Quality and quantity readings of degree expressions

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1. Introduction

It is well known that there is a set of expressions that determine the degree to which the property expressed by an adjective holds of its subject. For example, in *John is very lucky*, John is taken to be lucky to a high degree. However, a number of degree expressions allow a second interpretation, which seems to ascribe a property to a proportion of the subject, rather than to the subject as a whole. Thus, *the steak is half cooked* is ambiguous between having a regular 'quality' interpretation, on which the whole steak is halfway through the cooking process, and a 'quantity' reading, on which half of the steak is fully cooked. In this paper, we explore this ambiguity and argue that its source lies in a null operator optionally attached in the extended projection of the adjective prior to the degree expression being merged.

The quality/quantity ambiguity is not a quirk of *half*, but systematically arises with a range of degree modifiers:

(1) a. The steak is partially / 30% / a third cooked
    b. The steak is more cooked than raw

The example in (1a) can either mean that part of the steak is fully cooked, or that the whole steak has undergone part of the cooking process. The example in (1b) can either mean that the part of the steak which is cooked is larger than the part which is raw, or that the whole steak is closer to being cooked than to being raw.

The ambiguity is also not due to a quirk of *cooked*. Rather, all gradable adjectives whose scale is fully bounded permit both readings. This is easiest to demonstrate with plural subjects (for pragmatic reasons – in (2b), *open* cannot usually be true of half of a door):

(2) a. The glasses are half full
    b. The doors are half open

(2a) can mean either that half of the glasses are completely full, or that each glass is half full. (2b) can mean either that half of the doors are open, or that each door is half open.

For adjectives that do not denote a fully bounded scale, only the quantity reading is available with proportional modifiers such as *half*. This is simply due to such modifiers being incompatible with unbounded scales – there is no way to determine a halfway point on a scale which is not bounded at both ends (Kennedy & McNally 2005). Since *hot* and *dangerous* have no upper bound, (3a,b) only allow a quantity reading.

(3) a. The radiator is half hot
    b. The city is half dangerous

Non-gradable adjectives, which cannot be modified by degree expressions on a quality reading, similarly give rise only to the quantity reading with modifiers like *half*:

(4) a. *The toy is very wooden (and slightly plastic).
    b. *The filing system is very electronic (and slightly manual).
    c. The toy is half wooden (and half plastic).
    d. The filing system is half electronic (and half manual).

Although the quantity reading of expressions like *half cooked* has been observed before (Kennedy & McNally 2005, 2009), it has received little attention, let alone a formal analysis. Yet, a formal analysis appears to be necessary, since the quantity reading is at least as productive as the quality reading, if not more productive. An appeal to accidental lexical ambiguity of either degree expressions or adjectives would therefore be unsatisfactory.

Given that the quantity reading of many of the examples above can be paraphrased with a partitive construction (as in *half of the steak is cooked*), a simple formal analysis could take as a starting point the hypothesis that the degree expression is attached to the subject rather than the adjective. The main challenge such a theory would face is that this does not match the apparent surface constituency. Therefore, the only possibility would be to posit a hidden partitive DP that the subject moves out of:

(5) [The steak] is [half t] cooked

This analysis essentially says that *half* on the quantity reading is a floating quantifier stranded by movement (Bobaljik 1995, 2003). It therefore shares certain familiar problems with movement analyses of floating quantifiers. Firstly, the fronted category does not always fit the gap. For example, partitives with *more* require *of*, but in the structure under discussion, *of* must be omitted:

(6) *The steak is more of t cooked than raw

Other relevant degree expressions cannot appear in the partitive at all:

(7) a. *Partially the steak is cooked
b. Part of the steak is cooked

This means that a phonological transformation would be required to turn ‘part of’ into ‘partially’ when stranded. Even this is insufficient, however, since some degree expressions that allow quantity readings do not have an appropriate nominal counterpart:

(8) a. The city is completely dangerous
b. #The completeness/completion of the city is dangerous
c. The complete city is dangerous

The example in (8a) has a quantity reading. The subject in (8b) is a grammatical noun phrase, but it does not have the correct interpretation. The subject in (8c) does allow the right interpretation, but in this case *the city* is not a constituent, and so cannot be extracted.

Finally, degree expressions with a quantity reading can accompany attributive adjectives, but uncontroversial floating quantifiers cannot:

(9) a. The half cooked steak
b. *The both cooked steaks

A stranding analysis therefore does not seem to be a viable option.

In what follows we will develop an alternative analysis, which involves neither movement nor lexical ambiguity, but is instead based on the idea that there is a null operator that makes available the quantity reading when attached to the AP; this allows us to give a fully compositional semantics of the ambiguity that we ascribe to the AP. However, compositionality can always be trivially satisfied by positing additional silent syntactic material; in our view, unless any deviations from surface order and constituency are supported by independent evidence, the priniciple of compositionality is void of content. It is imperative that any extra material introduced solely to satisify compositionality is supported by syntactic evidence. We will develop three syntactic arguments in support of the existence of the null operator we propose, based on the possibility of stacking degree expressions, the sensitivity of quantity modifiers to the syntactic category of the predicate, and restrictions on the class of modifiers that allow the quantity reading.

