. Since the two adjectives are one dimensional, this reduces to the requirement that the sofa be pos long, and the table not be pos wide. The reduced acceptability of examples like this can be explained by a general restriction on the distribution of *–er* and *more* to scales with 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 consists of only two values, 0 and 1, unlike the case of a multidimensional adjective, in which it consists of many more values. The same restriction may also explain the unacceptability of combinations of *–er* or *more* with predicates whose denotations are binary (e.g., *prime*; cf., Kennedy 1999).

Thus, comparison morphemes can apply to predicates of either dimensional degrees or of dimension counts, and so are many other degree morphemes, such as existential and universal degree modifiers, including, for example, *slightly, a bit* and *somewhat* vs. *completely* and *totally,* respectively, as applied to either dimensional (*wet, dry, full, empty*) or multidimensional

[11] *More* is commonly analyzed as decomposing into *many* or *much* and *–er* (Hackl 2001; Solt 2009; Wellwood, Hacquard and Pancheva 2012; Wellwood 2015). A decomposition of multidimensional readings of adjectives would render them complex expressions with *many* as a constituent (as in λnλx. x is pos F in n many respects F of A). Then the LF of (36h) would be *–er(λn. The sofas are pos F in n many similarity respects F, λn. The sofas are pos F in n many dissimilarity respects F)*, with *more* being the phonological realization of both *–er* and the occurrence of *many* in the matrix clause. *Many* of the than-clause would not be spelled out because it is identical to a constituent in the matrix clause, similarly to *tall* in the LF *John is taller than Bill is (tall)* (Heim 2000).

adjectives (*dirty, clean, healthy* and *sick*). To illustrate, examples (37)-(38) present the crucial steps in the derivation of meaning for sentences with *perfectly*. On the proposed view, quantifying modifiers can operate either on the degree component (as in *perfectly empty*) or dimension counting component of the interpretation of an adjective, as in *perfectly* {*healthy, safe, identical*}, in which experimental evidence suggests that *perfectly* is used to convey 'P in every respect'.[12]

In terms of semantic composition, assume that the LF of *Bill is perfectly healthy* is *perfectly(S_c)(λd.Bill is d healthy)*. It contains a free variable S_c of type <d,t>, whose value is set in each context to be the scale of which the degree predicate (e.g., λd.Bill is d healthy) is a subset. Assume that *perfectly* denotes the degree determiner $\lambda D_c \lambda D \subseteq D_c$. $D(Max(D_c))$, namely a function from scales D_c and degree predicates D to truth iff the degree predicate contains the maximum point of the scale D_c (cf., Kennedy and McNally 2005; Kennedy 2007). For example, when *healthy* relates to one of its dimensions, (37a) is true iff the conditions in (37b-d) are met, namely, Bill is healthy to every degree d on the scale $S_{\text{healthy-qua-virus}}$. However, when the adjective relates to its multidimensional reading, namely to a relation based on dimension counting, the truth conditions are as in (38b,c,d), namely the sentence is true iff Bill is healthy in every respect (he exceeds the norm in as many health dimensions as there are in the context).[13]

(37) a. Bill is perfectly healthy (uttered in relation to the virus he caught last week)
b. $[\lambda D \subseteq S_{\text{healthy-qua-virus}}. D(Max(S_{\text{healthy-qua-virus}}))](\lambda d.R_{\text{healthy-qua-virus}}(\text{bill},d) \geq d)$
c. $[\lambda d.R_{\text{healthy-qua-virus}}(\text{bill},d) \geq d](Max(S_{\text{healthy-qua-virus}}))$
d. $R_{\text{healthy-qua-virus}}(\text{bill}, Max(S_{\text{healthy-qua-virus}}))$

(38) a. Bill is perfectly healthy (= healthy in every respect).
b. $[\lambda D \subseteq S_{\text{health-respects}}. D(Max(S_{\text{health-respects}}))](\lambda n.|Dim(R_{\text{healthy}}) \cap \lambda R.\forall d \in I_R, R(d,\text{bill})| \geq n)$
c. $[\lambda n.|\ \lambda R \in Dim_{\text{healthy}}.\forall d \in I_R, R(d,\text{bill})| \geq n](Max(S_{\text{health-respcts}}))$
d. $|\lambda R \in Dim_{\text{healthy}}.\forall d \in I_R, R(d,\text{bill})| \geq Max(S_{\text{health-respects}}) = |Dim_{\text{healthy}}|$

On the proposed account, adjectives do not come out of the lexicon with a respect argument. But, clearly, certain adjective modifiers relate to dimensions directly, as in *healthy except for a slight cold* or *healthy in every respect*. In fact, it is even possible to use two different modifiers simultaneously one for the dimension counting component and one for the dimensional degree, as in *Ann is {slightly, perfectly} healthy in {every, some} respect*, or *Bill is in every respect healthier than Ann*. This also means that a degree variable and a dimension variable can indeed be part of one and the same derivation of interpretation. Explicit quantification over respects can be accounted for in the following way.

