The comparative and degree pluralities*

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Abstract

Quantifiers in phrasal and clausal comparatives often seem to take distributive scope in the matrix clause: for instance, the sentence *John is taller than every girl is* is true iff for every girl it holds that John is taller than that girl. Broadly speaking, two approaches were developed that derive this reading without postulating the (problematic) wide scope of the quantifier: the negation analysis and the interval analysis of *than* clauses. We propose a modification of the interval analysis, in which *than* clauses are not treated as degree intervals, but degree pluralities. This small change has significant consequences: it yields a successful account of differentials in comparatives and it correctly predicts the existence of hitherto unnoticed readings, viz. cumulative readings of clausal comparatives. Finally, this paper also makes the case that using degree pluralities is conceptually appealing: it allows us to restrict the analysis of comparatives by mechanisms that are postulated independently in the semantics of pluralities.

1 Introduction

It is probably a universal property of language that it allows us to talk about single individuals as well as pluralities formed from them. Thanks to this property, we don't have to restrict our discussions to *Mary* or *the table over there*, instead, we can ascribe properties to pluralities, say, *Mary, Sue and John* or *the tables and chairs*. The semantic literature that studies pluralities often postulates the existence of entities that are non-atomic in nature, whether these be implemented in terms of sets (e.g. Hoeksema 1983, Gillon 1987, Schwarzschild 1996, Winter 2002) or algebraic sums/joins (e.g. Link 1983, Krifka 1989, Landman 1989, Landman 1996, Landman 2000). In addition, the literature has recognised the semantic mechanisms that govern the relations such pluralities engage with. For instance, (1) can be read in various

*[Update: 11 November] It came to our attention after submitting/uploading the first draft of our paper that Beck 2014 provides an analysis of comparatives that is similar to the one we propose here. The current version of the paper does not include a comparison of our account to Beck's, but we are planning to add that in the revised version.

ways. A distributive reading says that both women separately wrote twelve books (i.e. twenty-four in total). A collective reading says that Mary and Sue collaborated on a total of twelve books. Finally a cumulative reading says that there is a total of twelve books written by either Mary or Sue, where some were written by Mary and some were written by Sue. On top of postulating sum (or set) denotations for *Mary and Sue* and *twelve books*, the semantics for (1) will thus need to provide various ways in which these sums enter in the *write* relation.

(1) Mary and Sue wrote twelve books.

There is a good case to be made that plural individuals and semantic mechanisms that operate on plural structures are domain-independent and so the postulation of pluralities is not limited to the domain of entities. In the literature, one can find arguments for plural events (Krifka 1989; Schein 1993; Landman 2000; Kratzer 2003), plural information states (van den Berg 1996; Krifka 1996; Nouwen 2003; Nouwen 2007; Brasoveanu 2008), plural times (Artstein and Francez 2003) and plural propositions (Beck and Sharvit 2002). Missing from this list are plural degrees. Although degree pluralities do make an appearance in a handful of places in the literature (Matushansky and Ruys 2006; Fitzgibbons, Sharvit, and Gajewski 2008; Beck 2012), as far as we know there has so far been no dedicated argument in the literature in favour of an advanced parallel between the semantic structures available for entities and those available for degrees. In this paper, we will provide a motivation for a framework of degree pluralities. Up to a certain extent our rationale is simple. Degrees behave very much like entities and, so, they will partake in exactly the kind of semantic structures as entities do. For instance, (2) clearly has a cumulative reading, where John is 20 years old, Peter is 22 and Mary is 26. (The distributive reading would be non-sensical since it requires each of the three men to have multiple ages.)

(2) John, Peter and Mary are 20, 22 and 26 years old.

Any analysis of this example will have to resort to a cumulative relation between two pluralities: on the one hand the plural entity consisting of John, Peter and Mary and on the other hand the degree sum consisting of 20, 22 and 26 years. In other words, sentences like (2) already seem to commit the semanticist to the assumption that, like the domain of entities, the domain of degrees contains both atoms and sums.

Our claims go further than this resemblance between entity and degree ontology. The force of our proposal will be in the semantics of the comparative. We put forward an approach where the comparative is interpreted as a relation between degree pluralities, which entails that the comparative can be read distributively and cumulatively. We will support our proposal for a plural comparative in two distinct ways. On the one hand, we will provide data that suggests a necessarily plural (i.e. cumulative) interpretation of the relation between degrees expressed by comparative morphology. On the other hand, we will show that the plural degree framework allows for a reinterpretation of existing interval-based theories of degree morphology. Replacing intervals with pluralities will give a more natural analysis of quantifiers in *than* clauses and it also solves a hitherto open problem concerning differentials.

