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Adjectival versus Nominal categorization processes:
The Rule versus Similarity hypothesis

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Abstract

This paper presents the thesis that adjectives and nouns trigger processing by two different cognitive systems, those reported in the literature to be involved in the processing of rule-based versus similarity-based artificially construed categories, respectively. To support this thesis, the paper illuminates a number of links between findings reported in the literature concerning rule- versus similarity-based categories and a variety of corresponding structural, distributional, neural and developmental findings reported in the literature pertaining to adjectives and nouns. These links suggest that the rule versus similarity (RS) hypothesis for the adjective-noun word class distinction should be studied more directly in the future, by empirical means such as those available in the field of psycholinguistic research of rules and similarity. As part of the rule versus similarity hypothesis, the paper defends the thesis that nouns are conceptually gradable, but, unlike adjectives, their ordering dimensions are processed implicitly. Furthermore, nouns differ from multidimensional adjectives in that the nominal dimensions are incorporated through weighted mean operations (averaging), while adjectival dimensions are integrated through Boolean operations (such as *and* and *or*). Finally, the implications of the hypothesis are examined against several non-paradigmatic sub-classes of nouns and adjectives, including nominalizations, +human nouns, relational adjectives and Determiner-Adjective constructions.

1 The noun-adjective puzzle

Scholars generally agree that natural languages provide evidence for a typology of predicates consisting of word classes such as nouns, adjectives and verbs.[1] While nouns tend to occur in argument position, where their main function is to refer to objects, adjectives typically predicate of or modify arguments, thus occurring in predicate- or modifier-positions. Nonetheless, unlike verbs, adjectives rarely inflect for tense and aspect and in many languages for adjectives to occur in predicate position they have to combine with a copula or an affix.

Formal semanticists typically classify these different word classes uniformly as 'predicates', as in classical logic or other logical systems, disregarding the typologically dominant morphological, syntactic, functional and intuitive differences. While some semantic theories distinguish between verbs and other predicate types by taking verbs to denote actions or other event types, what distinguishes between adjectives and nouns? People intuitively suppose that nouns (like, for example, *bird*) denote 'object categories', while adjectives (like, for example, *red*) denote 'properties'. However, the difference between categories and properties is not well defined. After all, one cannot deny that *red* refers to the set of red objects and *bird* to the property of being a bird. Addressing this issue, I propose that nouns and adjectives trigger processing by different cognitive systems.

Empirical results demonstrate that grammatical categories have a neuroanatomical basis; for example, Miozzo et al 2010 review reports about bilingual aphasics involving disruption selectively affecting the production of verbs versus nouns and regular versus irregular verbs. Critically, these selective deficits were manifested in a strikingly similar manner across the two languages spoken by each of the individuals. To take another example, Cappelletti, Fregni, Shapiro, Pascual-Leone

and Caramazza (2008) show that the left prefrontal cortex is selectively engaged in processing verbs as grammatical objects. These authors write: "*Other word classes, like adjectives, may also be associated with distinct neural circuits, but the status of categories other than nouns and verbs has not been well studied."* (Cappelletti, Fregni, Shapiro, Pascual-Leone and Caramazza 2008, note 1, P. 718). This situation originates in part due to the fact that nouns and verbs are distinguished in human languages more than any other category, certainly more than adjectives (Evans 2000; Sapir 1921). At any rate, at present, we can still check the predictions of the proposal to be presented against somewhat indirect data.

Generally speaking, various aspects of lexical knowledge, including semantic dimensions (such as feline, pet and furry for *cat*), syntactic features (noun, countable) and morphological ones (type of plural inflection, etc.) are represented and stored with sufficient independence (Miozzo et al 2010), such that brain injury may disrupt one aspect of lexical processing while sparing others (see Rapp and Goldrick 2006 for a general review; for semantic versus other lexical features see Hillis and Rapp 2001 and Miceli et al 2002). To give a concrete example, one source of frontal activation reported in particular during verb processing relates to words' motor action attributes. Kellenbach, Wijers , Hovius , Mulder and Mulder 2002 used event-related potentials to investigate whether processing differences between nouns and verbs can be accounted for by the differential salience of visual-perceptual and motor dimensions in their semantic specifications. Three subclasses of nouns and verbs were selected, which differed in their semantic dimension composition (abstract, high visual, high visual and motor). While ERP effects were observed for both grammatical class and dimension type, there were no interactions between these. The effects of grammatical class (verbs vs. nouns) did not differ significantly between the semantic dimension types (abstract, visual, and motor) and, conversely, the effects of semantic dimension type were equivalent for each grammatical class . This pattern of effects provides support for lexical-semantic knowledge being organized in a manner that takes account both of category-based (grammatical class) and dimension-based (dimension type) distinctions (Kellenbach et al 2002: 564-5).

What, then, do word class distinctions represent? What semantic essence underlies the adjective-noun distinction, which is independent of the type of dimensions in their dimension list, thus compatible with this general type of findings? The present study investigates the proposal that, rather than on the dimension list, the difference between nouns and adjectives hinges on the default way the dimensions are incorporated. The basis for this idea comes from the cognitive-psychological study of categorization and concept learning of artificially construed categories. The literature concerning such categories is huge and often appears to contain inconsistent results. However, on a survey published in *the Annual Review of Psychology*, Ashby and Maddox (2005) argue that a consistent picture is revealed when studies are divided by categorization task. In particular, rule vs. similarity-based tasks have different neural and developmental correlates. The main distinction between rule vs. similarity based categories lies in the type of categorization rule, i.e. the way the categorization criteria ('dimensions') are combined to form categorization judgments. Classification in rule-based categories depends on a single dimension or a simple enough conjunction or disjunction of dimensions – one that subjects can reason about explicitly. In accordance, processing is by an explicit (declarative) memory system, namely, a system for storing, retrieving and otherwise processing memories we are aware of and can declare about. Conversely, in similarity-based categories, information about instances' degrees in multiple dimensions is integrated, typically by averaging or in a

holistic 'gestalt' manner. Crucially, these types of information integration occur at an early processing stage. In accordance, the dimensions and the ways they are incorporated are hardly accessible through introspection. Processing is reflexive and automatic, namely accomplished through an implicit procedural memory system. This paper explores the hypothesis that the morpho-syntactic cues distinguishing between adjectives and nouns in those languages exhibiting these cues trigger processing by the rule vs. similarity-based categorization systems, respectively.

Assume that dimensions are themselves predicates, not more and not less. In each context c, let each predicate, whether a noun or an adjective, be associated with (i) a degree function, Deg(P,c), i.e. a mapping of entities to degrees, (ii) a cutoff point, Standard(P,c), such that entities are P iff their degree in P exceeds P's cutoff point, and (iii) a set of predicates, F(P,c), P's dimensions in c; these assumptions are all justified later on in the paper. The interpretation of the dimensions of a predicate constrains the interpretation of the predicate (and vice versa) in a systematic way (Sassoon 2007); importantly, it does so in different ways in nouns and adjectives.

1) The Rule vs. Similarity (RS) hypothesis for the noun-adjective distinction
   a. *Nouns denote similarity-based categories*: They are associated with multiple dimensions (characteristic features) which are incorporated through mean operations at an early processing stage. Thus, for an entity to be classified under a noun, its mean degree in the dimensions of the category (or of one of its exemplars) should reach the membership threshold ('standard').
   b. *Adjectives denote rule-based categories*: They are associated with either a single categorization criterion or a set of criteria which are incorporated through Boolean operations (conjunction or disjunction, or equivalently, universal or existential quantifiers). Thus, to count as an instance of an adjective, an entity has to reach the standard in either a single dimension or a dimension-conjunction or -disjunction. The processing of the dimensions is explicit. Hence, as illustrated in section 1.2, adjectives, but not nouns, have dimensional argument slots that can be overtly saturated or bound.

The basic motivation for the hypothesis in (1) is that it provides an attractive solution to the category vs. property puzzle related with the noun-adjective word class distinction. Why are nouns and adjectives intuitively seen as denoting 'object categories' and 'properties', respectively? Each object corresponds to a plurality of dimensional values. According to the rule vs. similarity hypothesis, more features of denoted objects are encoded as part of the interpretation of nouns than of adjectives. Thus, in designating objects' means in multiple dimensions, nouns are more readily identified with the denoted objects than adjectives are. What is more, according to the rule vs. similarity hypothesis, speakers are aware of the adjectival dimensions, but are unaware of the nominal ones. Thus, speakers experience nouns as directly designating object sets, while adjectives are experienced as designating (predicating) single properties of objects, namely the ones corresponding with their dimensions. According to this new perspective, formal semanticists are correct in unifying the semantics of nouns and adjectives, both eventually denote object sets. At the same time, the intuitive category vs. property distinction is also justified by a difference in processing, i.e. whether dimension integration involves explicit or implicit memory systems.

This is the basic or intuitive motivation for the RS hypothesis. This paper is dedicated to showing that a variety of consequences of this hypothesis are supported

by empirical findings. The paper does so in three steps. As a first step, it examines whether classification in adjectival and nominal categories can indeed be described as rule-based and similarity-based, respectively (cf. section 1). At this stage, it is shown that an explanation of significant semantic differences between adjectives and nouns can be based on the RS hypothesis. As a second step, the paper asks whether what we know about the brain mapping and acquisition of adjectival and nominal categories is consistent with the rule versus similarity hypothesis. The preliminary answer given to this question in section 2 is positive. As a third and last step, the paper illustrates how the rule versus similarity hypothesis can handle a number of non-paradigmatic sub-classes of nouns and adjectives in English and in other languages.

The basic prediction of the RS hypothesis (cf. (1)) is the following.

2) a. If adjectival dimensions are rules, they function as categorization criteria.
   b. If nominal dimensions integrate by averaging, they do not add categorization criteria.

The rest of section 1 surveys evidence to the effect that the predictions in (2a,b) are borne out.

1.1. Mean-based classification in nouns

1.1.1 Similarity (mean-based) dimensions

Experimental results established that speakers characterize nominal concepts (nouns and noun phrases) by a rich set of dimensions. For example, the noun *bird* is characterized by dimensions like feathers, small size, flying, singing, perching, eating insects, etc.[2] (Rosch 1973).

On the one hand, Wittgenstein (1968 [1953]) and Fodor et al (1980) have shown that the dimensions that speakers associate with nominal concepts are not definitional (they do not stand for necessary conditions for membership in the denotation). Their arguments were supported in experiments with many different types of nouns (Hampton 1979 and 1995). Naturally, abstract words such as, for instance, *happines*, *war*, *identity*, *difference* and *possession* are typically characterized by complex clusters of non-definitional, characteristic features. Also, it is relatively easy to see that no clear cut criteria distinguish between chairs, armchairs and sofas or between glasses and vases. Yet, it has also been shown that, for example, kinship categories, which can be defined precisely, are typically processed using multiple similarity (mean based) dimensions, not categorization criteria; e.g., the category *boys* could be processed as the intersection of males and children (non-adults), but in practice people use a much richer cluster of non-definitional perceptual and behavioral features. Even the dimensions of natural-kind concepts are often not treated as strictly necessary for membership. For example, a horse genotype is intuitively thought to be necessary for horses. Yet, experiments show that entities that possess, for instance, a zebra genotype, but due to a special diet or medical treatment become highly similar to horses in appearance and behavior, are often judged to be horses. Nor do the noun dimensions stand for sufficient conditions for membership. For example, popes and homosexuals who have been living with a partner for many years are adult males that were never married, but are they 'bachelors'? Finally, the nonexistence of a definition is by no means constrained to ordinary use; it has been shown that experts such as doctors, rentgen technicians and bilogists use sympthomatic rather than definitional

features to characterize, e.g., desease types, x-ray findings and species, respectively (Murphy 2002).