2. Analysis

Following much of the literature, we assume that gradable adjectives have an open degree argument in addition to their thematic argument, and are therefore of type <d,et>. Not all gradable adjectives are alike, in terms of their scalar structure; we take *tall* to have a lower, but not an upper limit (although, see Kennedy and McNally (2005) for an alternative view on the scalar structure of *tall*). *Cooked*, on the other hand, has both a lower and upper limit. In (10b), the upper limit is indicated by the constant *c*:

(10) a. $[\![\text{tall}]\!] = [\lambda d\ \lambda x.\ 0 \leq d\text{: tall}(x) = d]$
b. $[\![\text{cooked}]\!] = [\lambda d\ \lambda x.\ 0 \leq d \leq c\text{: cooked}(x) = d]$

A degree variable can be saturated by a measure expression (which we assume is of type d), as in *3m tall* (see (11)). It can also be valued indirectly, which is typically the case when the predicate is input to modification by a degree expression of type <<d,et>et>. For example, if we say that a steak is half cooked on a quality reading, *half* takes the gradable adjective as its argument, yielding the expression in (12b):

(11) a. $[\![\text{3m}]\!] = \text{3m}$
b. $[\![\text{tall}]\!]\ ([\![\text{3m}]\!]) = [\lambda x.\ \text{tall}(x) = \text{3m}]$

(12) a. $[\![\text{half}]\!] = [\lambda Q_{<d,et>}\ \lambda x\ \exists d.\ Q(d)(x)\ \&\ d = \text{midpoint}(\text{scale}(Q))]$
b. $[\![\text{half}]\!]\ ([\![\text{cooked}]\!]) = [\lambda x\ \exists d.\ \text{cooked}(x) = d\ \&\ d = \text{midpoint}(\text{scale}(\mathbf{cooked}))]$

‘Midpoint(Scale(Q))’ is intended as shorthand for a function that takes a gradable predicate as input and returns the midpoint on its associated scale by calculating the point equidistant from the lowest and highest degree. This has the benefit of only allowing *half* to operate on a fully bounded scale, correctly ruling out examples like **John is half tall*, since the scale associated with *tall* does not have an upper bound, and therefore no point equidistant from the lowest and highest degree (we omit this information from here onwards for purposes of exposition).

This analysis implies that when a gradable adjective appears without an overt degree expression, it must nonetheless have combined with a null operator that binds the degree variable. After all, when we say that John is tall, we do not mean that John has some degree of tallness, but that he is taller than some contextual standard. Following Kennedy (1997), we will assume a null morpheme *pos*, specified in (13a). *Pos* combined with *tall* yields the expression in (13b)

(13) a. $[\![\textit{pos}]\!] = [\lambda Q_{<d,et>}\ \lambda x\ \exists d.\ Q(d)(x)\ \&\ d > \text{standard}(Q)]$
b. $[\![\textit{pos}]\!]\ ([\![\text{tall}]\!]) = [\lambda x.\ \exists d\ \text{tall}(d)(x)\ \&\ d > \text{standard}(\mathbf{tall})]$

All of this is more or less standard, but does not deliver the quantity reading. That reading, we propose, arises if an adjective whose degree variable has been closed off is selected by a null operator that we will call μ. The job of μ is twofold: first, it opens up the part structure of the thematic argument of the adjective, by asserting that the property described by it holds of only part of that argument; second, it quantifies over the size of this part in relation to the whole by introducing an open degree variable. The resulting function is of type <d, et>, and is therefore an appropriate input for further degree modification. The lexical entry for μ is given below:

(14) $[\![\mu]\!] = [\lambda P_{<et>}\ \lambda d\ \lambda x\ \exists y.\ y \sqsubseteq x\ \&\ P(y)\ \&\ \text{size}(y){:}\text{size}(x) = d]$

Let us consider the derivation for *half cooked* on its quantity reading. Our proposal implies that *cooked* must combine with *pos* and μ prior to modification by *half*:

(15) a. $[\![pos]\!]\ ([\![\text{cooked}]\!]) = [\lambda x.\ \exists d\ \text{cooked}(d)(x)\ \&\ d > \text{standard}(\mathbf{cooked})]$

b. $[\![\mu]\!]\ ([\![pos\ \text{cooked}]\!]) = [\lambda d'\ \lambda x\ \exists y.\ y \sqsubseteq x\ \&\ \exists d\ \text{cooked}(d)(y)\ \&$
$d > \text{standard}(\mathbf{cooked})\ \&\ \text{size}(y){:}\text{size}(x) = d']$

c. $[\![\text{half}]\!]\ ([\![\mu\ pos\ \text{cooked}]\!]) = [\lambda x\ \exists d'.\ \exists y.\ y \sqsubseteq x\ \&\ \exists d\ \text{cooked}(d)(y)\ \&$
$d > \text{standard}(\mathbf{cooked})\ \&\ \text{size}(y){:}\text{size}(x) = d'\ \&$
$d' = \text{midpoint}(\text{scale}(\mathbf{q\text{-}cooked}))]$

There is nothing new in (15a). In (15b), μ has asserted the existence of a part *y* of the thematic argument *x* that satisfies the predicate. It has also introduced a degree variable *d'* that expresses the size of *y* relative to *x*. In (15c), *half* applies to the output in (15b) in the same way that it applies to *cooked* on its quality reading. The result is a function of type <et> that can take the subject as argument and return a truth value. What must be true of the subject is that it has a part that is cooked to a degree above some contextual standard, and that this part consists of half of the subject[1].