In the semantic literature on the comparative, the interpretation of *than* clauses takes a central role, and it equally does so in this paper. We start in the next section with an introduction to the issues central to comparative degree semantics and the semantics of *than* clauses. We also give a sneak preview to our take on these issues (Sections 2 and 3). After that, we postulate a simple framework for plural degree semantics (Section 4). We show that using plural degree semantics can handle the crucial issues of comparative degree semantics relatively straightforwardly, including the interplay of comparatives with differentials, which poses a challenge to all existing semantic theories (Section 5). Furthermore, plural degree semantics predicts a reading that has so far played hardly any role in the discussion of comparatives. We call the reading a cumulative comparison and argue that it strongly supports our analysis (Section 6). Section 7 discusses open issues.

2 Background: quantifiers in *than*-clauses

At least since von Stechow (1984), semanticists used quantifiers in *than*-clauses as a testing ground to find the correct interpretation of comparatives. We illustrate this point by discussing two types of approaches to the comparative, which we will call, following previous literature, the *negation* and the *interval* approach respectively. Our starting point is the interpretation that the two approaches would assign to a run-of-the-mill case of comparison, (3), shown in (3-a) and (3-b). Before we proceed to discussing it, one warning to the reader: our semantics captures the essence of the two approaches but it glosses over a lot of detail and does not show the many varieties that exist in both approaches. The same is not only true for (3), but for the rest of this section, as well. We introduce these simplifications to make a general point about the empirical prospects of either approach, regardless of the details of their implementation.

(3) John is taller than Mary (is).

a. $\exists d[tall(j,d) \wedge \neg tall(m,d)]$ negation approach

b. $max(\lambda d.tall(j,d)) > max(\lambda d.tall(m,d))$ interval approach

(3-a) and (3-b) share the assumption that adjectives express monotone relations between individuals and degrees. The monotonicity lies in the fact that if John's height corresponds to d_j, then not only is John tall to degree d_j (i.e. $tall(j, d_j)$ is true), but John is also tall to any lower degree $d < d_j$. The monotonicity is explicitly expressed by assuming (4) as the interpretation of *tall* (and similarly for other gradable adjectives). So, for example, in (3-b), $\lambda d.tall(j, d)$ corresponds to the interval (0,John's height].

(4) $[\![\text{tall}]\!] = \lambda d \lambda x.x\text{'s height} \geqslant d$

Coupled with this assumption, (3-a) looks at the complement of Mary's interval of height, (Mary's height,∞), and says that this overlaps with (0,John's height]. (3-b) states that *max*(0,John's height] > *max*(0,Mary's height],i.e., John's height > Mary's height.

In their basic forms, both these approaches make surprisingly problematic predictions once we turn to apparently simple examples that have a universal quantifier in the *than*-clause, as in (5).

(5) John is taller than every girl is.

a. $\exists d[tall(j, d) \wedge \neg\forall x[girl(x) \rightarrow tall(x, d)]]$

b. $max(\lambda d.tall(j, d)) > max(\lambda d.\forall x[girl(x) \rightarrow tall(x, d)])$

Both (5-a) and (5-b) express that John is taller than the shortest girl. The required reading is much stronger, namely that John's height exceeds that of the tallest girl. What is striking is that this stronger reading can be obtained if we assume that the quantifier *every girl* takes wide scope (von Stechow 1984).

(6) a. $\forall x[girl(x) \rightarrow \exists d[tall(j, d) \wedge \neg tall(x, d)]]$

b. $\forall x[girl(x) \rightarrow max(\lambda d.tall(j, d)) > max(\lambda d.tall(x, d))]$

An analysis along the lines of (6) is an unlikely solution, however, given that it is generally assumed that quantifier raising is clause-bound (May 1985; Reinhart 1997), which means that we would have obtained (6-a) and (6-b) via an island violation. In the past decade or so, developments of the two approaches have avoided the need to resort to such violations by assuming that the relevant scope relation is located within the *than*-clause. This is most easily illustrated using the negation approach, which often assumes that at some level of description the *than*-clause contains an actual negation operator (Gajewski 2008; van Rooij 2008; Schwarzschild 2008). In our simplified setup, *than every girl is* could be represented as follows (assuming that the ellipsis is recovered in interpretation):

(7) [than [NOT [[every girl] [is [tall]]]]]

Such a setup makes it possible for the quantifier *every girl* to get scope over negation:

(8) [than [[every girl] 1 NOT [t_1 [is [tall]]]]]

Following standard assumptions, this would give us the term $\lambda d.\forall x[girl(x) \rightarrow \neg tall(x,d)]$, which corresponds to the interval that goes upwards from just above the tallest girl's height. The whole construction *John is taller than every girl is* can now be interpreted as saying that there exists a degree in that interval to which John is tall. In other words, John is taller than the tallest girl.