On the other hand, empirical studies have established that the noun dimensions help to measure typicality (exemplariness) and membership likelihood, i.e. they function as ordering dimensions. The most influential approach in the psychological analysis of concepts is called the prototype theory. The origins of the prototype theory go back to Wittgenstein (1968 [1953]) in "Philosophical investigations", and within cognitive psychology it has become a unified approach due to the extensive work of figures like Eleanor Rosch, Tversky and their associates.[3] The most central alternative to the prototype theory is formed by the exemplar theory. By and large, other cognitive approaches can be seen as branches of these two theories.[4] The conclusions drawn in this paper remain intact given the renovations of the exemplar approach. Thus, for reasons of space and clarity, the paper focuses on prototype models.

According to these theories an entity is classified under a natural concept iff its mean degree in the dimensions of the category or of one of its exemplars reaches a standard. For example, an entity is classified as a *bird* iff (roughly) its mean degree in the dimensions of *bird* (small size, feathered, winged, flying, perching, singing, eating insects, etc.) or of some *bird* exemplar (e.g. *robin, pigeon,* etc.) exceeds the standard.[5] These concept-theories, which analyze nominal concepts as mean-based, are extensively supported (for an extensive review see Murphy 2002; Hampton 1998). The weighted means predict judgments of exemplariness, likelihood and speed of classification, speed of retrieval, accuracy of memory, etc.

First and foremost, the last forty years of research in cognitive psychology have established beyond doubt that speakers consider certain entities as better examples than others of concepts that nouns denote. For example, robins are often considered more typical or representative of birds than ostriches, and bats are considered more related or similar to birds than cows. The weighted mean of an item on the concept's dimensions is a good indicator of its typicality. For example, robins average better than ostriches on *small, flying, perching, singing, eating insects*, etc. In addition, the weighted mean of an item on the dimensions of contrasting concepts is inversely related to its typicality in the concept. For example, if two items have the same weighted mean on the 'bird' dimensions, the one with the lower mean on the dimensions of, for instance, mammals, is regarded as a better example of a bird (Rosch and Mervis 1975).

Second, Hampton (1998) has found a very strong coupling between the typicality ratings and the ratings of membership-probability, in about 500 items of 18 nominal concepts (as published by McCloskey and Glucksberg 1978). When deviations occurred, they were highly systematic. Thus, in nominal concepts, typicality and (subjective) membership likelihood tend to go together. These and other experimental findings suggest that pretty often nouns have borderline cases. Significantly, speakers' judgments about the concept membership of, for instance, curtains for 'furniture' or avocado for 'vegetables', are much less consistent then their judgments about clear instances (McCloskey and Glucksberg 1978; Murphy 2002).

Third, the typicality judgments are connected to numerous processing effects. Most importantly, typicality correlates with online categorization times. For example, when robins are considered better examples of birds than ostriches, verification time for sentences like "A robin is a bird" is faster than for sentences like "An ostrich is a bird" (Rosch 1973; Roth and Shoben 1983). Retrieval of concept instances from long term memory appears to be performed by means of serial search which begins with the best examples of the concept (Rosch 1973 : 140-141).

1.1.2 Some formal details: Similarity as inverse mean-distance

Given these data, in standard concept theories, concepts P are associated with a set ('cluster'), F(P), of representative dimensions (typicality features), e.g., F(bird) consists of flying, feathered, winged, small, etc. This set is often called *the prototype* or *summary representation* of the concept. Each dimension F in F(P) has an attention weight W_F. For example, W_{size} tells us how important size is in discriminating birds from non-birds. In addition, P has a selected value on F, ideal(P,F). For example, ideal(bird,size), represents the ideal size for birds. In the prototype theory, typicality in a concept is conceived of as similarity to its prototype. For example, the similarity of a robin to a bird is indicated by the extent to which it matches the prototypical values in the bird's dimensions.

Formally, the *distance* of an entity d from P along a dimension F, D(d,P,F), is the difference between d's and P's values on F (cf. (3a)). If d and P completely match on a dimension the distance is 0. Otherwise, the distance may in principle be infinite (but distance is usually modeled on a 0 to 1 scale). When the dimensions are treated as non-gradable (as mapping entities to either degree 1 or degree 0), distance in a dimension is, accordingly, either 0 or 1.

3) a. The distance of d from P in a dimension F:
$$D(d,P,F) = |\, deg(d,F) - ideal(P,F) \,|$$
b. Arithmetic mean-distance (for $F(P) = \{F_1, \ldots, F_n\}$):
$$D(d,P) = W_{F_1}D(d,P,F_1) + \ldots + W_{F_n}D(d,P,F_n)$$
c. An arithmetic categorization criterion: $[[P]] = \{d \in D \mid D(d,P) \leq n\}$

The *mean distance* of d from P (in the concept's dimension set), represented for simplicity using an arithmetic mean, is the sum of d's (weighted) degrees in every dimension (cf., (3b); the dimension weights are all positive, and they sum up to 1). The *similarity* of d to P, S(d,P), is assumed to be inversely related to d's distance from P, D(d,P). The more typical instances of a concept are more similar to its prototype (their mean degree on the dimensions is higher). Thus, by identifying typicality with similarity to the prototype, the prototype approach derives the basic typicality effects, namely, the fact that speakers order entities by typicality and the fact that the noun dimensions are ordering dimensions, which together help mapping entities to degrees.

Finally, categorization is assumed to be based on similarity to the prototype. A certain similarity degree forms the categorization standard. An entity is classified as P iff its similarity degree reaches this standard. In other words, categorization is a process in which it is decided whether the mean distance of an entity from the concept's prototypical values on the dimensions is small enough (smaller than some standard mean distance n; cf. (3c)).

This standard-based categorization-principle accounts for many typicality effects. First, it predicts the fact that likelihood of categorization is, by and large, monotonically related to similarity to the prototype. Second, the existence of borderline cases (or a gap) in nouns is now predicted, because for some entities it may not be clear whether they reach the standard or not (if their degree is very close to the standard, or if the precise standard is unknown). Since nouns clearly exhibit properties of vague concepts (in particular, different forms of the Sorites paradox), this feature of the analysis is also a basis for an account of vagueness effects in the nominal domain. Third, by assigning important dimensions (like "horse genotype") a particularly high weight, this principle

derives the intuition that they can almost count as necessary and sufficient for membership. They might be violated only if the values on the other dimensions may compensate (may be sufficient to reach threshold; Hampton 1979). Fourth, the online processing effects are predicted, too. In items with low degrees in some dimensions, more dimensions need to be considered in order to determine that they reach threshold.

Last but not least, the set of known concept members, [[P]], plays a crucial role when the concept standard is unknown. A criterion like (3c) predicts that newly encountered entities, whose mean similarity is higher than that of already known members, can be automatically regarded as members. Thus, this theory allows for a finite memory representation for concepts (or predicate intensions). It captures the fact that we can determine membership of infinitely many new instances under the concepts we are familiar with, on the basis of a finite set of known facts (dimensions and members).[6]

The typicality (mean-based) effects in nouns are robust and pervasive. Citing Murphy (2002):

> *"As a general observation, one can say that whenever a task requires someone to relate an item to a concept, the item's typicality influences performance"* (Murphy 2002: 24).

Thus, the prediction in (2a) is robustly supported in cognitive psychology. It is mainly the second type of prediction regarding adjectives as rule-based (cf. (2b)) that needs to be further explicated and justified. This will be the main concern of the next section, along with a discussion of certain problems with the gradable semantic analysis of nouns presented above.

1.2. Rule-based (Boolean) classification in adjectives

1.2.1 Conceptual versus morphological gradability

In 2.1 we have justified a gradable analysis of nouns. However, this type of analysis of nouns and noun phrases is often rejected by linguists for the following reasons. Although numerous psychological facts show that, conceptually, nouns are gradable (they map entities to their mean degree on a set of dimensions), a variety of semantic facts show that nouns are usually incompatible with degree structures. The term *gradable* is used in semantics to refer to predicates, like *tall, bald, old, large, good, healthy,* and *clever*, namely, adjectives, which are distinguished from nouns by several characteristics. First and foremost, gradable predicates can felicitously combine with comparative morphemes (as in "Sam is cleverer than Dan"), superlatives (as in "the cleverest"), degree modifiers (as in "very clever" and "too clever"), etc. A few adjectives (for instance, *extinct, even, married* and *nuclear*), and all the nouns in languages like English (e.g., *bird, apple* and *chair*), are classified as *non-gradable,* because they cannot felicitously combine with these comparison- and degree-morphemes, as demonstrated in (4).

4) a.* Tweety is more (a) bird than Tan is
   b.* Tweety is the birdest
   c.* Tweety is very / too (a) bird

To account for these facts, generally, semantic theories assume that in gradable predicates (unlike non-gradable ones), entities possess the properties to different extents (or degrees). Entities are judged to be instances of gradable predicates iff the extent to which they satisfy the relevant gradable property (the ordering dimension) is within the norm, that is, iff they reach the standard for membership under that predicate, standard(P,c) (5a). The qualities or attributes that permit grading are denoted by comparative relations like 'taller' or "less tall" (5b) (von Stechow 1984; Klein 1991).[7]

5) a. A standard-based membership criterion:

$$[[P]]_c = \{ d \in D \mid deg(d,P,c) \geq standard(P,c) \}$$

b. A degree-based ordering criterion:

$$[[\text{more } P]]_c = \{ \langle d_1,d_2 \rangle \in D^2 \mid (deg(d_1,P,c) - deg(d_2,P,c)) > 0 \}$$

These semantic theories assume that the interpretation of non-gradable predicates, including virtually all nouns, does not involve any mapping of entities to degrees. They are directly associated with object sets, not degree functions. This explains the incompatibility of nouns with comparative structures like "more P than", superlatives, and other degree modifiers.[8]

A notorious advantage of the hypothesis in (1) is that it suggests a principled explanation for both the psychological and linguistic facts. Despite the fact that both nouns and adjectives are conceptually gradable in the sense of being related with a degree function, the graded structure is implicit in nouns and explicit in adjectives. Upon processing of a nominal concept, speakers are only aware of the object set eventually construed based on the entities' mean degrees in the dimensions. Thus, speakers reject combinations such as **more bird* claiming that all birds are equally good category members. In opposition, while processing adjectival concepts speakers are aware of the graded structure and the scale it imposes, thus accepting modification of adjectives by degree morphemes. What is more, the ordering imposed by a nominal concept can easily be accessed through the use of any adjective that takes a nominal argument and returns its graded structure, as in *better example of a bird, more typical of a bird, more normal, characteristic, representative,* or even simply *more of a bird*, which can be understood as equivalent to any one of these relations (6a-b). As these relations are based on adjectives, whose interpretation is by default processed explicitly, a graded structure is consciously available in virtue of which the combination with a comparison morpheme is judged well-formed and perfectly interpretable.

6) a. A robin is more typical of a bird than an ostrich
b. A robin is more of a bird than an ostrich
c. The noun activity is 'nounier' / less 'nouny' than the noun bird (Ross 1973)

In fact, nouns turn easily into adjectives, by adding a morpheme like 'y', as in *birdy*, and the resulting adjective is readily gradable, as demonstrated in (6c). This fact is hard to explain if nouns are directly associated with an object set, but it is captured easily by the assumption that nouns readily provide a set of dimensions. Normally, these dimensions are processed implicitly (in a mean based fashion), but they can be processed explicitly when the noun saturates the internal argument of an

adjective like *typical of* (its 'dimension-set' argument) or combines with an adjectival affix like 'y'. Thus, the RS hypothesis explains why it is so easy to recategorize nouns as adjectives and vice versa (as in *tally, the beautiful, an Italian,* etc.) Also, as the next section attempts to show, it correctly predicts the similarity and differences in interpretation in minimal pairs such as *bird / birdy*, *bird / typical of a bird* and *an Italian/ Italian*.