Assume that a preposition such as *with respect to* must occur to introduce into the derivation a respect argument. It projects a PP which adjoins to multidimensional adjectives. It denotes the modifier interpretation $\lambda R \lambda R_A$: $R \in Dim_A$. R, namely a function from a dimensional degree relation R, such as the one denoted by *(healthy with respect to) the flu*, and a multidimensional interpretation R_A, e.g., the dimension counting relation denoted by *healthy*, into R, providing that

[12] The acceptability and frequency of co-occurrence of *perfectly* with an adjective is in high correlation with its universality as opposed to existentiality scores, as defined in section 2.2 (Sassoon 2012, 2013a).

[13] Notice that *perfectly* selects closed scale predicates. The restriction to closed scales is added by assuming that the denotation of *perfectly* relates to scale maxima (Kennedy 2007).

R is a dimension of A (e.g., that not having flu is a health respect). The semantic composition is illustrated in (39a).

Importantly, for this semantics to work, it should employ a method to retrieve the dimension set Dim_A from the argument R_A. Crucially, the method to retrieve the dimension set depends on the type of degree relation – it is different for dimension counting relations and for relations based on multiple dimensions which do not involve counting, such as relations based on averaging (e.g., $\lambda d\lambda x.$ $(\mathbf{w_{F1}f_{F1}(x) + \ldots + w_{Fn}f_{Fn}(x)}) \geq d$ or $\lambda d\lambda x.$ $(\mathbf{f_{F1}(x)^{W_{F1}} \times \ldots \times f_{Fn}(x)^{W_{Fn}}}) \geq d$). I propose that the restricted distribution of *with respect to* and similar propositions results from the fact that they make use of a method which is only applicable to dimension counting relations. It is for this reason, that they are more acceptable with multidimensional adjectives than with nouns (cf., *#This bird is a duck with respect to flying/ color*). Hence, the condition '$R \in Dim_A$' in (39a) is a mere shorthand for 'providing that A is a dimension counting relations, R is one of the dimensions of A generating it'.

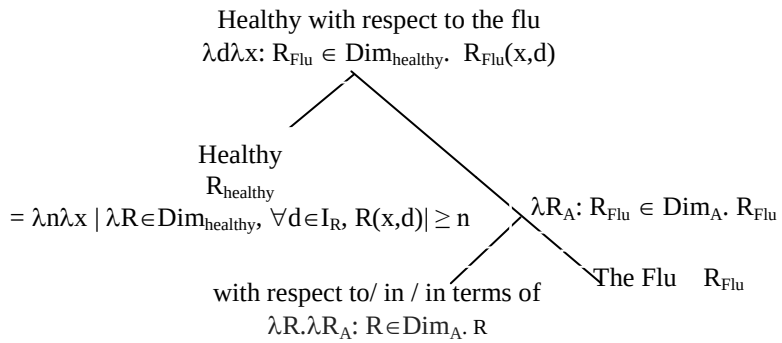
The method to test whether A is such a dimension works as follows. Consider a dimension counting relation such as $R_{healthy}$ and the set of dimensions $Dim_{healthy}$ generating it. A degree relation R_F is a member of $Dim_{healthy}$ iff for any two individuals, x_1 and x_2, if x_2, but not x_1, is within the norm of F ($\neg\forall d \in I_F$, $R_F(x_1,d)$, but $\forall d \in I_F$, $R_F(x_2,d)$), then all other things being equal (i.e., if x_1 and x_2 are both within the norm or both not within the norm of any other member of $Dim_{healthy}$), it follows that $Max(\lambda d.R_{healthy}(x_2,d)) - Max(\lambda d.R_{healthy}(x_1,d)) = 1$.

We see that in actuality, the semantics of *respect* phrases is only applicable to dimension counting relations. Other relations, based on averaging, won't do, because their dimensions cannot be identified using the above method. This explains the distribution of *with respect to* modification, which only applies to nouns in non default contexts at which they are associated with dimension counters (e.g., when birdhood is defined by means of a certain number of genes, cf. section 2.2).