The subject can be either singular or plural. When it is singular, the reading we obtain is straightforward: *the steak is half cooked* means that half of the steak is cooked. However, when the subject is plural, as in *the steaks are half cooked,* two interpretations are available. One reading, which is collective, asserts that half of the steaks are cooked (for example, if there are four steaks, then two are cooked and two are not). The other reading, which is distributive, asserts that half of each steak is cooked. The readings arise by applying the predicate either to the plurality of the steaks, or to the atoms comprising the plurality.

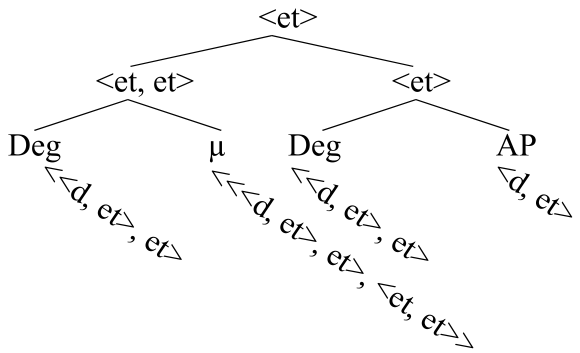
Interestingly, a potential 'mixed' reading is absent; *the steaks are half cooked* cannot mean that half of the mass of steaks is cooked, or that the steaks are on average half cooked. For example, the sentence is not true in a situation where 50% of the steaks are three-quarters cooked, and 50% of the steaks are one-quarter cooked. We take this to mean that when picking out a part of a plural entity comprised of atoms, the 'atomic structure' is respected to the best extent possible; any part selected will ideally contain only full atoms. Take an example like *the doors are half red*. If there are four doors, then on the collective reading, two of the doors will be red. It is not possible in this case to 'split the atoms': a situation in which one door is completely red, one door not red at all, and another two 50% red cannot be described by the sentence. We are not sure whether this is an absolute requirement or an economy condition which can be overridden in certain situations. The crucial case would be the same example, but now in a situation in which there are three doors, so that there is no way in which to pick out half the doors without splitting at least one atom; the best you can

[1] We have simplified the formula by substituting *q-cooked* for the scale of quantity of cooked-ness, which is a

do is have one door completely red and one 50% red. Our judgments on this example are unclear. It is, however, clear that a situation in which door 1 is 50% red, door 2 75% red, and door 3 25% red does not verify the example.

In principle, the μ operator could alternatively be defined to take the degree expression as its first argument. In our view, the choice is largely arbitrary, but we have opted for attachment in the extended adjectival projection, because the type of the operator comes out as simpler. The type assigned to μ on our preferred analysis is <et,<d,et>>. The alternative analysis would require μ to have type <<<d,et>,et>,<et,et>>, as shown in (16):

(16)



In what follows, we will also see certain facts about the behavior and distribution of μ that receive a more natural explanation if the operator selects the predicate, rather than the degree expression.

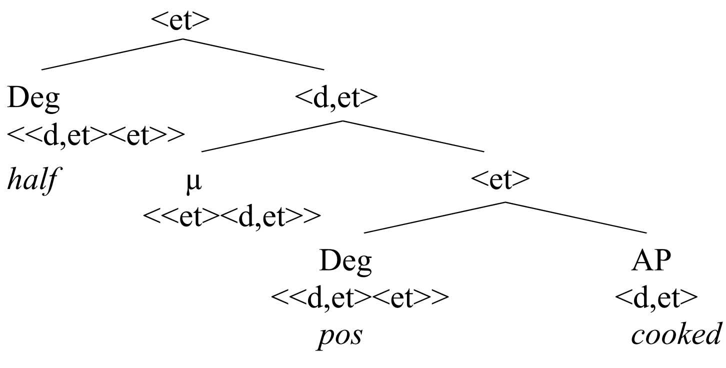
3. Predictions

We will now consider the empirical consequences of the analysis outlined in the previous section. We will look at three domains: (i) stacking and ordering of multiple modifiers, (ii) application to categories other than APs, and (iii) interaction with the synthetic/analytic alternation in comparatives. These three domains constitute distributional evidence for μ.

3.1 Cooccurence of modifiers

Our analysis assigns the following structure to an expression like *half cooked* on its quantity reading:

(17)



In (17), the lower degree modifier is the silent element *pos*, but nothing in the analysis bars insertion of an overt degree modifier in this position. Thus, we correctly predict that examples like the following are grammatical, with the lower degree expression assigned the quality reading and the higher the quantity reading:

(18) a. The steaks are half$_{QNT}$ three-quarters$_{QLT}$ cooked.
b. The boys are half$_{QNT}$ very$_{QLT}$ tall.
c. The city is mostly$_{QNT}$ too$_{QLT}$ dangerous to walk around after dark.

Notice that if the order of modifiers is switched the readings in (18) do not survive. The examples are either ungrammatical, or receive a different interpretation. It seems, then, that the modifier assigned the quantity reading cannot c-command the modifier assigned the quality reading.

(19) a. *The steaks are three-quarters$_{QLT}$ half$_{QNT}$ cooked.
b. *The boys are very$_{QLT}$ half$_{QNT}$ tall.
c. *The city is too$_{QLT}$ mostly$_{QNT}$ dangerous to walk around after dark.

This ordering effect is straightforwardly predicted. If the lower degree expression is to have a quantity reading, the adjective must first combine with μ. The input to μ should be of type <et>, however, which implies that only an adjective that has already had its degree variable saturated can be its input. Consequently, in the examples in (19), there must be a null degree expression that combines with the adjective first (this would presumably be *pos*). But if *pos* satisfies the d-variable in the adjective, further quality modification is impossible, leaving the higher degree expression uninterpretable.