Other examples of adjectives that are used to access nominal graded structures include size adjectives as, for instance, in *a huge idiot*; see Morzycki 2009 for discussion) and quantity adjectives like *much* as, for instance in *this is pretty much a chair*.

The only degree construction in English I am aware of in which nouns occur bare (with no mediating adjective or other morpheme) is the between-predicate comparison (comparison of the form "more P than Q"). Nominal concepts are licensed in this construction more freely than adjectives are, as, for example, in *more a bird than a horse, more a car than a truck, more an Italian than a Japanese* and so on. Speakers treat such comparisons as perfectly grammatical and interpretable, despite the fact that they cannot always say precisely what the underlying scale is. These facts, which are usually not noticed or not addressed by semantic theories, are hard to explain if nouns are non-gradable and not associated with ordering dimensions, but they are straightforwardly captured by the RS hypothesis (the assumption that the linguistic interpretation of nouns is based on mean functions). Plausibly, between predicate comparisons favor nominal mean functions over one-dimensional adjectival functions (cf. ?*more green than long*; Kennedy 1999), because the former but not the latter are readily normalized for the purpose of averging and thus comparable (construed as having a shared scale; Sassoon 2007).

In conclusion, the new perspective seems to be promising and fruitful as a basis for explaining the semantic contrasts between nouns and adjectives, and it is considerably improved in terms of its psychological adequacy. It explains why nouns are conceptually gradable, yet do not directly combine with degree morphemes. All in all, nouns behave very much like our standard formal semantics for gradable predicates would expect. They map entities to degrees and they are linked with ordering dimensions. Nouns also exhibit vagueness effects (including borderline cases and instantiations of the Sorites paradox), which typically accompany gradable, rather than sharp concepts. Thus, by assuming that the semantic interpretation of nouns is non-gradable, linguists pay a heavy price in terms of the dissociation between the semantics they assume for nouns and many other things that we know about them. All things considered, the assumption that nouns *are* semantically gradable seems better off. In addition, nouns combine with "more-of" comparatives, and with degree modifiers like "pretty much", and they are licensed in between-predicate comparisons (comparisons of the form "more P than Q") more freely than adjectives are. The infelicity of nouns in, for instance, within-predicate comparisons, must have reasons other than lack of gradable meaning; a possible reason is the implicit nature of the nominal dimensions and mean function; only special constructions ("more P than Q") or, mainly, adjectives (like *typical* and *much*) are capable of accessing the nominal dimensions (processing them explicitly; more on this shortly).

1.2.2 Conceptual dimensions versus linguistic 'respects'

Semanticists standardly assume that the meaning of one-dimensional adjectives like *tall* includes an ordering dimension, such as 'height' (Kennedy 1999). In fact, many

gradable adjectives are linked with several ordering dimensions (Kamp 1975). For example, the adjective *healthy* can be ordered on a number of dimensions, such as *blood pressure, pulse, fever* and *lung functions*; the adjective *intelligent* can be ordered on dimensions such as *mathematics, literature* and *personal relations,* etc. The range of dimensions in the interpretation of adjectives is highly context dependent (Klein 1980: 6-8). Significantly, the contextually relevant dimensions of a multi-dimensional adjective can be overtly specified as part of its argument structure, using a "with-respect-to" (wrt) prepositional phrase (as in "healthy with respect to blood pressure"). In addition, grammatical operations can access the dimensions of multi-dimensional adjectives and operate on them (Bartsch 1986; Landman 1989). For example, we can quantify over these dimensions or respects (as in "healthy in every respect" and "generally healthy"). The oddness of combinations like "tall with respect to height" and "tall in every respect" is likely due to the fact that 'tall' is a one-dimensional adjective. As for nouns, although they are clearly associated with ordering dimensions, for reasons which are not immediately obvious, they differ from gradable adjectives in that their dimensions cannot be accessed by grammatical operations, like wrt-operators or quantifiers, as demonstrated in (8) (for a discussion of exceptional nouns see section 3).

7) a. Tweety is healthy in every respect
   b. Tweety is generally healthy
8) a. #Tweety is a bird with respect to flying / size
   b. #Tweety is generally a bird

Again, these facts are explained by the RS hypothesis. First, according to the RS hypothesis nouns are associated with a set of weighted dimensions, but the integration of entities degrees in these dimensions occurs at an early processing stage, a stage speakers are not aware of. This explains the fact that grammatical operations such as quantifiers and 'with respect to' phrases cannot access the nominal dimensions (as illustrated by the infelicity of, e.g., *#Tweety is a bird in every respect*; *# generally a bird*; *#a bird wrt flying*, etc.) The nominal dimensions are bound by a mean-based operation at an early processing stage, which yields immediate categorization judgments (an object set). Thus, the dimensions involved go unnoticed. Put differently, nominal dimensions are not handled each one separately, they are automatically integrated via averaging, which is incompatible with having a dimensional argument role.

Conversely, adjectives have respects arguments. When their respect arguments are saturated (as in, e.g., *healthy with respect to blood pressure*) or bound (as in, e.g., *healthy in every respect*), the dimensions function as categorization criteria**,** as predicted by the RS hypothesis (cf. (1b),(2b)). Finally, also wrt-modification and quantification over dimensions, which are impossible in bare nouns become possible if the nouns are slightly modified.

9) a. Tweety is a typical bird in every respect
   b. Tweety is generally typical of a bird
   c. Tweety is typical of a bird wrt flying/ size

When a nominal concept saturates an adjectival argument as in (9) (or turns adjectival via an adjectival suffix as in, e.g., *birdy*), its semantic interpretation changes systematically. This change is not problematic because nouns are readily associated

with a set of dimensions; it is only the mode of processing of the dimensions that changes. Instead of incorporating them by means of averaging (through the similarity-based categorization system), they get incorporated by means of Boolean operations, i.e. they are processed through the rule based system, namely through explicit memory. The procedure is open to introspection. The number of dimensions selected can be consciously monitored and this fact can be expressed using grammatical operations, as illustrated in (9).[9]

In fact, intuitively, modifying a predicate P with a wrt-phrase makes sense only when several dimensions are treated as necessary conditions for membership in either its positive or its negative denotation, and as a consequence, entities may indeed be regarded as P in one respect and as "not P" in another respect. Thus, a predicate P can be modified by a wrt phrase (i.e. it can assign a 'wrt' argument-role) iff each of P's dimensions can function as a categorization criterion, as in *healthy wrt blood pressure, but not healthy wrt lung functions*. Conversely, in nominal concepts like *bird* or *not a bird*, the dimensions are normally not necessary for membership. At best, some of them are very important typicality dimensions. Thus, nouns normally do not license 'wrt' phrases. In fact, when the nominal dimensions do add categorization criteria, a wrt phrase *is* licensed. For instance, if an expert characterizes birds by the possession of, say, 100 separate genes, which all and only the known birds possess, she might indeed describe new species that possess only 50% of these genes, as *birds in this respect, but not in that respect*. This is clearly a scientific context in which the noun's use relates to a definition deviating in nature from its ordinary daily interpretation. At any rate, we see that a rule-based ('definitional') processing goes hand in hand with the licensing of a respect argument slot.[10] Finally, in the dimension set of one-dimensional adjectives like *tall*, we cannot find two different dimensions that form necessary conditions for *tall*, so the requirment for the licensing of a wrt-phrase is not met. All considered, a wrt-phrase can only be licensed in multi-dimensional adjectives.

Like any other argument, the wrt-parameter can interact with determiners (as in "is healthy in every respect"). And in fact, a determiner which quantifies over respects states how many of the dimensions form necessary conditions (add categorization criteria) in the context of use. As discussed in the next section, interactions with (explicit or implicit) quantifiers turn out to be particularly relevant to the analysis of adjectives.

Importantly, the RS hypothesis does not exclude the possibility of implicit processing of some parts of an adjective's interpretation; rather, it requires awareness of a certain categorization dimension. For example, colour concepts are construed based on aspects such as saturation and hue; these dimensions were revealed through empirical research; standard speakers are hardly aware of their role in colour categorization (they are processed implicitly). Thus, these dimensions do not function as adjectival respects. However, speakers explicitly associate each colour term with a single scalar property which they regard as a basis for the categorization criterion, i.e., colour predicates are conceived by speakers as one-dimensional. These single scalar properties, then, count as interpretation respects. Indeed, across languages, color terms are usually adjectives (Dixon 1982) and infants acquire them significantly later than nouns (Bornstein 1985).[11]

To recapitulate, an additional piece of evidence supporting a different analysis for nominal and adjectival dimensions is, then, the fact that natural languages refer to them by different names. While the adjectival dimensions are called *respects* (as in, e.g., *Dan is not healthy in three respects: bp, pulse and fever*), the nominal

dimensions can be called *typical* (as in *Flying, singing and perching is typical of birds*). This would be unexpected had these dimensions been exactly the same. Before moving onward, let me emphasize two important remaining points.

First, phrases starting with the words *in the sense of* are on first sight similar to wrt-phrases; however, they are very different in that they are much less selective in terms of their distribution. Every predicate can have different senses, but only adjectival (rule-based) senses can, each, have multiple respects, for the reasons just discussed. Second, as numerous examples from the corpus of contemporary American English (COCA 2010) illustrate, different uses of wrt-phrases exist, which are not dimensional-argument uses, i.e. not relating to a dimension of a word sense. These uses can be licensed with nominal concepts, perhaps even more easily than with adjectival ones.

One irrelevant use regards spatial or comparison relations. In this type of usage, wrt phrases can be substituted with *relative to* and *compared to* or *in comparison with*.

10) a. What is second wrt the third?
    b. …is in a 30 degrees position wrt the horizontal axis
    c. …high velocity with respect to earth

'The third' is not a dimension of interpretation of *second* (neither a categorization criterion nor an ordering mean-based criterion), and 'the horizontal axis' is not a dimension of *30 degrees position* in the above sense. Nor is 'earth' a dimension of *velocity*. Rather the arguments of these wrt phrases (*the third*, *the horizontal axis* and *the earth*) are individuals or discourse entities similar to those denoted by the nominal concept modified by the wrt phrase (*the second, 30 degrees position* and *high velocity*, respectively); they stand in some relation (a sequence relation, a spatial relation, a comparative relation of e.g. higher velocity, etc.) In opposition, *blood pressure* does not stand in a spatial or comparative relation with *healthy*; rather, it functions as a categorization criteria of *healthy* in the sense that in order to count as healthy, one has to have normative blood pressure.

Another irrelevant use pertains to wrt-phrases marking a subject matter argument or a topic of discussion. In this usage, wrt phrases can be substituted with *about, concerning, regarding* or *of*. Characteristic nouns with a subject matter argument include, for example, *problem, situation, question, hypothesis, position, opinion, proposal, rules, views, information, knowledge, roles, agreement, disagreement* etc.