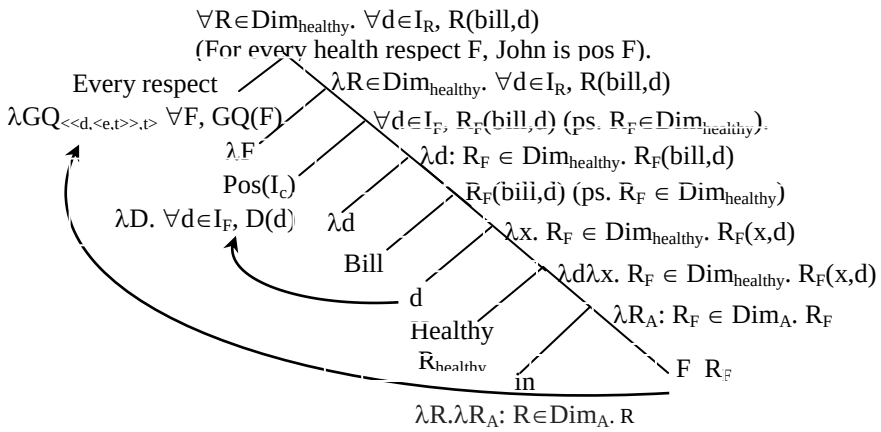
Next, PPs with quantifiers over respect arguments such as *in every respect* or *in some respect* have interpretations similar to the one in (38d), but their derivation involves explicit quantification over respects, as illustrated in (39b). First, the quantifier is raised leaving a trace F of type <d,<e,t>> within the PP adjoined to the adjective. The preposition heading the PP, *in*, has the same denotation as the preposition *with respect to*. It takes the meaning of the trace F, R_F, and the multidimensional reading of *healthy*, $R_{healthy}$, and returns the interpretation $\lambda d\lambda x$: $R_F \in Dim_{healthy}$. $R_F(x,d)$ (namely, the relation R_F, with the presupposition that it is a health respect).

Then, semantic composition proceeds as usual for positive forms. *Pos* raises leaving a trace of type d. The semantic values of that trace *d* and the subject *Bill* saturate the arguments of the degree relation R_F denoted by *healthy with respect to F*, and abstraction over d creates the degree predicate λd: $R_F \in Dim_{healthy}$. $R_F(x,d)$. Then, the degree determiner denoted by *pos* applies, resulting in truth iff R_F holds of Bill and every degree d in R_F's standard interval. At this point, abstraction over R_F yields a set of relations R which are health respects and Bill has every degree in their standard interval. This set feeds the quantifier denoted by *every respect*, resulting in truth iff Bill is within the norm of every contextually relevant health respect, i.e., he is healthy in every respect.

(39) a. Healthy with respect to the Flu



b. John is healthy in every respect



Having considered the way this compositional analysis captures the basic meaning and distribution of respect modifiers, let us move on to examine some additional data points in light of it. First, notice that a measure phrase can be added to an interpretation based on a dimensional degree, as in (40a).[14] However, there is no way to add a dimension-counting measure phrase at the position of *2 centimeters* (cf., (40b)). It is, however, possible to count dimensions using a PP as in (40c).

(40) a. The table is 2 centimeters longer than the sofa is wide.
b. #John is {two, many, all} respects {healthy, healthier than Mary}.
c. John is {healthy, healthier than Mary} in {many, all, ?two} respects.
d. #The sofas are {two respects, in two respects} more similar than dissimilar.
e. #The sofas are {slightly, somewhat, a lot} more similar than dissimilar.
f. #Bill is {slightly, a lot} more crazy than dumb (Morzycki 2011).
g. Ann is more optimistic than Bill: For n many (e.g., all, most, some) respects F in $Dim_{optimistic}$, more(λd. Ann is d F, λd. Bill is d F).

[14] Here, *-er* has three arguments, two degree predicates and a differential degree, as in: λDλD'λd.Max(D') – Max(D) ≥ d, and *2 cms* denotes the degree quantifier λD. D(2cm), which as usual, has to move, leaving a degree trace d that saturates the third argument of *–er*. The degree predicate created by abstraction over d saturates the argument of *2 cms*, such that the sentence is true iff the interval λd.Max(λd.long(the table,d)) ≥ Max(λd.wide(the sofa,d) + d) includes the degree 2cms (see Breakstone et al. 2011 for a detailed account and references).

The current analysis seems to correctly predict the unacceptability of (40b), as there is no respect-introducing PP in this structure. On the proposed account, the multidimensional reading of adjectives does not have a respect argument F, only a dimension-count argument n. Respect arguments are only introduced through modification by a proposition like *with respect to* and only by virtue of that quantifiers or numerals can occur, access and operate on dimensions.[15]

This account directly predicts the grammaticality of sentences with PP measure phrases such as those in (40c).[16] Finally, the unacceptability of PP respect modifiers in between-predicate comparisons (cf., (40d)) may relate to the structure itself. According to Morzycki (2011), other measure phrases are odd in it as well (e.g., compare to (40e,f)). These issues deserve more research in the future.