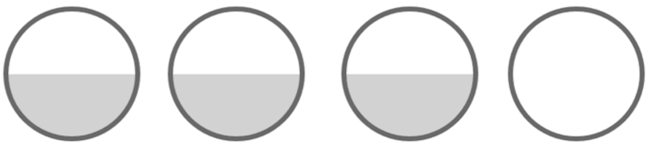
A further prediction is that attachment of degree modifiers on a quantity reading is recursive. As already mentioned, μ selects a sister of type <et>. Subsequent attachment of a degree expression delivers a category of type <et>, which is therefore a possible new input for μ. Our assessment is that this recursion indeed exists, but is limited by independent pragmatic factors.

The most easily accessible examples of recursion obtain when one modifier is interpreted distributively and one collectively. The sentence in (20) means – and we apologise for the awkward paraphrase – that most of the steaks are such that half of each of them is cooked to some contextual standard.

(20) The steaks are mostly$_{collective}$ half$_{distributive}$ *pos* cooked.

This situation is depicted in the following diagram:

(21)



The stacking of collective quantity modifiers on top of distributive ones is productive. Examples like the following are complicated, but unobjectionable:

(22) a. The steaks are eighty percent$_{QNT}$ half$_{QNT}$ well$_{QLT}$ cooked
b. The desserts in this restaurant are mostly$_{QNT}$ three-quarters$_{QNT}$ too$_{QLT}$ sweet and one quarter disgustingly acidic.
c. The cities in this region are half$_{QNT}$ partly$_{QNT}$ very$_{QLT}$ dangerous

Our analysis of (20) involves a distributive operator D (Link 1987) located between the modifiers.

(23) [mostly [μ [D [half [μ [*pos* cooked]]]]]]

Since D returns a function of the same type that it requires as input, it does not affect the possibility of recursion of quantity modifiers. The full derivation of *mostly half cooked* is given in (25), while D is defined in (24)

(24) $[\![D]\!] = \lambda P_{<et>}\ \lambda x\ \forall y.\ y \sqsubseteq x \wedge \text{atom}(y) \rightarrow P(y)$

(25) a. $[\![\textit{pos}\ \text{cooked}]\!] = \lambda x\ \exists d.\ \text{cooked}(d)(x) \wedge d > \text{standard}(\textbf{cooked})$

b. $[\![\mu]\!]\ ([\![\textit{pos}\ \text{cooked}]\!]) = [\lambda d'\ \lambda x\ \exists y.\ y \sqsubseteq x \wedge \exists d.\ \text{cooked}(d)(y) \wedge d > \text{standard}(\textbf{cooked}) \wedge \text{size}(y)\text{:size}(x) = d']$

c. $[\![\text{half}]\!]\ ([\![\mu\ \textit{pos}\ \text{cooked}]\!]) = [\lambda x\ \exists d'.\ \exists y.\ y \sqsubseteq x \wedge \exists d.\ \text{cooked}(d)(y) \wedge d > \text{standard}(\textbf{cooked}) \wedge \text{size}(y)\text{:size}(x) = d' \wedge d' = \text{midpoint}(\text{scale}(Q))]$

d. $[\![D]\!]\ ([\![\text{half}\ \mu\ \textit{pos}\ \text{cooked}]\!]) = [\lambda x\ \forall z.\ z \sqsubseteq x \wedge \text{atom}(z) \rightarrow [\exists d'.\ \exists y.\ y \sqsubseteq z \wedge \exists d.\ \text{cooked}(d)(y) \wedge d > \text{standard}(\textbf{cooked}) \wedge \text{size}(y)\text{:size}(z) = d' \wedge d' = \text{midpoint}(\text{scale}(Q))]]$

e. $[\![\mu]\!]\ ([\![D\ \text{half}\ \mu\ \textit{pos}\ \text{cooked}]\!]) = [\lambda d''\ \lambda x\ \exists w.\ w \sqsubseteq x \wedge [\forall z.\ z \sqsubseteq w \wedge \text{atom}(z) \rightarrow [\exists d'.\ \exists y.\ y \sqsubseteq z\ \&\ \exists d.\ \text{cooked}(d)(y) \wedge d > \text{standard}(\textbf{cooked}) \wedge \text{size}(y)\text{:size}(z) = d' \wedge d' = \text{midpoint}(\text{scale}(Q))]] \wedge \text{size}(w)\text{:size}(x) = d'']$

f. $[\![\text{mostly}]\!] = [\lambda x\ \exists d''.\ [\exists w.\ w \sqsubseteq x \wedge [\forall z.\ z \sqsubseteq w \wedge \text{atom}(z) \rightarrow [\exists d'.\ \exists y.\ y \sqsubseteq z \wedge \exists d.\ \text{cooked}(d)(y) \wedge d > \text{standard}(\textbf{cooked}) \wedge \text{size}(y)\text{:size}(z) = d' \wedge d' = \text{midpoint}(\text{scale}(Q))]] \wedge \text{size}(w)\text{:size}(x) = d''] \wedge d'' > \text{midpoint}(\text{scale}(Q))]$

g. $[\![\text{mostly}]\!]\ ([\![\mu\ D\ \text{half}\ \mu\ \textit{pos}\ \text{cooked}]\!]) = \exists d''\ \exists w.\ w \sqsubseteq \text{steaks} \wedge [\forall z.\ z \sqsubseteq w \wedge \text{atom}(z) \rightarrow [\exists d'.\ \exists y.\ y \sqsubseteq z \wedge \exists d.\ \text{cooked}(d)(y) \wedge d > \text{standard}(\textbf{cooked}) \wedge \text{size}(y)\text{:size}(z) = d' \wedge d' = \text{midpoint}(\text{scale}(\text{q-cooked}))]] \wedge \text{size}(w)\text{:size}(\text{steaks}) = d''] \wedge d'' > \text{midpoint}(\text{scale}(\text{q-cooked}))]$