11) a. During our tenure, there was the question wrt Macedonia of its diplomatic recognition…
    b. Another is the situation wrt strategic weapon, which continues to be a matter of friction between us
    c. That was the failure wrt 9/11
    d. Where is the difficulty wrt the matter of the coherence of Smith's varying statements…

"Strategic weapon" is not a dimension of interpretation of *situations* (neither a categorization criteria nor an ordering mean-based criteria), and 9/11 is not a dimension of *failure* in this sense. At best, these are examples of situations (problems) and failures, respectively. In opposition, *blood pressure* is not an example of a healthy individual, but rather a categorization criteria in the sense that in order to count as healthy, one has to have normative blood pressure.

At any rate, it is not the case that wrt phrases are generally common with other abstract nouns (*war*) or relational nouns (*mother*), certainly not in a dimensional interpretation. In fact, considering COCA 2010, a balanced and annotated linguistic corpus, one finds three times as many uses of wrt phrases with adjectives than with nouns in copula constructions, as in *is Adj. wrt* versus *is a/an/∅ noun wrt*. The proportion of wrt phrases among the "copula + noun" counts is 0.00006, while the proportion of wrt phrases among the "copula + adjective" counts is 0.00018 (three times as much; cf. Table 1). A more fine-grained analysis of the distribution of uses of wrt phrases with adjectives versus nouns awaits future research.[12,13]

Table 1: Wrt-pharses in COCA, April 2010

	Is a P wrt	**Are P wrt**	**Was a/an/∅ P wrt**	**Were P wrt**	**Will be a/an/∅ P wrt**	**Total**
A nominal P	8	6	1	1	0	**16**
An adjectival P	121,015	38,906	79,878	17027	4891	**261,717**
	Is a P	**Are P**	**Was a/an/∅ P**	**Were P**	**Will be a/an/∅ P**	
A nominal P	42	27	16	27	2	**114**
An adjectival P	221,774	131965	178874	70059	20148	**622,820**

In conclusion, psychological theories that treat nouns as gradable and multi-dimensional, fail to explain important semantic contrasts. A main difficulty with incorporating a gradable analysis of nouns (and noun phrases) into the semantic theory is that important distinctions might become blurred. First, if nominal concepts denote degree functions, it is not clear why they are incompatible with (within-predicate) comparatives, equatives and other degree modifiers. Second, if nominal concepts are multi-dimensional, it is not clear why it is impossible to quantify over their dimensions. It seems that a larger problem is looming behind these questions, namely the problem of giving an adequate account of the semantic distinction between nouns and adjectives. A notorious advantage of the RS hypothesis (cf. (1)) is that it suggests a principled explanation for these facts, which hinges upon distinctions in the type of graded structure (degree function and dimension type) and processing course of nominal and adjectival concepts.

1.2.3 Bare multidimensional adjectives as rule based

Previous studies of adjectives pay little attention to multi-dimensional adjectives (like *healthy*, *normal*, *similar*, *typical*, etc.) and the way they differ or do not differ from nouns. We have seen that when adjectival dimension arguments are explicitly saturated (as in, e.g., *healthy wrt blood pressure and lung functions*) or bound (as in *healthy in every respect*), they function as categorization criteria. However, an open question is what happens when a multidimensional adjective occurs bare, as in, e.g., "John is healthy". Do the dimensions incorporate through Boolean operations such as conjunctions and quantifiers also in this case? It is quite intuitive to think that they are not; rather, in this case we use averaging. However, if we look at speakers' judgments with respect to this question more carefully, a different picture is revealed.

Consider, for example, a context in which health is measured by the dimensions *blood pressure*, *pulse* and *fever*. Imagine that Dan has the maximal degree in two of

these dimensions, but is not within the norm in the third. Conversely, imagine that in all these dimensions, Sam's levels are within the normative range, but they are the lowest possible, so Dan's mean on the dimensions is higher (cf. Figure 1).

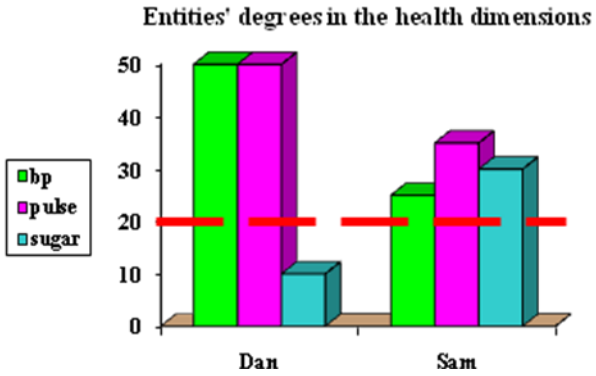


Figure 1: Dan's average health level is higher but, unlike Sam, he has one non-normative value

Intuitively, in this scenario, Sam is healthy, but Dan is not, because Sam, but not Dan, reaches the norm in all the contextually relevant respects. Because of that, intuitively, Sam is healthier than Dan. But this shows that it is not the case that we directly compare Sam's and Dan's means on the dimensions. Had we done that, we would have judged Dan to be healthier than Sam. Rather, first, we fix negative and positive denotations for healthy, *based on dimension intersection* (for the positive denotation, we select entities that reach the standard in all the dimensions). Afterward, we fix the ordering relation to be such that positive denotation members are always healthier than negative denotation members. And only then if at all, do we allow comparisons based on mean degrees, such that among the positive denotation members, those which average better in the dimensions are regarded as healthier, and among the negative denotation members, those which average better are regarded as healthier.

If these observations are on the right track, they show that indeed there exists a systematic semantic difference between nouns and adjectives. While nominal denotations consist of entities whose mean on the dimensions is sufficiently high, the situation is different in adjectives (see also Bale, 1997). First, in adjectives like *healthy* and *typical of a bird*, the denotation consists of entities that fall under *all the dimensions* (e.g., when one is healthy in every respect except one has the flu, strictly speaking, one is *not healthy*). Thus, the default interpretation of these adjectives involves universal quantification ('all') over dimensions (cf. figure 1). Let us call these adjectives 'conjunctive', as stated in (12b). Second, in adjectives like *sick* and *atypical*, the denotation consists of entities that fall under some dimension, possibly only one. For example, an entity that is sick in but one respect is intuitively judged to be sick. Thus, the default interpretation of these adjectives involves existntial quantification ('some') over dimensions (cf. figure 2). Let us call these adjectives 'disjunctive', as stated in (12c).

12) Let $F(P,c) = \{F_1 \ldots F_n\}$ be the dimension set of P in context c; $\forall c \in T$, $\forall d \in D$:
    a. If P is *nominal*, $d \in [[P]]_c$ iff $S(d,P,c) \geq standard(P,c)$, where S is defined in section 1.1.2.
    b. If P is a *conjunctive-adjective*, $d \in [[P]]_c$ iff $\forall F \in F(P,c)$: $d \in [[F]]_c$,
    (iff $d \in [[F_1]]_c$ *and* … *and* $d \in [[F_n]]_c$)

c. If P is a *disjunctive-adjective*, $d \in [[P]]_c$ iff $\exists F \in F(P,c)$: $d \in [[F]]_c$
(iff $d \in [[F_1]]_c$ *or* … *or* $d \in [[F_n]]_c$)

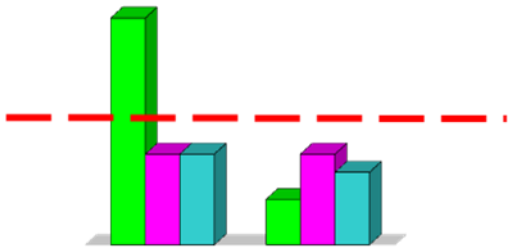


Figure 2: Only Dan has a non-normative value on a health criterion

In particular, predicates of the form "typical of P" are conjunctive multi-dimensional adjectives. Their (default) interpretation is mediated by a universal quantifier over P's dimension set, as demonstrated in (13).[14] This proposal derives the intuition that the adjectival phrase "typical of P" is stronger than the nominal predicate P (it has more categorization criteria), although it is hard to put a finger on the exact dimensions which add criteria, since the dimension set is context dependent, and since the possibility of implicit 'wrt' modification (as in "typical wrt flying") or even of non-default quantification (as in "typical in some respects") is always available.

13) a. $[[\text{Dan is typical of a bird}]]_c = 1$ iff
$\forall F \in F(\text{typical of a bird},c)$: $[[\text{Dan is F}]]_c = 1$
(Dan is typical in every respect).
b. F(typical of a bird,c) = {typical wrt size, typical wrt flying,…}
c. $[[\text{Dan is typical of a bird wrt size}]]_c = 1$ iff
$|\ \deg([[\text{Dan}]]_c,\text{size}) - \text{ideal}(\text{bird},\text{size})\ | < n$ (cf. (3a-c))

A features like, e.g., *feathered*, which is very important for the concept *bird*, may well loose its central status when considering the corresponding adjective *typical (of a) bird* (Hampton 1979, 1998); this is predicted, since additional, less important *bird* dimensions turn into ctegorization criteria of *typical of a bird* along with *feathered*.

How can we empirically explore the typology in (12)? The context-dependency of the adjectival dimensions makes it hard to experimentally support or refute, e.g., a conjunctive dimension-integration hypothesis. It is hardly possible to design a questionnaire or a classification procedure that will completely control subjects' dimension selection. But only this will allow to say whether subjects in fact treat all the dimensions they select as categorization criteria (as predicted), or not (counter the proposal's prediction). However, a new corpus-based method can be used to overcome these difficulties, which is based on the following two facts. First, exception phrases can operate on dimension sets (as in *healthy except for high blood pressure*); second, the licensing of exception phrases demands an accompanying universal (or quasi universal) quantification as in (14a-b).

14) a. **Everyone** is happy **except** for Dan
b. **No one** is happy **except** for Dan
c. #**Someone** is happy **except** for Dan

(14c), is, therefore, infelicitous except in an alternative "in addition to" interpretation; the only interpretation that interests us here is unavailable (the one whereby Dan presumably does not sing, as in (14a)).

Thus, compatibility with exception phrases can form evidence for the hypothesis that the interpretation of an adjective involves universal quantification over dimensions, rather than existential quantification or averaging. Our proposal predicts that 'except' will be freely licensed as an operation on the dimension-set of conjunctive adjectives. This prediction is borne out by the facts. A simple google search for key-words like "healthy except", "typical except" and "healthier except" provides abundant examples, as demonstrated in (15).

15) a. I am a 64-year-old man, quite healthy except for high blood pressure...
b. Sam's early development was considered typical except for slight articulation
errors noted in kindergarten which resolved spontaneously.
c. … my Mother's family, mainly tradish, eat more of the tradish foods and they
seem to be healthier except the cancer aspect
d. $[[\text{Dan is healthy except wrt blood pressure}]]_c = 1$ iff
$\forall F \in (F(\text{healthy},c) - \{(\text{healthy wrt}) \text{ blood pressure}\}): [[\text{Dan is F}]]_c = 1$
(Dan is healthy wrt every dimension except blood pressure).

Conversely, we predict that this will hardly ever occur with disjunctive-adjectives, whose default interpretation is mediated by an existential quantifier (and hence a non-default universal interpretation is likely to be explicitly marked, as in "sick in every respect"). Example (16) shows that indeed 'except' cannot operate on the dimension set of a (bare) disjunctive adjective, and in fact, Google searching for key-words like "sick except" and "atypical except" barely provides any examples of this sort.

16) # They appear to be sick, except for the diarrhea

Finally, our proposal predicts that a *negated* disjunctive adjective like "not sick" will denote the set of entities that fall under *no* 'sick' dimension. For example (17a), an example of a negated use of 'atypical', is understood as conveying that the children were atypical in no respect, except for their inteligence. Crucially, 'no' is a universal quantifier. Thus, we predict that 'except' phrases will occur as operating on the dimension-sets of negated disjunctive adjectives, and again, this turns out to be the case, as the examples in (17) demonstrate.