More important to our present interest is that the proposed account correctly predicts that, beside *pos*, other degree determiners can also occur in the specifier position of the modified adjective *healthy in every respect*, as in *healthier in every respect* or *perfectly healthy in every respect*. In fact, I propose that **often** the use of comparative forms such as those in (34)-(36) in contexts at which no particular dimension is under discussion triggers an interpretation involving implicit quantification over respects, as in (40f), because this interpretation does not necessitate accommodation of equal weights for the different dimensions of an adjective. Rather, quantification in natural languages tends to be restricted (von Fintel 1994), so it can range over life risking dimensions only, or over no life risking dimensions. Thus, e.g., it is easier to interpret *Bill is healthier than Ann* as stating that Bill is generally healthier than Ann (healthier in all or most contextually relevant respects) than as stating that he is healthier in more respects.

Moreover, plausibly, readings of multidimensional adjectives in which they refer to a single dimension are obtained through the application of an implicit respect operator such as the one denoted by *with respect to* (as when, e.g., *healthy* relates to the flu, or *optimistic* is understood to be about love). These proposals explain why the overall acceptability of multidimensional predicates in degree constructions correlates with the degree to which they can take a dimension counting relation as an interpretation and the degree to which quantification over their respects is possible.

Let us summarize. On the proposed account, most degree constructions with multidimensional adjectives A can be interpreted in one of the following way:

(i) as relating to the dimension counting relation, R_A.

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[15] The distinction between measuring (as in *2 centimeters longer*) and counting (as in *There are two more boys than girls in the room; ?There are two more problematic respects than there are good ones in this plan*) may be relevant here as well. *Respects* are not names of units of measurement, so they cannot be used to measure degree intervals, and multidimensional adjectives do not denote sets of respects, and since their denotation does not contain such individuals, it doesn't enable counting or quantifying over them directly (only through mediation by a *with respect to* phrase).

[16] The difficulty to interpret versions with a numerical respect phrase such as *two respects* may be related to the fact that measure phrases generally dislike modifying closed scale adjectives (cf., the acceptability difference between *The pool is 20 inches {deep, long, wide}* and *#The bottle is 200 milliliters full/empty*). Cardinality scales are not always closed, but in the case of cardinalities of sets of respects, the scales do seem to be closed, as the licensing of *perfectly* suggests. Intuitively, they seem to be finite and presumably relatively small sets which help speakers in the practice of making categorization decisions. They also seem to be vaguely defined, and subjective, and this as well makes the use of precise terms such as *two respects* or *85%* odd. Measure phrases generally appear where there are solid, objective facts that can be observed through a conventional procedure of measurement. But the sets of respects associated with multidimensional interpretations of adjectives are highly context and speaker dependent, and often not explicitly agreed upon.

(ii) as relating to a dimension, by virtue of implicit modification by a PP composed of a preposition denoting a respect operator, whose complement is one of A's respects.

(iii) as relating to a dimension variable in the scope of a quantifier, again, by virtue of modification by a preposition denoting a respect operator, whose complement is a quantifier (e.g., *every respect*).

What is predicted about the acceptability of multidimensional nouns in the given constructions? If they do not denote a dimension counting relation, none of these readings is expected to be possible, unless a shift in interpretation occurs. Hence, according to the proposed account, all nouns are expected to be less acceptable than adjectives in degree constructions. By default nominal dimensions are bound by averaged similarity operations, and thus nouns rarely denote dimension counting relations. For example, on this account, positive forms with a nominal predicate such as *This is a duck* and *She is a philosopher* are based on single complex degree relations, such as those in (41a,b). These relations are built from their dimensions not through dimension counting, but rather, through weighted sums or products of the dimensional degrees of entities. As a consequence, respect operators cannot be used to introduce a dimension argument, and for this reason, their dimensions are not accessible for quantifiers to bind.

(41) a. philosopher: $R_{philosopher} = \lambda d\lambda x.\ (\mathbf{w_{F1}f_{F1}(x) + \ldots + w_{Fn}f_{Fn}(x)}) \geq d$.

b. duck: $R_{duck}(x) = \lambda d\lambda x.\ (\mathbf{f_{F1}(x)^{W_{F1}} \times \ldots \times f_{Fn}(x)^{W_{Fn}}}) \geq d$.

c. philosopher' (after accommodation of binary dimensions of equal weights):
$R_{philosopher'} = \lambda n\lambda x.|\ \mathbf{\lambda R \in Dim_{philosopher}.\forall d \in I_R,\ R(x,d)}| \geq \mathbf{n}$.

d. more a philosopher than a linguist; more a car than a truck; more a duck than a goose.