This a fairly complex set of truth conditions, but the core result is that *the steaks are mostly half cooked* will have the following truth conditions: "there is a part *w* of the steaks comprising more than half of them, and for each atomic part *z* of *w*, there is a part *y* of *z* which is cooked to a contextual standard, and the size of *y* in relation to *z* is half". This will be true in a situation like (21).

Notice that the opposite order of modification, with the lower degree expression being assigned a collective reading, is ungrammatical. The following example is ruled out on the interpretation that half of the steaks are such that most of each of them is (fully) cooked:

(26) *The steaks are $\text{mostly}_{\text{distributive}}$ $\text{half}_{\text{collective}}$ cooked.

This restriction follows if there is a distributive operator, but no collective one. As the entire predicate in the scope of the D operator is distributed over the atoms in its subject, no quantity modifier in the scope of a distributive operator can receive a collective reading, which in turn means that no collective modifier can be c-commanded by a distributive one.

The question now presents itself whether stacking of quantity modifiers is possible if they are not separated by a distributive operator. We think it is, although judgments are complicated by the fact that the relevant examples run the danger of violating Grice's (1975) Maxim of Manner, and therefore require a very specific context to be judged felicitous. Consider an example like *the doors are half half red*, on a collective reading of both modifiers. On the intended reading, this sentence should be true if a quarter of the doors are red. But obviously it is also possible to describe this situation much less obtusely by using *the doors are a quarter red*.

Nonetheless, there are circumstances in which using the more complex expression is acceptable. In (27), the painter stresses that he is halfway to meeting the requirement of having painted half the doors. The expression *half half red* allows this to be stated explicitly, as opposed to *a quarter red*:

(27) [Context: A painter is supposed to paint ten out of twenty doors, but he has only painted five.]
Foreman: Vince, these doors are not half red yet.
Painter: Yes, but they're HALF half red.

In similar contexts, it is possible to have two quantity modifiers in the scope of the distributive modifier:

(28) [Context: A painter is supposed to paint ten doors half red (covering only the lower half), but he managed to paint them only a quarter red.]
Foreman: Vince, these doors are not half red yet.
Painter: Yes, but they're HALF half red.

Combinations of a collective and distributive quantity modifier, as in (20) and (22), are not in danger of violating the Maxim of Manner, as there is no simple expression that can replace the two modifiers. These examples therefore do not require a facilitating context.

In sum, stacking of quantitative degree expressions is possible, under the conditions predicted, so long as care is taken to satisfy semantic and pragmatic principles.

We do not see how an analysis without μ could satisfactorily account for the patterns of modifier stacking discussed above. A floated quantifier style analysis would force the subject to be associated with multiple gaps, requiring serious complications of standardly assumed constraints on movement. A lexical ambiguity account of adjectives would have to posit a (possibly arbitrary) number of open degree arguments, and stipulate that the very lowest must refer to the intensity of the property expressed by the adjective, while all higher degree arguments must refer to the quantity of the subject that satisfies that property. Assuming an element like μ provides a straightforward account of the stacking of degree expressions.

3.2 Crosscategorial Distribution

The analysis proposed above predicts that degree modifiers can combine with categories other than gradable adjectives if these categories first merge with μ, so that the modifiers can assume a quantity reading. Therefore, even categories that do not have a quality reading, due to not introducing a degree argument as part of their lexical semantics, can receive a quantity reading. This prediction comes about because the degree argument involved in quantity reading is added by rule, while the one involved in quality readings is given lexically.

We have already shown that the quantity reading of degree modifiers is generally available with gradable adjectives. Non-gradable adjectives like *wooden* permit degree expressions with a quantity reading (e.g. in *The toy is half wooden* (*and half plastic*)). As such adjectives are of type <et>, they are suitable input to μ. Subsequent degree modification proceeds as before.

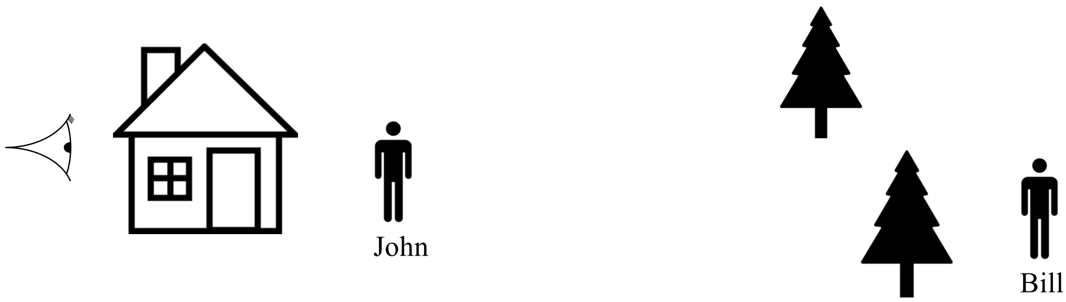
(29) a. $[\![\text{wooden}]\!] = \lambda x.\ \text{wooden}(x)$
b. $[\![\mu]\!]\ ([\![\text{wooden}]\!]) = [\lambda d\ \lambda x\ \exists y.\ y \sqsubseteq x \wedge \text{wooden}(y) \wedge \text{size}(y){:}\text{size}(x) = d]$

Degree expressions on a quantity reading can also attach to non-adjectival categories, whereas quality readings are only available as a marked option, requiring coercion of gradability.