17) a. Apparently, the children were not at all atypical, except that they were brighter than the average high- school Senior
b. They do not appear to be sick, except for the diarrhea
c. $[[\text{Dan is not sick except wrt blood pressure}]]_c = 1$ iff
$\neg\exists F \in (F(\text{sick},c) - \{(\text{sick wrt}) \text{ blood pressure }\}): [[\text{Dan is F}]]_c = 1$ iff:
$\forall F \in (F(\text{sick},c) - \{(\text{sick wrt}) \text{ blood pressure }\}): [[\text{Dan is F}]]_c \neq 1$
(Dan is sick wrt no feature, except blood pressure).

Generally, then, negated universals are existential, and vice versa (as the equivalences in (18a-b) illustrate.) Hence exception phrases are expected to combine with negated disjunctive, but not conjunctive, adjectives (18c-d).[15]

18) a. (healthy ⇔ healthy in *every* respect) **iff** (not-healthy ⇔ not-healthy in *some* respect)
b. (sick ⇔ sick in *some* respect) **iff** (not-sick ⇔ sick in *no* respect)
c. Dan is not sick, except for blood pressure (= sick in no respect except b.p.)
d. ?? Dan is not healthy, except for high blood pressure

Hence, in order to test quantitatively the predictions of the proposal that adjectival dimensions are integrated through Boolean operations (**conjunction** and **disjunction** or equivalently **universal** and **existential** quantification), rather than mean operations (averaging), I have done the following. First, the data found in linguistic corpuses is rather poor due to the low frequency of exception phrases. Hence, non-linguistic corpuses should be used such as the world wide web. Despite many possible artefacts (including, for instance, productions of non-native speakers), Lapata and Keller (2005) show in a variety of ways that Google-based counts correlate with frequencies obtained from a carefully edited, balanced corpus such as the BNC and they reliably predict speakers' judgments.

All the items searched were put in inverted commas (as in: "healthy except"). This means that other word orders are ignored, but it is a necessary step in order to reduce much inrrelevant data. Furthermore, certain uses of exception phrases are irrelevant and should be ignored. Examples include phrases with an explicit occurrence of (quasi) universal quantification, as in (19), e.g., in (19a) we find the expression *everything* which suffices to licence an *except* phrase. Hence, we cannot use this example as evidence to the view that *healthy* triggers accomodation of an an implicit universal; this procedure is tricky, as universal quantification can sneak in in very many ways.

19) a. **Everything** normal except for high blood pressure
b. **Nothing/ Little** abnormal except for high blood pressure
c. **The** tests appeared normal except for high blood pressure
d. **Totally/ Completely/ Absolutely** healthy except for failing eyesight
e. **Otherwise/ All in all** healthy except for failing eyesight

Also uses in which *except* does not operate on the adjective's dimensions, illustrtaed in (20)-(22), should be ignored.

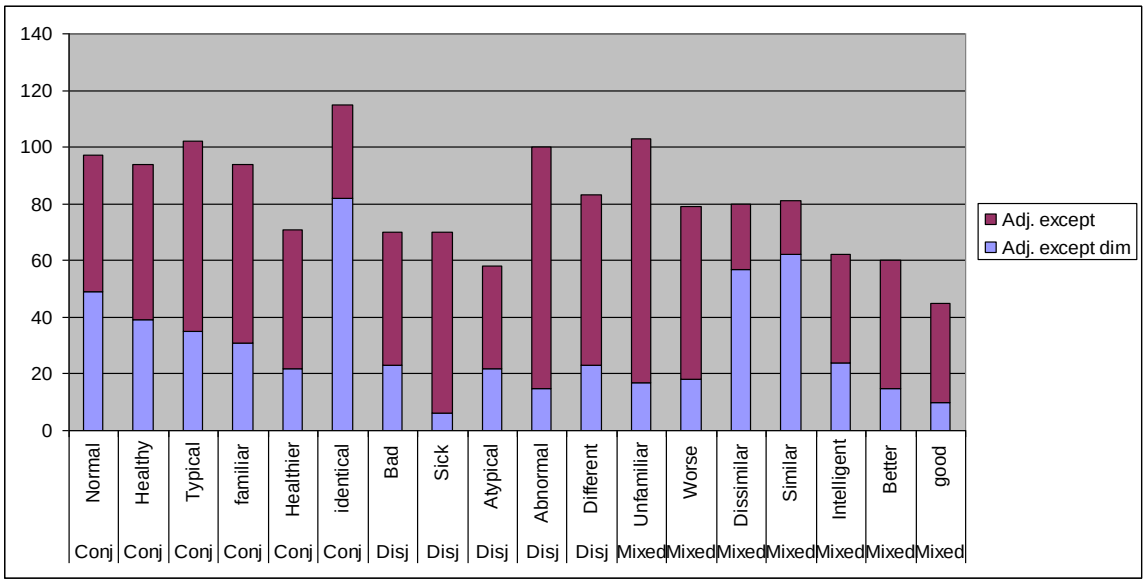
20) *Quantification over entities, events, time points, etc.:*
a. Everyone's been sick (except me--ha!) …
b. Never been sick (except a cold last year)
21) *Mitigation*: I was off sick, except I was only half sick; the rest was tiredness
22) *A different clause*: One would never know I was sick. Except for being bald, I look great …

Furthermore, due to the low frequency of negated forms in comparison to non-negated forms in natural use, negated form should be independently searched for, such as "not healthy except", "wasn't healthy except", "isn't healthy except" and so

on. Finally, the predicate stimuli consisted of 18 adjectives (*normal, healthy, typical, familiar, healthier, identical,bad, sick, atypical, abnormal, different, unfamiliar, worse, dissimilar, similar, intelligent, better* and *good*), ~100 Google search-results of the form "*P except*" with each. I also looked at 5 nouns (*bird, table, mother, capital* and *carrot*), ~70 Google search-results of the form "*P except*" with each.

The main result important for the present paper is the following. Significantly, more than a third (36.5%) of the ~1500 "adj. except" counts tested are of the type "adj. except a dim" (for their distribution among the examined adjectives see figure 3). What is more, none (0%) of the ~370 "noun except" counts tested are of the type "noun except a dim". Hence, it turns out that **no** dimension-set uses are found with the tested nouns, confirming a mean-based integration of their dimensions, while **hundreds** of such uses are found with the adjectives, confirming a Boolean dimension-integration for their dimensions.

Figure 3: 36.5% of the "Adjective except" counts are "Adjective except a dimension" counts



Also, a deeper analysis of the results supports the existence of three types of multidimensional adjectives, predominantly conjunctive, predominantly disjunctive and mixed (cf. the typology in (12)); a detailed description of these issues falls beyond the scope of the present paper (but see Sassoon 2010b).

In sum, these findings support the proposal that when a predicate is classified as adjectival, its dimensions are combined using Boolean operations (quantifiers or conjunctions), not averaging operations. In that, adjectival predicates sharply differ from nominal ones, and particularly resemble artificially construed rule-based categories. This brings us to the end of part 1 of this study. We discussed a variety of arguments pointing at the conclusion that the structure of adjectival and nominal categories corresponds to the structure of rule- versus similarity-based artificially construed categories. While Similarity-based processing is the natural option for nouns, rule-based processing appears to be an available and perhaps preferable option for adjectives. Let us, therefore, move on to the second stage of our study.

2. The neural and developmental predictions of the RS hypothesis, existing support

The rule versus similarity distinction has well-studied neural correlates and corresponding developmental correlates. This section reviews some of these basic psycholinguistic characteristics in attempt to see whether developmental and neural findings from the literature pertaining to adjectives and nouns are consistent with the RS hypothesis.

2.1 Neural correlates

Since rule-based ('Boolean') processing tasks involve an explicit hypothesis testing procedures, they demand the use of working memory and executive functions, thus recruiting primarily frontal-striatal regions (including the anterior cingulate, the prefrontal cortex and the head of the caduate nucleus). Conversely, similarity ('mean-based') tasks that involve implicit procedural learning, recruit regions, such as the tail of the caduate nucleus, which do not project directly to the prefrontal cortex. This corresponds with non awareness of the mean-based categorization rule (for a more detailed discussion of this neuropsychological model and its motivation see Ashby and Maddox 2005: 163-165).

As admitted by central figures in the field of psycholinguistics, the noun adjective-distinction is likely to exhibit neural dissociations though this issue is only poorly studied (cf. section 1). One type of data comes from studies of aphasia and dyslexia. Numerous reports exist of patients whose speech, reading or writing performance is differentially affected for nouns, verbs, and adjectives. The typical result reported is for better performance for nouns relative to verbs and adjectives. For example, Irigaray (1973) found reduced adjective rates in probable dementia of Alzheimer type participants by comparison with normal controls; In another study of aphasics, McNeil, Doyle, Spencer, Goda, Flores and Small (1997), asked an aphasic subject to produce a synonym or antonym for a verbally presented word; a cueing treatment applied upon failure to produce a correct response. The subject reached criterion for production of noun synonyms, but failed to reach criterion for adjective synonyms. Another report by Coltheart, Patterson and Marshall (1980) concerns a dyslectic patient misreading adjectives as related nouns (e.g., *wise* as *wisdom*; *strange* as *stranger*, etc.) or vice versa (e.g., *truth* as *true*); performance with concrete nouns is reported to be better than with adjectives, verbs or abstract nouns.

Concerning localizations, noun processing tasks include naming tasks with object categories which are typically nominal (animals, artifacts, ets.). In these studies, in accordance with the RS hypothesis, temporal, rather than frontal activation is typical (cf., Bookheimer 2002; Martin 2003: 66-67, Cappelletti et al 2008: 717; Shapiro et al., 2006); e.g., Shapiro et al. (2006) report of cognitive processes specific to noun and verb production (event-related responses), which were indistinguishable for real words and pseudowords, abstract and concrete words, regular and irregular morphological transformations, or processing difficulty effects (measured in reaction time) within a given category. One explanation for the nominal temporal region activation is to support the retrieval of lexical information including dimensional clusters (whereas left inferior frontal gyrus contributes to syntactic unification and motor action processing).

Furthermore, interestingly, studies of nominal categories report left frontal activation (BA 45,47) in similarity and abstract/concrete judgments (Martin 2003: 66-

67). This result is not surprising considering that these tasks involve adjectival processing, demanding selective attention to some of the stimuli' features (e.g., their value along the *abstract* vs. *concrete* dimension).

The indirect support for the RS hypothesis suggests that future research may profit from studies directly comparing grammatical processing of adjectival versus nominal constructions (e.g. *These things are balls* vs. *These things are red*), starting with the neuro-cognitive model proposed by Ashby and Maddox 2005 for rules and similarity-based categories. Such studies are necessary to support or refute the hypothesis of a more significant involvement of frontal regions in the activation of adjectives than nouns, as detailed above (Ashby and Maddox 2005: 163-165).

2.2 Developmental correlates

The neural dissociation between rules and similarity-based categories has developmental consequences. Children younger than 3 years old consistently perform similarity-based processing tasks. Conversely, due to the late maturation of the prefrontal cortex, by age 3 children tend to still have difficulties in consistently using rules, which only get resolved at age 5 (Frye et al 1995; Zelazo et al 1996, 2004; Thomason 1994). Furthermore, children up to age 10 often base categorization on similarity even where definitional properties exist (Keil 1989).