However, additive nouns like *philosopher* are expected to be more acceptable than multiplicative nouns like *duck*, because under certain assumptions their interpretation can turn to one based on dimension counting. Assuming that the dimensional weights $w_1 \ldots w_n$ are of equal weight ($w = 1$) and the dimensional degree functions are binary (they only map entities to 0 or 1), the function in (41a) reduces to the function in (41c). This is an interpretation based on dimension counts such as those characterizing multidimensional adjectives. Thus, these nouns are expected to be relatively natural in degree constructions at which multidimensional adjectives can occur. The need to accommodate binary dimensions of equal weights is expected to only result in a small decrease in acceptability. By contrast, the same assumptions don't lead to a dimension-counting relation in the case of *duck*, because its original interpretation is based on multiplication rather than on addition, as illustrated in (41b). Hence, multiplicative nouns are expected to be less acceptable than additive nouns in degree constructions at which multidimensional adjectives can occur. Thus, the facts reviewed in sections 2.1-2.2 are captured.

A remaining question is whether, without mediation by a respect operator, degree morphemes such as, e.g., *-er, -est, slightly, perfectly, very, too,* or *enough*, can ever apply to degree predicates which are based on an averaged similarity relation which is not a dimension counting relation (e.g., (41b), or (41a) assuming that not all the dimensional weights, $w_{F1} \ldots w_{Fn}$, are equal and/or not all the dimensions $F_1 \ldots F_n$ are associated with binary degree functions). There are two possibilities. If nothing in the semantics of these degree morphemes prohibits degree predicates based on such relations, then in order to explain why nouns are not acceptable in these constructions, we have to postulate that nouns cannot denote degree relations, because grammar

forces them into the type <e,t> (so they directly denote entity sets such as λx. $(\mathbf{w_{F1}f_{F1}(x)} + \ldots + \mathbf{w_{Fn}f_{Fn}(x)}) \geq$ s, where s is a standard degree).

Alternatively, assuming that some restrictions in the semantics of the given degree constructions prohibit their application to degree predicates based on averaged similarity relations, then, even if nouns can indeed denote such relations, they would not fit in most degree constructions. This alternative suggestion also highlights the difference between degree constructions such as those discussed here and comparison constructions such as those in (41d), which stand out in being fully compatible with the averaged similarity scales of nominal predicates, and the metalinguistic scales associated with them (as was noted in section 1.3).[17]

The experimental results reviewed in section 2.1 seem to support this alternative suggestion. They suggest that nouns are good in degree constructions to the extent that they allow a shift to a dimension counting interpretation. This is expected given the proposal that the tested degree constructions are restricted to degree predicates derived from a dimension counting relation. By contrast on the hypothesis that nouns are always type <e,t>, an improved status in degree constructions for nouns in which the <e,t> denotation is allowed to be based on dimension counting (additive nouns) is unexpected.

3. Broader implications: Back to propositional and size modifiers

[17] For the deeper reasons for which most degree constructions dislike arguments denoting multidimensional degree predicates which are based on averaged similarity relations, the interested reader is referred to Sassoon (2013a, chapter 9) and (2016a).

Shortly, many degree constructions, including, e.g., *-er, -est, very, too,* and *enough*, appear to select for dimensions compatible with differential modifiers (*interval-scale* dimensions), as in *two inches longer* and *slightly shorter* (cf., Schwarzschild and Wilkinson 2002, and references therein). Interval-scale dimensions are based on a mapping of entities to degrees that correctly represent degree differences (rather than mere ordering between entities). Even relatively abstract adjectives seem to allow for an interval-scale construal, e.g., *slightly happier* and *a lot more beautiful* are acceptable combinations, perhaps by virtue of the dimension-counting interpretations of these adjectives.

In contrast, nouns appear to reject an interval-based construal. They seem to be mostly based on categorical dimensions (e.g., wings: yes/no) or ordinal dimensions (bird movement type: flying > swimming > running; see Gardeforse 2004 for multiple examples), and on averaged similarity functions, which seem to also be ordinal at best. These functions are mediated by the setting of many free parameters, e.g., dimensional weights and degrees. These free parameters can be assigned numerical values in multiple ways (Kamp and Partee 1995); e.g., along the dimension movement, all flying, swimming and running entities can map to 1, 1/2, and 0, respectively, or to 1, 2/3, 0, respectively, and so forth. Different numerical assignments yield the same entity orderings, but different degree differences. This creates a clash between nouns and most difference modifiers. The latter select as arguments degree predicates based on interval-scales (cf., *#two degrees a philosopher*; *#too chair; #a slight/bit duck; #very pine*).