For example, the basic semantics of prepositional phrases seems to be locational. Locational semantics is encoded in terms of vectors rather than scales, which we take to be different notions (although one may be derived from the other; see Faller 2000 and Winter 2005). This implies that quality degree modification of locational PPs is not possible. For example, *John is more behind the house than Bill* does not mean that the vector length between John and the house is greater than that between the house and Bill. Similarly, *John is very* (*much*) *behind the house* does not permit an interpretation in the vector length between John and the house is considerable.

One way to bring about quality readings with locational PPs is to coerce metalinguistic semantics on them. The truth conditions of a metalinguistic comparative have to do with the degree to which an expression is appropriate description in a given situation (see Wellwood (2014) for detailed discussion of metalinguistic comparatives). Thus, *John is more 'behind the house' than Bill* means that the predicate *behind the house* is a better description of John's position than it is of Bill's. This could be true in the situation depicted below. Due to John's close proximity to the house, and Bill's close promixity to other salient objects, John's being 'behind the house' is more salient than Bill's (even though both are behind the house from the point of view of the observer):

(30)



However, there is a much more accessible reading of locational PPs modified by degree expressions, namely one in which the degree expression determines the proportion of the subject that the PP applies to. Some examples are given below.

(31) a. The truck is half behind the house.
b. The blanket is more on the floor than on the bed.
c. The capsized trawler is now mostly under the surface.
d. It is still partly above the surface.

The acceptability of these examples follows straightforwardly if μ can freely attach to categories that do not inherently have a degree argument, creating a suitable input for subsequent degree modification. The example in (31a) would involve the partial derivation in (32), giving rise an interpretation of *half behind the house* according to which half of the subject is located at the end of a vector originating from the back of the house.

(32) a. $[\![\text{behind the house}]\!] = \lambda x\ \text{behind-the-house}(x)$
b. $[\![\mu]\!]\ ([\![\text{behind the house}]\!]) = [\lambda d\ \lambda x\ \exists y.\ y \sqsubseteq x \wedge \text{behind-the-house}(y) \wedge \text{size}(y){:}\text{size}(x) = d]$

Like PPs, NPs allow modification by proportional degree expressions. Examples are easily constructed using mass nouns or bare plurals:

(33) a. This jam is three quarters sugar.
b. This jam is more sugar than fruit.
c. Our sweaters are mostly wool, with some cotton for comfort.
d. Sorry, my contribution to this discussion has been partly nonsense.

(34) a. His contribution to any discussion is three quarters *erm*s and a quarter *ah*s.
b. This stew is more chillies than vegetables.
c. The filling of this duvet is mostly chicken feathers.
d. This salad is partly cheap beans and partly old lettuce leaves.

As before, the grammaticality of these examples follows, given that μ can freely attach to categories that do not inherently have a degree argument. Prior to modification by *three quarters*, *sugar* in (33a) undergoes the partial derivation in (35). Once the degree variable is valued by the degree expression, the resulting interpretation will be that three quarters of the jam is sugar.[2]

(35) a. $[\![\text{sugar}]\!] = \lambda x.\ \text{sugar}(x)$
b. $[\![\mu]\!]\ ([\![\text{sugar}]\!]) = [\lambda d\ \lambda x\ \exists y.\ y \sqsubseteq x \wedge \text{sugar}\ (y) \wedge \text{size}(y)\text{:size}(x) = d]$

Surprisingly, with VP we find two patterns. Some degree modifiers can be attached to VP and yield a quantity reading; examples are given in (36). Most degree modifiers, however, do not allow this. All the examples in (37) are ill-formed on a quantity reading.

(36) a. The oil has mostly been put in barrels (but some of it is still in the tanker).
b. The cliff has been partly worn away.
c. The crowd, for the most part, left shortly after John started to talk.

(37) a. *The oil has three-quarters been put in barrels (but 25% is still in the tanker).
b. #The crowd is more laughing than crying.[3]
c. *The cliff has been forty percent worn away.

We first look at how the ungrammatical cases in (37) could be explained. We assume that μ does not only require attachment to a category of type <et>, but must also meet a particular syntactic requirement: it must be located at the edge of an extended projection. In the case of PP, AP and NP predicates, the extended projection as a whole is of the right type to be input to μ. The maximal extended verbal projection, however, is not of type <et>, but of type t, which means that μ, when merged with a verbal category, cannot simultaneously receive an input of the appropriate type and also be attached at the edge of the extended projection. If μ cannot be merged, then of course the degree expressions dependent on it cannot be merged either.