For example, as numerous studies show (Frye et al 1995; Zelazo et al 1996), given a pile of cards with red and blue triangles, 3 year olds succeed in tasks such as "if red, put here, otherwise put there"; yet, they fail when circles are added and the task demands paying selective attention to one of two dimensions. After responding correctly to a task such as e.g., "if red, put here, otherwise put there", children fail to perform correctly with a new rule such as "if triangle, put here, otherwise put there", as this task requires suppressing the old rule and attending to a new one. Also, children fail when the task demands attention to a conjunction of dimensions, as in, for instance, "if a red triangle, put here, otherwise put there". These results were obtained with many different types of stimuli, including a variety of types of natural categories. At first performance improves with age, adults doing better than children, but as adults grow old, their performance deteriorates again.

Thus, selective attention to one of several dimensions or to a dimension conjunction or disjunction is demanding. I propose that this is precisely the capacity required for the interpretation of adjectives. Adjectives with multiple dimensions have a 'dimension' argument slot. Recall that this slot can be either saturated (as in, e.g., *healthy with respect to blood pressure*; *talented/ good in mathematics*), or bound (as in, e.g., *healthy in every respect, generally sick, no different except for size*). When an adjective occurs bare (as in, e.g., *Dan is healthy / sick / different*), the dimension argument is often implicitly saturated or bound. This means that speakers and listeners have to pay selective attention to one of multiple dimensions, or to conjunctions or disjunctions of dimensions, suggesting that adjectival processing is demanding in the same way rules are. This supports the RS hypothesis according to which adjectival dimensions are typically processed with the rule-based system, as they combine via Boolean operations.

In opposition, nouns like *bird* typically do not have a dimension argument (as illustrated by the infelicity of, e.g., *#Tweety is a bird with respect to flying/ except for size; #is generally a bird*, etc.) This directly follows from the view that nominal dimensions are integrated via weighted-mean operations at an early processing stage, suggesting that nominal dimensions are typically processed with the similarity-based

system. Their processing does not require selective attention to one of several dimensions, nor to conjunctions nor disjunction of dimensions. It should therefore be less demanding in terms of working memory and executive functions.

This section reviews evidence for these claims based on existing acquisition literature.

First, in accord with the hypothesis that only adjectival dimensions are processed via declarative memory systems, evidence for adjectival, but not nominal dimensions, exists in parental output. For example, parents tend to ask "What is it?" when expecting a noun as a response, while they tend to ask a dimension-based question, for example "what color is it?", when they aspire for an adjectival answer (Gassar and Smith 1998). Thus, parental output might enhance explicit processing of dimensions in adjectival, but not in nominal categories.

Second, as illustrated shortly, in terms of relative ordering, acquisition (i.e., relatively frequent and consistent correct use) of adjectives is significantly delayed compared to nouns. This is surprising given that nouns are typically characterized by a wide range of features (so many so as to defy definition, cf. Rosch 1973; Wittgenstein 1953), while one-dimensional adjectives associate with a single dimension and multidimensional adjectives relate to a relatively restricted set of dimensions (e.g., health measures, intelligence measures, etc.) The RS hypothesis provides a simple explanation to this puzzle. It is preciely the need to suprress irrelevant dimensions that turns the acquisition and use of adjectives more diffcult.

Third, a difference in acquisition rate between nouns and adjectives typically occurs in children 3-5 years old. The time course of acquisition, then, corresponds with the developmental facts reported concerning rule based categories (Ashby and Maddox 2005). Importantly, at age 3, children already gain control of meaning components of one-dimensional adjectives like *tall*, namely of comparison classes, standard types, etc. (Syrett, Kennedy and Lidz 2009). However, they still do not use adjectives consistently. In the following, I survey evidence for the claim that nouns are learnt earlier, faster and with fewer errors.

Adjectives are still rare in the output at age 3, including ones which are most frequent in adult usage, such as color and size adjectives. This is reported for diverse languages (e.g., Gassar and Smith 1998: 269-271 for English and Spanish, Gozderv 1961: 437-8 for Russian, Berman 1988 for Hebrew, etc.) In addition, errors in understanding are frequent with adjectives at age 3-5, consisting in confusion between dimensions, replacing, for example, *dark* with *loud* or *tall* with *wide*; also, children may confuse between antonyms, using, for instance, *tall* instead of *short* and in response to questions such as, e.g., *what color is it?* children may confuse *red* with *green*.

Evidence for the late acquisition of adjectives is manifested also in cases of incomplete acquisition. Polinsky 2005 has compared between 4 competent speakers of Russian and 5 adult incomplete learners, whose acquisition of Russian was interrupted at age 4 (n=3), 5 (n=1), and 6 (n=1). The incomplete learners turn out to perform significantly better with nouns than with adjectives (Polinsky 2005). For example, recognition time is longer for adjectives than for nouns only in incomplete learners. Also, translation to a second language is less accurate and is based on words from other classes in adjectives, but not in nouns. These word class effects are stronger than frequency effects (Polinsky 2005: 423). These facts are explained by the fact that the use of adjectives requires selective attention to one or more of multiple dimensions, which is difficult.

The same results are obtained when considering the acquisition of invented words construed as nouns and adjectives. One and a half year olds learn nominal labels of artificial categories ("this is a dax") efficiently and remember them well over several days and weeks, while three year olds still have difficulty learning adjectival labels ("this is a dax one"; "dax, not red"). Learning of adjectival labels has proved modest at best.

The syntactic frames in which a novel word is introduced provides unambiguous evidence of its intended classification as a count noun or an adjective (e.g., ''This is a fopin'' vs. ''This is a fopish one''). By age three, children acquiring English are sensitive to these syntactic as well as semantic considerations. They distinguish novel words presented as nouns from those presented as adjectives and they interpret novel words presented as nouns as referring to categories of objects. However, often, they interpret novel adjectives as denoting object categories like nouns; they do so less often when the objects in question are known to have a nominal label, but even then children have difficulties (Markman and Jaswal, 2004; Waxman and Lidz 2006 and references therein). Thus, a strong linkage between nouns and object categories (i.e. mean-based categories) occurs early on, while adjectives at first are associated with object categories and only at a second developmental stage are linked to properties.

For example, Waxman and Kosowski (1990) show that at 12- and 13 months novel words presented either as count nouns or as adjectives direct infants' attention to object categories. Thus, the property-category distinction between count nouns and adjectives does not appear in the initial phases of word learning. This is compatible with our proposal whereby, due to the late maturation of the prefrontal cortex, children tend to process rule based categories as similarity based ones.

In Booth and Waxman (2003) study, slightly older (14-month-old) infants have shown partial sensitivity to the semantic word class distinction. They were introduced to four toy objects sharing a category and a property value (for example, purple horses). The experimenter labeled these objects either with novel nouns (e.g., ''These are blickets'') or adjectives (''These are blickish''). In addition, infants viewed an object whose category and property value are different (e.g., an orange carrot), which was labeled with a negated noun (''not a blicket'') or adjective (''not a blickish one''). Finally, the experimenter introduced two test objects differing in either the property (e.g., a green horse) or category (a purple chair). When infants were asked to 'find another blicket' (the noun condition) they strongly favored the category match. Yet when infants in the adjective condition were asked to 'find another blickish one' they showed no preference for either test object. These findings were obtained in different measures (e.g., word extension, novelty tasks, an automated procedure, etc) and were replicated in numerous studies (cf. Waxman and Booth 2001, Booth and Waxman 2009 and references therein). In conclusion, by 14 months of age, infants are sensitive to the property vs. category distinction and predicates' word class influences infants' decision as to whether the extension of the word is a mean based category or a property (rule). Children more consistently relate nouns to mean-based categories than objects to properties (rules).

Berman (1988) provides a different type of evidence showing that adjectival acquisition differs from that of nouns. Adjectives resemble verbs in that they typically function as predicates not arguments. However, in Hebrew, adjectives resmble nouns in that they inflect for gender, number and definiteness, but not for tense and person. Accordingly, acquisition studies in Hebrew reveal the following differences between word classes. First, verbs are learnt in morphological paradigms, whose items are interchanged with each other; for example, *ligdol* 'to grow up' may be interchanged

with *legadel* ‘to grow (something)’ or with *lehagdil* ‘to enlarge’. Second, nouns are learnt individually; thus, examples like, e.g., *godel* ‘size’, *hagdala* ‘enlargment’, *gidul* ‘plant, tumor’ and *gdula* ‘virtue, high merit, talent’ are not interchanged; rather, nouns are learnt with their semantic fields (for instance, spoon-fork-knife). Adjectives, in turn, are learnt later, first with their semantic contrast set, like nouns (e.g., big/small; red/blue/…, etc.), then with their morphological paradigm, like verbs, e.g. *gadol* ‘big’ with *megudal* ‘enlarged’, etc.

A possible explanation for the acquisition lag may hinge upon the fact that adjectives’ interpretation depends on the noun they modify (cf. Pustejovsky, 1991); this can be illusterated by the different interpretations of *fresh* when combined with different nouns (eggs, air, starts, ideas, etc.) Similarly, a fast typist types quickly, a fast car can move quickly, and a fast waltz has a fast tempo. Notice however, that nominal categories also exhibit a wide range of interpretations. For example, there are different bird kinds, there are literal as well as metaphoric interpretations for *bird*, etc. At the end of the day, both nouns and adjectives boil down to sets of objects, with the exception that the categorization rule for adjectives makes use of relatively fewer dimensions.

In line with the RS hypothesis, Gassar and Smith 1998 argue that nominal and adjectival concepts both denote categories, but these categories differ markedly in their size, overlap and, importantly, number of relevant dimensions. As Gassar and Smith 1998 emphesize, these factors may affect acquisition rates and processing difficulties. Importantly, they illustrate that category size and overlap, typically depend on the number of category dimensions. One can imagine the set of possible objects as a space whose axes are dimensions such as size, texture, brightness, and so on (perceptual properties). One dimensional adjectives such as *little* and *dark* are applicable to a very large proportion of this space of possible objects; since for these words most sensory dimensions are completely irrelevant, many different kinds of objects can be dark and many can be little. Nouns such as dog and box, on the other hand, apply to a very small proportion of the space of possible objects, since their referents must fall within a restricted range of values in many different dimensions. Thus, dogs are, in comparison with, e.g., all the little things, very much alike. For the same reasons, adjectival categories typically overlap with categories on other dimensions (red things can be big or small) but noun categories at the concrete basic level typically do not (a dog cannot be a house or table).

Gassar and Smith 1998 propose that it is these kinds of differences that make nouns easier to learn than adjectives, demonstrating that the noun advantage could emerge through such differences alone by means of a connectionist network that learns invented ‘nominal’ (i.e. multidimensional mean-based) categories faster than ‘adjectival’ (one-dimensional) ones. Acquisition was measured by the number of training instances required for the network to learn the categories as well as by error types. On each run, the network was given 1000 pairs of input and output (i.e., object representations together with appropriate labels for them); adjustment of the dimensional weights in the network followed the presentation of each pair. Then the network performance with 500 new inputs was measured. The results of experiment one (Gassar and Smith 1998) consist of a close to perfect performance on the nouns by the 4th run, and a continuous improvement in performance on the adjectives, which by the 10^{th} run still do not reach the noun level.

To respond correctly to adjectival contexts, the network has to learn to selectively attend, modeling young children’s difficulty in attending selectively to individual dimensions (e.g., Gibson 1969; Smith 1989). The difficulty with adjectives occurs

when distracting dimensions are available, e.g., black vs. white is difficult iff attention to size, shape, etc. has to be suppressed. What is more, given a specified dimension, for example, the linguistic context *what color is it?* and a *red* input, the probability that the network responds with *orange*, *yellow*, *green*, *blue*, or *purple* is greater than the probability that it responds with *big*, *rough*, or some other non-color adjective. The network 'knows' that *red*, *blue*, and *green* are words of the same dimensional kind before it knows which specific sensory inputs are red. This knowledge derives from early association of adjectival outputs with the appropriate linguistic-context (their explicitly taught dimension). This type of errors is characteristic of children.