Recall that between-predicate constructions, in addition to being compatible with nouns, are also incompatible with difference modifiers, as Morzicki (2011) observes (cf., (40e,f)). The two facts appear related.

A restriction to interval-scales can be added into the interpretation of degree constructions by assuming that their interpretation is mediated by a differential operator *diff*, which poses a constraint on the difference between the compared degrees, a constraint which has to be met given any degree assignment, i.e., in any world w' similar to w except in the numerical assignments of values to dimensional degrees and weights: $\lambda D_{<d,st>}.\lambda w.\forall w' \in W_c, \text{diff}(D_{w'})$ (Sassoon 2016a). Consider for instance, the morpheme *-er* and assume that it always has three arguments, as in: $\lambda D_{<d,st>}\lambda D'_{<d,st>}\lambda d\lambda w.\text{Max}(\lambda d.D'(d,w)) - \text{Max}(\lambda d.D(d,w)) \geq d$, and that *2 cms* denotes the degree quantifier $\lambda D_{<d,st>}.\ \lambda w.\forall w' \in W_c, 2\text{cm}(D_{w'})$. The sentence *X is 2cm longer than Y* is true in w iff in every accessible w', the interval $\lambda d.\text{Max}(\lambda d.\text{long}_{w'}(x,d)) - \text{Max}(\lambda d.\text{wide}_{w'}(y,d) \geq d$ includes a degree which is twice the degree assigned in w' to any centimeter long object (the difference between x and y is 2 cms in any w'). Such a condition is deemed false when differences between degrees of entities vary across worlds, as in nouns.

The present study has broader implications for our understanding of the range of possible interpretations of adjectives and nouns with various modifiers. One such implication concerns propositional modifiers that can express an attitude toward a proposition about degrees and thus serve as tests of predicate monotonicity, as explained in section 1.1.

Like other degree modifiers, they as well are predicted to be able to operate either on a dimensional degree relation, as Nouwen (2011) assumed (see (5) repeated below as (42a), which in words means that some degree to which Jasper is tall is surprising), or on a dimension-counting relation, at least in the case of multidimensional, additive predicates, as illustrated in (42b) (in words, some number of health respects which Jasper is within their normative range is surprising). Future research is required to assess how dominant such readings are, if at all. One way to test this is by assessing the acceptability of multidimensional predicates in these constructions and whether it correlates with their acceptability in constructions involving quantification on dimensions.

(42) a. $[[\text{Jasper is surprisingly tall}]] = \lambda w \exists d\text{: } \text{tall}_w(j,d) \,\&\, \text{surprising}_w(\lambda w'\text{:}\text{tall}_{w'}(j,d))$

b. $[[\text{Jasper is surprisingly healthy}]] = \lambda w \exists n \in S_{\text{health respects}}. |\text{Dim}_{\text{healthy},w} \cap \lambda R \forall d \in I_R, R(j,d)| \geq n \,\&\, \text{surprising}_w(\lambda w' \exists n \in S_{\text{health respects}}. |\text{Dim}_{\text{healthy},w'} \cap \lambda R \forall d \in S_R, R(j,d)| \geq n)$.

Moreover, the acceptability of nominal degree-modified constructions as in (43) with additive vs. multiplicative nouns can be assessed. An advantage to additive nouns would support the availability of an interpretation of the sort given in (43a), and so will a correlation with constructions involving quantification on nominal dimensions as in (43b,d). This semantics formulates the intuition of de Vries (2010) regarding the interpretation of *total* as positing quantification on nominal dimensions (e.g., (42b) is true iff Jasper is within the norm of every idiocy respect F). The readings in (43a,b) seem to exist because, e.g., *genius* and *idiot* are additive, so their interpretation can shift into one based on dimension counting, as explained in 2.1 and 2.3. Thus, they license degree modifiers such as *incredible* and *total*. In addition, their dimensions can be made accessible for quantificational operations to bind, through the introduction of a respect argument, as in (43c,d).