[2] We follow Moltmann (1997) in taking the human conceptualization of parts, and the linguistic instantion of them, to be different from what is permitted by standard mereology. Parts can be the discrete objects that constitute, say, a car or a bicycle, but they can also be the ingredients that make jam, or a good gin and tonic. Once a gin and tonic has been made, the ingredients cannot be referred to as ‘parts’ in extensional mereology: there is no unique part of the cocktail that consists just of ‘gin’ or ‘tonic’. However, we can apparently still think of them, and we argue that the grammar can refer to them, as parts in a part-whole structure.
[3] This example is acceptable on an irrelevant metalinguistic interpretation, where the crowd’s action is better described as ‘laughing’ than as ‘crying’ (Wellwood 2014).

Why should this syntactic requirement hold? One possibility is that we characterise μ as a functional head devoid of categorial features. The theory of extended projection requires, among other things, that a functional head of category κ must be part of an uninterrupted sequence of heads of category κ, terminating in a lexical head of the same category (see Grimshaw (1991, 2005)). If a functional head has a category, it will therefore select a complement of that same category. By the same logic, if a functional head does not place categorial restrictions on its complement, it follows that it cannot itself have a category. It also follows that such a head must be attached at the edge of the extended projection; if it were attached below any head which has categorical features, it would interrupt the extended projection line connecting this head to the associated lexical head. So, the distribution of μ follows from the hypothesis that it is a functional head, in conjunction with the theory of extended projection, and the observation that quality readings can be obtained with multiple categories (there is a precedent for this kind of argumentation in Philip's (2013) analysis of linkers, which must also be located at edge of the extended projection they combine with).

We now turn to the question of why quantity modification of VPs is allowed with a limited set of modifiers. The logic of the argumentation above implies that such modifiers cannot depend on the presence of μ; rather, the relevant degree expression must have the semantics of μ built in. That is, these modifiers must inherently have the capability of opening up the part structure of the subject (as represented by the predicate's unsaturated argument variable) and specifying the size of this part in relation to the whole. This would allow them to be attached to all categories, including VP, as the above complications with μ are avoided: if μ need not be merged, there is also no danger of it interrupting an extended projection. A sample derivation is given below:

(38) a. $[\![\text{partly}]\!] = \lambda f_{<et>}\ \lambda x\ \exists y.\ y \sqsubseteq x\ \wedge\ \text{size}(y):\text{size}(x) > 0\ \wedge\ f(y)$
b. $[\![\text{worn away}]\!] = \lambda x.\ \text{worn away}(x)$
c. $[\![\text{partly}]\!]\ ([\![\text{worn away}]\!]) = \lambda x\ \exists y.\ y \sqsubseteq x\ \wedge\ \text{size}(y):\text{size}(x) > 0\ \wedge\ \text{worn away}(y)$

How does the semantics of μ get into these phrasal degree expressions? There are two possibilities. It could be that there is a rule of function composition that combines μ directly with a degree modifier. Alternatively, the degree expressions in question could simply have a richer lexical semantics than those that rely on the presence of μ, as a lexical property. A theory based on function composition would be self-defeating, as it would predict that every degree expression should be able to combine with μ before combining with a predicate. The contrast between (36) and (37) would then be underivable. By contrast, the lexical theory correctly predicts that the expressions that do attach to VP must be stored in the lexicon. Indeed, *mostly*, *partly*, and *for the most part* must all be stored in the lexicon: the suffix *–ly* does not productively combine with quantifiers or nouns, and *for the most part* is a fixed expression. The picture that emerges is one in which part-whole structures are, in the normal case, introduced by an element μ that is attached at the edge of the extended projection of a predicate; in exceptional cases, they can be introduced via the lexical semantics of certain modifiers.[4]

An account without a syntactic element like μ could not account for this distributional behaviour, namely that VP behaves differently to other syntactic categories.

[4] Interestingly, these modifiers all have a temporal reading as well, which can be roughly paraphrased as *usually*. This may suggest that the part-whole relation introduced by the modifiers can interact with temporal or event-related information, but this is unfortunately an issue that we cannot explore in this paper.

3.3 Degree expressions that do not allow quantity readings

The proposal outlined above makes the strong prediction that degree expressions that are regular functional heads, selecting a complement of a particular category, will not permit a quantity reading. Consider why. Such degree expressions would have to attach after μ has made available the part-whole structure necessary for the quantity reading. However, as μ does not have categorial features, its presence would interrupt the sequence of heads running from the lexical item to that degree expression, contra to the theory of extended projection. In order to test this prediction, we need to have some diagnostics by which we can determine whether a given degree expression is a functional head or a phrasal modifier. A range of relevant criteria is discussed in Neeleman et al (2004); by these criteria, the degree expressions classified as heads are *too*, *very*, *as*, *how*, and *that*. One test is whether a given degree expression can attach directly to *so*; assuming that *so* is a-categorial, it cannot be selected for by a functional head requiring an adjectival category as its complement. The ungrammaticality of **too so*, **very so*, **as so*, **how so*, and **that so* indicates that *too*, *very*, *as*, *so*, and *how* are such functional heads (for related discussion, see Corver 1997a, b). We therefore expect that these degree expressions cannot support a quantity reading. This is indeed the case:

(39) *I asked for three-quarters of the system to be electronic.*
  a. *But this system is too manual to finish the task in time
  b. *But this system is very manual
  c. *But this system is still as manual as electronic.
  d. *So, how electronic is this system?
  e. *But I didn't expect it to be that electronic.