In experiment 4, nominal categories were organized by an equally restricted range of variation on all four dimensions, while in adjectival categories the range of variation on some dimensions was wide and on others narrow (as is typical of adjectives). The nominal categories were learned significantly more rapidly. Experiment 2 exhibited the same effect where the crucial difference was in category size (nominal categories are typically smaller, as explained above). In contrast, in experiment 3, nouns were construed one dimensionally; the only factor distinguishing adjectival from nominal outputs was the lack of direct learning of the lexical dimensions of nouns. This factor seems to play a role in the nominal advantage, although to a lesser extent.

At last, recall that given the RS hypothesis, adjectives may well be multidimensional, but still not mean-based. Rather their dimensions may combine through Boolean operations. It is therefore important to see whether the acquisition (consistent semantically correct use) of logical words referring to Boolean operations (such as conjunctions and disjunctions or universal and exsistential quantifiers) is in fact delayed till at least age 5. While the pragmatics of such words (derivation of scalar implicatures or its failure thereoff) is a vivid topic of investigation, hardly any studies examine the acquisition of the bare semantics (truth conditions) of these words. Fortunately, the one study I am aware of (Gedalyovich 2003, focusing on Hebrew) verifies our hypotheses. In accordance with the thesis that adjectival dimensions are integrated via Boolean operations, whose processing demands working memory resources dependent on the prefrontal cortex, the acquisition of words directly denoting Boolean operations is also typically late. In particular, developmental data directly pertaining to semantic acquisition of Hebrew conjunctions and disjunctions (coordination constructions) is delayed to age 5 and beyond. According to Gedalyovich 2003 children can use coordination structures earlier in life, but due to processing demands they fail to do so consistently. This is precisely the time course reported for the acquisition of adjectives, in accordance with the thesis that adjectival dimensions are processed as rules (conjunctions / disjunctions) and consistent use of rules maturates at age 5.

Going beyond acquisition, the noun-adjective distinction turns out to have important implications with regard to inference. For example, subjects tend to draw conditional inferences from nouns to adjectives (as in *if a circle, then red*, more easily than vice versa (as in *if red, then a circle*; Kleiter, 1986; Fugardy et al 2009). Naturally, a mean value in multiple dimensions can hardly be inferred from a single dimension value, but a single dimension may be inferred from a mean.

To summarize:

23) a. Rules are easy to reason about explicitly. Conversely, similarity-based criteria are hardly accessible through introspection.

b. Explicit, rule-based ('Boolean') processing tasks are more demanding, requiring working memory and executive functions, which recruit frontal-striatal circuits. Conversely, Similarity (mean-based) tasks involve implicit procedural learning.
c. Children younger than 3 years old consistently perform similarity-based processing tasks. Conversely, due to the late maturation of the prefrontal cortex, by age 3 children tend to still have difficulties in consistently using rules, which only get resolved at age 5 (Frye et al 1995; Zelazo et al 1996, 2004).

In accordance, the acquisition of adjectives lags behind that of nouns and is characterized differently; the number and sort of dimensions affect acquisition rate, where fewer dimensions and Boolean (rather than mean-based) dimension integration result in a learning difficulty. Thus, a preliminary examination of psycholinguistic data seems to confirm our conclusions from previous sections. While Similarity-based processing is the natural option for nouns, rule-based processing appears to be a dominant option for adjectives. All considered, the RS hypothesis seems to be on the right track, suggesting that its neuro-developmental predictions should be directly studied by psycholinguists in the future. The advantage of the RS hypothesis is that it provides clear neural and developmental predictions to start with, as well as well studied paradigms to study them (see detailed discussion and references in Ashby and Maddox 2005).

The third and final stage of the present study addresses non-paradigmatic subclasses of nouns and adjectives. Such subclasses provide a serious challenge to any theory pertaining to word classes. Let us see what the RS hypothesis has to say about some of these problematic cases.

3. The domain of application of the RS hypothesis within and across languages

3.1 Semi-adjectival nouns

At present, I am aware of two types of nouns that systematically license dimensional *with respect to* (wrt) modification, namely animate nouns like *an idiot* and property denoting nouns ('nominalizations') like *happiness, height, health, success, agreement, similarity, difference* etc. These nouns are similar to adjectives in other respects as well (such as agreement, argument structure, etc.). Nominalizations form exceptions to almost any generalization about nouns, whether syntactic or semantic. For example, usually verbs or adjectives denote eventual types (categories of events or states), while nouns denote non-eventual entity-types, and usually, the verbs or adjectives have an elaborate argument structure, while the nouns do not (Landman 2000). The property denoting nominalizations are atypical of their category in that they often seem to denote eventual types (*success, disaster, agreement*) and they have an elaborate argument structure. For instance, while normal nouns cannot take *for* arguments (as in *# Tweety is a bird for a water-bird*), these exceptional nouns can (as in *the conference was a success for a student conference*). Animate nouns like *idiot* also often resemble adjectives. For example, in languages like Hebrew, the morphological form of either verbs or adjectives (24a), but usually not of nouns (24b), agrees with the subject in gender. In addition, the copula can be omitted when the

predicate position is occupied by an adjective (24a), but usually not when it is a noun (36b). The animate nouns behave like the adjectives (24c).

24) a. *Dan (hu) yarok* [Dan is green$_{MASC}$]; *Beth (hi) yeruka* [Beth is green$_{FEM}$]
b. *Dan #(hu) cipor* [Dan is a bird]; *Beth #(hi) cipor* [Beth is a bird]
c. *Dan (hu) idiot* [Dan is an idiot$_{MASC}$]; *Beth (hi) idiotit* [Beth is an idiot$_{FEM}$]

Accordingly, these nouns allow (or they sound better with) wrt phrases (as in *Dan is an idiot wrt money / in every respect / except wrt money*, and in *the conference was a success wrt the quality of the papers / in every respect / except for the papers*). It might be that, e.g., nominalizations (difficulty, success, typicality, health, …) fall beyond the scope of the RS hypothesis (1a) and ought to be characterized differently more in a par with adjectives. Future research should focus on nominalizations and their interpretation. As yet, it is hard to say definitive things about them. But as things stands now, it is at least possible that their ability to combine with wrt-phrases or for-phrases is due to the fact that adjectives that combine with a wrt phrase can then be nominalized and the result is a nominalization with a wrt phrase.

Furthermore, in nominalizations the wrt-argument functions differently. It neither adds the categorization criterion which it usually adds, nor reduces the number of ordering criteria as it usually does in adjectives. For instance, compare *healthy wrt bp* with *health wrt bp*. An entity falls in the denotation of the adjective *healthy wrt bp* iff it possesses enough of some quality – in fact, if it possesses enough of the quality 'health wrt blood pressure' (= being close enough to the ideal blood pressure for health). So the wrt-phrase not just turns *healthy* into a one-dimensional adjective (with a dimension which is an easily measurable quality), but also adds a clear and usable categorization criterion. In contrast, it does not seem to be the case that an entity falls in the denotation of the noun *health wrt bp* iff it possesses enough of some quality (certainly not of one that can be easily measured or even clearly grasped.) To fall under the denotation, the entity itself presumably has to **be** a quantity of something, e.g. of 'health wrt blood pressure'. But it certainly does not have to possess a large enough quantity of 'health wrt blood pressure' (which is what it itself **is**). It is only in the adjective that the requirement to possess *enough* of the relevant type of health comes in, and in that sense the wrt-argument adds a categorization criterion to the adjective, which is not added to the noun. To fall under the denotation of the nominalization, the entity does have to have enough of 'being health wrt bp' – that is, to **be** 'health wrt bp' to a large enough degree. But that does not give us any useful information in terms of determining membership. In that sense, the wrt phrase does not supply a (usable) categorization criterion.[16]

Similarly, concerning animate nouns, possibly, animate adjectives can combine with wrt phrases and then turn into animate nouns. In sum, nouns which are derived from adjectives (or are systematically connected to an adjective), namely, nominalizations and animate nouns, may inherit the wrt-phrase from the adjective. Animate nouns seem to have a double entry, both as a noun and as an adjective. As adjectives they can be modified by *more* and *wrt*, and they can denote human beings, cities etc. (as in *Dan is more Italian than Sam wrt their cooking* and *Florence is more Italian than Torino wrt food and weather*). The nominal entry is more restricted. It can only denote human beings (as in *Dan is an Italian wrt cooking* versus *# Florence is an Italian wrt food*). So the noun is characterized by a richer set of dimensions, as expected from a noun. The noun phrase is interpreted more like the modified noun

phrase *an Italian man*. So the wrt-phrase is licensed in virtue of the occurrence of an adjective, *Italian*.

This proposal goes well with the fact that *more* is incompatible with nominalizations and animate nouns. In my searches of the internet, I have found but few examples with *more* in within-predicate comparisons (comparisons of degrees of two entities in one predicate), where the predicate was a noun and *more* occurred without the morpheme *of*.

25) a. That's how much more a success Torino was, compared to Athens
b. I'm always a boy; but I'm more a boy when I perform
c. I'm more a boy than everyone in your team

In all the other cases, when *more* occurred with a noun (whether a basic noun, nominalization or an animate noun), the comparisons were between degrees in two different predicates.

d. Probably this is more an Italian tradition than a British one
e. To Italians he is almost more an Italian than an English poet
f. these young Japanese Americans prove their patriotism through unquestioning obedience to authority, ironically a trait more Japanese than American
g. Columbus was more a "success" for having landed in the Bahamas than in Bombay
h. He's much more a boy from Long Island than a boy from Brooklyn
i. The hero seemed more a boy than a man.

In that, the nouns are sharply distinguished from the corresponding adjectives, for which plenty of examples can be found of within-predicate comparisons:

j. The southern part of the region is far more Italian than Alto Adige
k. More charming than Boston, more romantic than Vegas and more Italian than Naples, Providence is an undiscovered gem of a city with no traffic. ...

Examples like *Dan is more Italian than Sam* become odd when an article is added (as in *#Dan is more an Italian than Sam*), unless the particle *of* is added.

We see then that despite appearance to the contrary, a number of facts suggest that these apparent counterexamples to the RS hypothesis are not real.

3.2 Semi-nouny adjectives

While the noun category is relatively stable in the languages of the world, languages vary widely with regard to the existence and size of the set of adjectives (Dixon, 1982). For example, Igbo (from the Kwa subgroup of the Niger–Congo family) has a total of 8 adjectives, Hausa has 12, and Bantu languages have adjective classes ranging from ten to fifty words. Some languages have noun like dimensional adjectives, whereas others have verb-like ones, a distinction expressed for example by the type of Degree constructions avaiable in a language.[17] Furthermore, languages with a well established adjective set still exhibit variance which may affect processing and hence development. This section discusses two types of borderline cases – French

relational adjectives, which are clearly derived from nouns (and are often instantiated as nouns in, for instance, English) and the Spanish Det-A construction, in which a determiner and an adjective occur with no overt noun.

3.2.1 *Relational adjectives*

Examples of adjectives that may well fall outside the scope of the RS hypothesis are those usually called 'relational' (cf. Rodriguez Pedreira 2000, Schuwer 2005, McNally and Boleda 2004).[18] Focusing on French examples like those in (26), we see that many of these adjectives classify as nouns in English, where they can function as modifiers in noun-noun compounds.