(43) a. $[[\text{Jasper is an incredible genius}]]_w = \lambda w \exists n \in S_{\text{genius-respects}}. |\lambda R \in \text{Dim}_{\text{genious},w} \forall d \in I_R, R(j,d)| \geq n \,\&\, \text{incredible}_w(\lambda w'\text{: } \exists n \in S_{\text{genius-respects}}. |\lambda R \in \text{Dim}_{\text{genious},w} \forall d \in S_R, R(j,d)| \geq n)$.

b. $[[\text{Jasper is a total idiot}]]_w = \lambda w. |\lambda R \in \text{Dim}_{\text{idiot},w}. \forall d \in I_R\, R(j,d)| \geq \text{Max}(S_{\text{idiot-respects}})$.

c. $[[\text{Jasper is a genius in math}]]_w = \lambda w\text{: } R_{\text{math},w} \in \text{Dim}_{\text{genious},w}. \forall d \in I_{\text{math},w}, R_{\text{math},w}(\text{bill},d)$

d. $[[\text{Jasper is a genius in every respect}]]_w = \lambda w\text{: } \forall R \in \text{Dim}_{\text{genious},w}. \forall d \in I_R, R(\text{bill},d)$

The proposed analysis of *total* is analogous to the analysis of *perfectly* proposed in (38). However, *perfectly* allows for an additional reading in which it operates on a degree of a dimension of the gradable predicate in the clause, as in (37). A parallel reading has been claimed to be absent here, i.e., *Jasper is a total idiot* cannot mean that in some idiocy respects F, Jasper is totally F (as in, e.g., $\lambda w.\ \text{idiot-in-math}_w(j) \geq \text{Max}(S_{\text{idiot in math},w})$), because gradable nouns like *idiot* and *genius* have been thought to not have a prototype and thus to violate the demand for a scale maximum. This assumption, however, is at odd with the intuition that a prototypicality scale does exist, even if some of the dimensions it is based on have an open scale; e.g., Einstein is a

prototypical example of *a genius*, even though more intelligent people are imaginable, which may be more prototypical. This case can be captured by representations as in (41).

An explanation for the missing reading can nonetheless be given based on the present study. This explanation deserves additional theoretical and practical research in the future. The given interpretation may be difficult to get because a precondition for the acceptability of nouns in degree constructions is accommodation of binary dimensions with equal weights. But with binary dimensions, namely dimensions which scale consists of only 0 and 1, quantifiers over degrees such as *total* are expected to be odd, because, presumably, their licensing is conditioned on a domain of quantification bigger than 2.

Notice that this account predicts that in languages that allow combinations of degree morphemes like *very* with (some) additive nouns (e.g., Hebrew, Spanish and especially Mandarin Chinese), a combination such as *very man* can only be analyzed as conveying 'has many properties of men'. It cannot be analyzed as relating to dimensions selected by a *with respect to* operator, because accommodation of binary dimensions is required for *man* to be able to denote a dimension counting relation, which is required for the licensing of a *with respect to* operator. But a binary dimension is not compatible with degree morphemes. This prediction seems to be borne out, but more research is needed to test it systematically. The analysis may extend to the English combination *real man* (see discussion of adjectival modification shortly). In this use of *real*, modification as in *{very, perfectly} real man* is expected to only be possible to use in order to express 'has {many,all} *man* dimensions'.

Yet other implications pertain to size adjectives such as *big* and *huge* in their positive forms. When modifying certain nouns, as in *this midget is a big fan*, they do not attribute big physical size. Morzycki (2009) argues that this interpretation of *big* occurs when it modifies a noun that is itself morphologically gradable; e.g., *smoker*, which Morzycki analyzed as denoting a measurement of frequency or affinity for smoking. On this view, size adjectives function as degree modifiers, similar to *very*, which map nominal degrees d to their relative size.

Morzycki further observes that nominal gradability readings of size adjectives are absent in predicate position (as in *the fan is big*), or in negative size adjectives (as in *a small fan just came in*, which relates to physical size, not fan-hood). These features are unique to nominal-gradability readings, as opposed to what he refers to as abstract size readings (as in *this mistake is big/small*) and significance readings (*he is huge!*). The position generalization is captured by postulating a morpheme *meas* in the nominal degree projection, which is not available in other positions. *Meas* takes as arguments a gradable noun, a size adjective, and an entity and returns truth if and only if the entity falls under the noun and its degree in the noun is big.

However, as Morzycki (2012) observes, this account does not explain why gradable nouns are not generally compatible with gradability morphemes (e.g., **faner, *fanest, *too fan*). The results reported in this paper give rise to a slightly modified account, which rests on the observation that the gradable dimensions of adjectives are often context dependent, and their choice is affected, among other things, by the noun they modify. For example, the dimension of *long* is different for tables than for stories. Assuming that nouns are themselves associated with dimension sets, size adjectives may, under certain circumstances, be able to access and operate on these sets.