By contrast, we expect that phrasal modifiers do permit a quantity reading. As they are not part of the extended projection of the category they merge with, they do not impose c-selectional requirements on that category in the way that functional heads do. Examples of phrasal modifiers are *more*, *less*, *completely*, and *partly*, which can all combine directly with *so*. These modifiers do indeed allow a quantity reading:

(40) *I asked for three-quarters of the system to be electronic.*
  a. But this system is more manual than electronic.
  b. But this system is less electronic than manual.
  I asked for at least some of the system to be electronic.
  c. But this system is still completely manual.
  I asked for 100% of the system to be electronic.
  d. But this system is still partly manual.

A similar account is possible for the fact that *more* can support a quantity reading, but *-er* cannot, not even with adjectives like *blue* that otherwise freely permit both analytic and synthetic comparatives:

(41) a. The sky is more_{QLT} blue than it was yesterday.
  b. The sky is $\text{bluer}_{\text{QLT}}$ today than it was yesterday.

(42) a. The carpet is more_{QNT} blue than (it is) red.
  b. *The carpet is $\text{bluer}_{\text{QNT}}$ than (it is) red.

As is well known, *-er* selects an adjectival base. However, attachment of μ creates a node without categorical features, which means that μ cannot attach before *-er*. *More*, on the other hand, is phrasal, and therefore does not impose any categorical selectional restrictions.

We do not see how a non-syntactic account of quantity readings could capture the fact that modifiers selecting an adjectival complement resist such readings.

There is a further restriction on the class of degree modifiers that support a quantity reading, which is more mysterious. It seems that degree expressions that involve comparison to a contextually determined standard do not permit quantity readings. This is illustrated in (43):

(43) *I asked for three-quarters of the system to be electronic.*
   a. *But this system is not electronic enough.
   I asked for the system to be electronic.
   b. *But this system is still a good deal manual.
   c. *But this system is still a little manual.

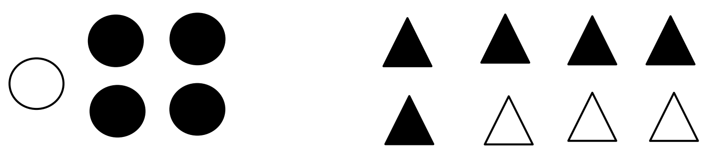
We do not know why this is, but would speculate that there is a general ban on ‘second-order comparisons’: it is not possible to directly compare the proportion of parts in one object to the proportion of parts in another object (proportion itself being a comparison of part sizes). This is what would be required to compute the truth conditions of sentences like those in (43), as is schematized below:

(44)
$$\frac{\text{size of manual part of } \alpha}{\text{size of } \alpha} > \text{standard} \left(\frac{\text{size of manual part of } x}{\text{size of } x} \right)$$

For example, a proportional reading of *a good deal* in (43b) would imply that the proportion of the manual part (as compared to the electronic part) in the system is large, potentially too large, judged by the contextual standard of proportions. Therefore, if there is a ban on second-order comparisons, (43b) is correctly ruled out, as are (43a) and (43c), which would similarly require comparison to a contextually-determined standard.

There is some independent evidence for this speculation. Consider the following collection of circles and triangles:

(45)



The number of black circles is smaller than the number of black triangles; however, the proportion of black circles in the set of circles is larger than the proportion of black triangles in the set of triangles. This second fact, as far as we can tell, cannot be expressed with a simple comparative such as (46). Evaluating the truth conditions of this example would require comparing the number of black circles to white circles, comparing the number of black triangles to white triangles, and finally comparing these two comparisons (see (47)). This is precisely the kind of calculation ruled out by a ban on second-order comparison.

(46) #The circles are more black than the triangles.

(47) $$\frac{\text{number of black circles}}{\text{number of circles}} > \frac{\text{number of black triangles}}{\text{number of triangles}}$$

Note that if the *than*-clause does not mention the contrasting shapes, but rather the contrasting property within just one group of shapes, the resulting sentence is unproblematic:

(48) The circles are more black than white

This is because evaluating the truth conditions of (48) simply requires comparing the number of black circles to the number of white circles, which does not violate the ban on second-order comparison.

The pattern is quite general; the *than*-phrase in quantity comparatives must introduce a property rather than an object:

(49) a. #This system is more manual than that one.
b. This system is more manual than electronic

We leave it open whether this ban on second-order comparison should be implemented in the grammar, and if so, how. If it is real, however, it provides a unified explanation for the fact that *enough*, *a good deal*, and *a little*, and certain comparative constructions, do not permit a quantity reading.

4. Conclusion

Our analysis gives rise to a one-way dissociation: all categories that permit a quality reading of degree modifiers will also permit a quantity reading, but the reverse does not hold. The prediction comes about because the degree argument involved in quantity readings is added by rule, while the one involved in quality readings is given lexically.

As far as we can see, a non-structural account of quantity readings (either a purely pragmatic account, or one that stipulates a quality/quantity ambiguity in the lexical semantics of the predicate; see Kennedy & McNally 2009) would have no way to capture the data. Even if there were a way to allow stacking of modifiers (such as assigning gradable adjectives a type of <d,d,<e,t>>, with an additional degree variable making reference to quantity), we can see no non-stipulative way of capturing the ordering effects observed with multiple degree expressions. It would also be an open question why phrasal degree expressions, but not degree heads, can give rise to a quantity reading, or why VP is the only lexical category to disallow this reading. A structural account of the quantity reading is therefore to be preferred.

23rd October 2015

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