26) a. Une carte routière (a road map);
b. Un régime présidentiel (a presidential regime); un voyage présidentiel (a visit of the President to …)
c. Une lampe halogène (halogen lamp)
d. La piscine municipale (the public swimming pool)
e. Le voyage alsacien du ministre (the minister's trip to Alsace)
f. Le cerveau humain (the human brain)
g. Le pays natal (native country)
h. Le lait maternel (mother's milk)
i. L'acné juvénile (teenage acne)
j. une spécialité regional (a regional speciality)
k. tronc cérébral (brain stem)
l. une décision gouvernementale, un compte bancaire, un directeur administratif, la recherche scientifique, une réunion ministérielle….

This group of adjectives is well defined, with the following characteristics in French. Some of those apply to English too. First, a relational adjective comes *after* the noun it modifies (e.g., * *Une routière carte*), whereas non-relational adjectives can often be placed before or after the noun. Second, these adjectives are not normally used predicatively (27a,b), although in contrastive constructions, predicative use is facilitated (27c).

27) a.?? Cette carte est routière (This map is a road map)
b. ?This regime is presidential (This is a presidential regime)
c. Cette critique n'est pas musicale mais littéraire (this critique is not a musical, but rather, a litral one)

Third, a relational adjective is not normally modifiable by a degree adverb (e.g., **Une carte très routière*), which is also true in English (**Her very/extremely/relatively native country;* ??*A slightly presidential regime*). Thus, these adjectives are not morphologically gradable, which is typically a nominal feature (cf. Section 2).

Finally, the more academic, formal and technical a register, the more frequent the occurrence of relational adjectives rather than nouns used attributively. There are notably many relational adjectives in academic English as well; for instance, we find *renal failure* next to *kidney failure*, *dental decay* next to *tooth decay*, pulmonary cancer next to *lung cancer*, etc. Naturally, academic endeavours involve an attempt to define words explicitly and precisely, namely by defining criteria rather than merely

implicit mean-based features. Given the RS hypothesis, this in itself explains the tendency to coin adjectives where natural language speakers not doing science coin nouns.

3.2.2 *The 'det A' construction*

Spanish differs from English and French in both the syntactic contexts in which adjectives can appear and the semantic functions associated with them. Spanish exhibits a syntactic phenomenon of phrases consisting of a determiner followed by an adjective, with no overt noun. Unlike English, cf. (28-31a), or even French (28-31b), in Spanish this highly productive, lexically unrestrictive process is pervasive (28-31c).

28)	a. the poor	b. les pauvres	c. los pobres
29)	a. *the smooth	b. *le lisse	c. el suave
30)	a. *the asleep	b. *l'endormie	c. el dormido
31)	a. *the careful	b. *les prudents	c. los cuidadosos

These det-A constructions typically refer to nominal object categories. The ''dropped'' noun in these expressions can be either human or not human, singular or plural, specific or generic. Its interpretation is often roughly equivalent to the English ''type'' or ''one.'' The determiner and adjective retain gender and number concord with the 'dropped' noun.

With regard to acquisition (Waxman, Ssenghas, and Benveniste 1997), children as young as two years of age appear to have productive control over the Spanish det-A construction as testified by its occurrences in the CHILDES (produced for example by the age of 2;8 and 3;5.) In accordance, in Spanish, children learn that adjectives, like nouns, may be used to denote object categories. Three to seven year-old Spanish speakers extend novel words presented as either count nouns or adjectives on the basis of object-category communality (Waxman, Ssenghas, and Benveniste 1997). Although this was less pronounced with novel adjectives than nouns, this inclination appeared to become stronger with age and increasing language experience. Also, infants acquiring English successfully extend adjectives but not nouns on the basis of property-based commonalities (e.g., color, texture) by 21–23 months of age, while infants acquiring Spanish do so latter, between 23–29 months (and they continue to extend also based on object categories, as explained earlier). Thus, children acquiring different languages appear to acquire slightly different tacit expectations regarding the range of application associated with the grammatical category adjective. For a typological map of languages allowing adjectives without nouns see Gil 2005a. The RS hypothesis applies to a language or a construction to the extent it exhibits the adjectival or nominal cues discussed in section 1 (including, mostly, morphological gradability, i.e. compatibility with degree morphemes, accessible dimensions i.e. compatability with wrt phrases, quantification over dimensions and dimensional exception phrases).

4. Conclusions

I hope to have shown that the RS hypothesis provides a new and frutful direction of research of the puzzling topic of word classes. It provides a coherent explanation of a wide set of facts pertaining to the structure of nominal and adjectival categories (namely, psychological and linguistic facts pertaining to the categorization criteria and

degree function of nouns and adjectives), to the brain mapping and acquisition of these categories and to a number of non paradigmatic sub-classes of nouns and adjectives. This suggests that future research will profit from a more direct study of the implications of the RS hypothesis. In addition, it may be fruitful to adress certain plausible extensions of this thesis.

In particular, it is probably possible to extend the RS hypothesis to distinguish between verbs and adverbs, since some distinctions between these two word classes parallel the distinctions between nouns and adjectives. Furthermore, considering gradability in verbs, English verbs devide into two different groups. Some verbs resemble nouns in not being gradable, e.g., *kissed more* can only mean 'was involved in more kissing events' or 'in a temporally longer kissing event; it cannot mean 'exemplifies better the property *kissed*'. Other verbs closely resemble adjectives, including for example measuring verbs such as *weighs, costs* and *lasts,* as well as stative psych verbs such as *interests,* and *loves*. Some languages possess a more pronounced set of 'adjectival' verbs. I leave it for future research to see what the implications are with regard to the RS hypothesis, for example, whether verbs exemplifying the complete set of adjectival semantic features (namely, accessible dimensions and morphological gradability) are in fact processed as rule-based.

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Notes

1. For a different view, see Gil 2000 and Haspelmath et al 2005.
2. While in semantics the notion 'dimension' refers to gradable properties like length or blood-pressure, in psychology it also covers ordinary properties like flying.
3. For a review of this work see Mervis and Rosch (1981). For a review of earlier studies which form the basis for this work see Lakoff (1987; chapter 2). Reviews of more recent developments and theoretical approaches are found in, for instance, Hampton (1997) and Murphy's (2002) seminal "big book of concepts".
4. The origins of the exemplar theory are found in Medin and Schaffer's (1978) context model. Exemplar models include Hintzman's (1986) Minerva model; Nosofsky's (1988) generalized context model; Kruschke's (1992) ALCOVE model; Estes's (1994) array model, etc.
5. This analysis has been applied to the semantic analysis of predicates by cognitive linguists such as Lakoff (1987), but to the best of my knowledge this applications are insensitive to word class distinctions and their relation to the rule vs. similarity distinction.
6. Exemplar models extend the number of representations which we encode in memory. For instance, it is assumed that, for a concept like 'bird', we encode in memory separate dimension sets for 'robin', 'duck', 'chicken', etc. It is predicted that if an item is highly similar to at least one known exemplar, it is highly similar to the concept. In addition, concepts like 'bird' are assumed to belong to a set of "contrast-concepts" (that includes concepts like 'mammals', 'reptiles', 'insects', etc.) Items are

assumed to be classified in the contrast concept to which they resemble most (Ashby and Maddox 1993). The tendency to employ a prototype or an exemplar strategy appears to vary across concepts, contexts, and speakers (Smith and Minda 1998; 2000). From the semantic perspective, each strategy seems to describe a different interpretation. A noun like 'bird' may relate to either the kind 'bird' or bird sub-kinds (Carlson 1977; Dayal 2004; Sassoon 2007).

7. Unfortunately, a proper review of semantic theories of gradability and comparison is beyond the space limits of this paper. Detailed reviews are found in the third volume of the *Journal of Semantics* (especially, von Stechow 1984), Klein (1991) and Kennedy (1999).
8. Exceptional formal semantic theories assigning nouns gradable interpretation are Kamp and Partee 1995 and more recently Morzycki 2009.
9. Perhaps we can utter statements like *Non-Japanese who love Japan become more Japanese than the Japanese* also because the noun and adjective denotations need not be completely identical in virtue of the indeterminacy in the dimension set of the adjective and to some extent also the noun. In the given example, the noun denotes the set of Japanese by nationality or birth, while the adjective is interpreted wrt behavior (the behavior of the non-Japanese by birth is more of a stereotypical Japanese behavior than the behavior of the Japanese by birth). That is, statements like *Dan is Japanese* need not relate to a completely identical dimension set as ones like *Dan is a Japanese*, if, for instance, *Japanese* in the former statement is interpreted *wrt stereotypical Japanese behavior*. Notice also that nouns can function as adjectives merely by virtue of the
10. Notice also that nouns can function as adjectives merely by virtue of occurrence in modifier position, which is typically adjectival (as in, for instance., *a hypo turtle*; crucially, e.g., *a turtle which is a hypo* should be something that is both a turtle and a hypo, while a hypo turtle is simply a turtle with some dominant hypo feature.
11. Color terms, specifically, are acquired later than many other property terms; according to Bornstein 1985 this results from dependency on the maturation and integration of cortical neurological structures specific to color naming.
12. The search for copula constructions is crucial, for in other hits of the form "noun wrt" or "adjective wrt" one cannot tell whether the wrt phrase in fact modifies the predicate preceding it. Some counts of the form "noun wrt" may actually be uses in which the wrt phrase modifies an adjective (as in, for instance, *Bill was notoriously healthier than his friends wrt to blood pressure*) or any other word (as in *significant differences among birds with respect to blood pressure*).
13. Adding to the calculation definite noun counts (of the form "is/are/was/… the noun wrt") does not affect the results significantly (the proportion of wrt phrases among the "copula + noun" counts turns from 0.00006 to 0.00007). More importantly, all of the eight new hits are basically examples of irrelevant uses (none is such that the wrt phrase designates a nominal dimension).
14. Similar observations about the interpretation of typicality modifiers were given by McCready and Ogata (2007). However, the current proposal is novel in that it derives these interpretations from a basic interpretation rule for adjectives in general.
15. In principle, another interpretation for "#Dan is not healthy (in every respect) except bp" could have been available, whereby negation outscopes the (implicit) universal quantifier, as in "it is not the case that Dan is healthy in all respects except bp". However, this reading is not available, except perhaps with a very special intonation, meaning that the distribution of exception phrases is restricted to 'positive' (upward entailing) contexts (von Fintel, 1994). Thus, indeed, no exception phrases are expected to occur with negated conjunctive adjectives, especially in written corpuses.
16. If you know what counts as *blood pressure* or *health* it may be easy for you to say how much of it there is. But how do you decide that something counts as a (quantity of) *health*, this or that type of *malady*, *happiness*, *success* etc.? A rich set of symptomatic non-necessary dimensions characterizes disease types, and entities like *success* can hardly be defined by a set of necessary conditions which are jointly sufficient. Thus, nominalizations are mapped to the noun category because they are not associated with a set of respects, and they are often associated with a rich set of typicality dimensions. The denotation of some nominalizations (say, *height*) may be fixed in the whole context structure, but the denotations of many others (*success*; *health*) may be highly context dependent.
17. See Stassen 2005b for a typological map of comparison structures in the world languages; for formal characteristics distinguishing adjectives from verbs in the languages of the world see Stassen 2005a; see Gil 2005a for a discussion of how languages vary with respect to grammatical encoding of different types of attribution (genitive, adjective and relative clause constructions).
18. I am deeply grateful to Philippe De Brabanter for bringing these adjectives to my attention and teaching me about their intriguing characteristics.

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