The position generalization can be captured by postulating that, unless an adjective has a dimension set argument (as *typical* does in, e.g., *typical of birds*), only in attributive position can it access the dimension set of the noun it modifies, perhaps by virtue of a syntactic head whose semantics does the job. This syntactic head may denote an operation OP such that OP(R_{big})

would be a function from a nominal dimension counting relation (when such can be denoted by a noun), R_N, into a relation $R_{big\text{-}F}$ providing that *big-F* is a dimension of *big* and F is a dimension of the noun N in the context of use (accessed through the application of a respect operator), and the scale of $R_{big\text{-}F}$ is the upper subset of the scale of R_F. Thus, on this sketch of an account, OP(big) can apply to a noun N iff: $\exists R_F \in Dim_{N,w}$ s.t. $R_{big\text{-}F} \in Dim_{big,w}$ where $S_{big\text{-}F} = \{d \in S_F^+ \supset S_F: d > Max(I_F)\}$. For example, OP($R_{big}$,$R_{fan}$) is a relation $R_{big\text{-}F}$, whereby F is a feature of fans, big-F is a dimension of *big* in the context, and the scale of $R_{big\text{-}F}$ is the upper subset of the scale of F so that the domain of application of $R_{big\text{-}F}$ is the set of fans, and therefore, its standard interval, $I_{big\text{-}F}$, contains a degree that only big fans have. The resort to the extended scale S_F^+ is inspired by Morzycki's assumption that extreme adjectives (like I take *big F* to be) denote degrees off the normal scale (e.g., higher than those considered for *F*).

This is no more than a sketch of an account to be considered in the future. It uses Morzycki's logic, but spares the need to stipulate that size adjectives are adverbial (adnominal) modifiers, while most other adjectives are not. Hebrew data suggests that size adjectives can indeed be adjectives, because like adjectives and unlike adnominal or adverbial modifiers in this language, they agree in number and gender with the noun they modify (cf., *maa'ricot gdolot*$_{Adj}$; 'fan-**fem-pl** big-**fem-pl**'; 'Big female fans', vs. *mea'shnot kaved*$_{Adnom}$, 'smokers-**fem-pl** heavy-**male-sg**'; 'heavy smokers').

The set of examples of nouns modified by size adjectives reported in the literature (the so-called gradable nouns), typically, includes nouns such as *idiot, nerd, soccer fan, airhead, goat cheese enthusiast, simpleton, Barbie doll lover, loser,* and *weirdo* (de Vries 2010). All of these examples belong to the social domain (de Vries 2015). Thus, their dimensions are expected to be relatively accessible for grammatical operations to access and relate to or quantify over as in *big fan, idiot with respect to his political views* and *complete/total idiot*.

But this approach extends beyond size adjectives; e.g., to explain the different interpretations of *old* in *He is an old friend* and *This friend is old*, or of *heavy* in *He is a heavy smoker* and *This smoker is heavy*. In attributive position, dimensions of additive nouns may generally be available for adjectives to operate on, whereas in predicate position, only lexical dimensions of the adjectives themselves may be available (see also Constantinescu 2011).

A last observation is that all the examples of gradable nouns seem to have morphologically gradable open scale dimensions (e.g., *stupid, intelligent, admiring, enthusiastic*; de Vries 2010) which size adjectives select and use for their interpretation. But according to the story told in this paper, their contextual scales have to be rather coarse for them to be accessible for binding by grammatical operations. How coarse the scales really are is an open question. More research is needed. One prediction is that degree modification would be more acceptable with attributive adjectives when these are interpreted along one or more of their own lexically specified dimensions than when they select a dimension of the noun they modify. For example, the difference in acceptability between *heavy rock* and *heavier rock* should be smaller than the difference between *heavy smoker* and *heavier smoker*, as introspection does seem to suggest. That is, this analysis has the potential to explain the reduced acceptability of comparatives such as *John is a bigger genius than Mary* (Morzycki 2009).

These speculations deserve future investigation. At any rate, the attributive use of adjectives is acquired much later than their predicative use (Ravid and Levie 2010 and references therein), probably because it is far more complex. The present paper raises new aspects of this complexity, but a fuller account awaits more theoretical work also of additional aspects of this complexity.

To conclude, this paper has addressed the role of multidimensionality in the grammar of gradability. It has pointed out the semantic roles of dimension-binding operations, highlighting:

(i) connections between the acceptability of adjectives and nouns in degree constructions and related cognitive psychological findings about the meanings of their positive forms;
(ii) ways to derive compositionally various possible interpretations of degree constructions involving multidimensional predicates; and
(iii) new questions for future research to address.

Thereby, it aims to contribute to our understanding of morphological gradability and its underlying cognition.

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