Although this derives the desired interpretation, there are some interesting and serious problems with this view. Most importantly, if (8) has come about by quantifier-raising the subject, then we would expect to see ambiguity, or at least we would like to have some rationale for why universal quantifiers always seem to take wide scope with respect to negation.[1] Worse, one would have to explain how constructions that normally do not display movement are necessarily interpreted in a high position, whereas others are not. For instance, for (9) only the low negation reading is available, whilst for (10) only the high negation reading is there.

(9) John is taller than Bill and Peter.

a. $\exists d[tall(j,d) \wedge \neg(tall(b,d) \wedge tall(p,d))]$ unavailable

b. $\exists d[tall(j,d) \wedge (\neg tall(b,d) \wedge \neg tall(p,d))]$ available

(10) John is taller than Bill or Peter.

a. $\exists d[tall(j,d) \wedge \neg(tall(b,d) \vee tall(p,d))]$ available

b. $\exists d[tall(j,d) \wedge (\neg tall(b,d) \vee \neg tall(p,d))]$ unavailable

As we will see below, the fact that no actual ambiguity observed is motivation for Beck (2010) to aim for an analysis that involves a fixed scope relation for all *than*-clauses. Before we turn to such ways of improving on the basic interval and negation approach, we would like to mention another aspect that makes the negation and interval approach problematic.

The issue we sketched above is that the two standard approaches predict a more-than-minimum reading rather than the required more-than-maximum reading for *than*-clauses with a universal quantifier. In general, comparatives always seem to provide the latter rather than the former reading (but see below). For instance, (9) and (10) are synonymous - they both mean that John is taller than whoever is tallest from Bill and Peter. One could think then that the mechanism we are after is simply one which returns the maximum degree of all the individuals in the domain of quantification in the than-clause, independent of the quantifier relation that is involved. Such a mechanism, however, would be too simple for the case of differentials, where the desired readings are a bit trickier still. Consider

[1] van Rooij (2008) proposes such a rationale, using the Strongest Meaning Hypothesis of Dalrymple, Kanazawa, Mchombo, and Peters (1998). But see Section 2.3.3 of Beck (2010) for problems with this line of avoiding ambiguity.

(11).

(11) John is exactly 3 inches taller than every girl.

As before, the correct interpretation for (11) can be paraphrased by giving the quantifier wide scope, as in (12).

(12) Every girl is such that John is exactly 3 inches taller than her.

Not only does (11) say that John is exactly 3 inches taller than the tallest girl, it requires John to be exactly 3 inches taller any of the other girls too. In other words, (11) entails that all the girls are the same height.

The issue is that nothing in either the negation or the interval approach allows us to refer to the individual heights of the entities in the domain of quantification. Take the form in (8), for instance, which provided the correct interpretation for a regular comparative by letting the than clause denote $\lambda d.\forall x[girl(x) \rightarrow \neg tall(x, d)]$. As we said above, this is an interval leading up from the tallest girl's height. Crucially, this interval does not contain the heights of any of the girls and, so, there is no way the ultimate truth-conditions are going to include the entailment that the girls are all equally tall.

For the interval strategy, one may have found a way to associate *than every girl is* with the interval (0,the tallest girl's height]. Crucially, however, this is a dense interval, where the individual heights of the girls are no longer discriminated. The semantics of the comparative further reduces this interval to its maximum, comparing that degree to the height of the subject. Thus, there could be no semantics for the differential such that if combined with this interval, the entailment would come out that all girls are equally tall, simply because the semantics has no access to the individual girls' heights.

These aspects of the interval and the negation approach have been rather neglected, we believe. In fact, the contemporary approaches building on the basic negation and interval strategies leave this issue pretty much unresolved, as is argued in detail by Fleisher (2014). Our goal is to solve the puzzle of quantifiers in than clauses in such a way that it automatically accounts for an appropriate semantics of differentials. We do so by reinterpreting modern versions of the interval strategy, in particular that of Beck (2010), to which we turn now.

3 Beck's selection approach

The main innovation in Beck (2010) is, we believe, to assume that standard clauses involve a selection mechanism akin to the one found in the semantics of definite descriptions or questions. Her analysis is furthermore based on a variation of what we called the interval strategy that is due to Schwarzschild and Wilkinson (2002) and Heim (2006). In this approach, *than*-clauses are lifted to express sets of intervals, rather than simply intervals. To illustrate the strength of the approach, it suffices to assume that intervals are introduced at the level of the adjective as in (13), but see Beck (2010) and, especially Heim (2006) for alternative possibilities.

(13) $[\![\text{tall}]\!] = \lambda D_{\langle d,t \rangle}.\lambda x_e.x\text{'s height} \in D$

The combination of (13) with the semantics of quantifiers and the abstraction over intervals leads to the following meaning for *than*-clauses of the form *than Q is/are tall*.

(14) $\lambda D.Q(\lambda x.x\text{'s height} \in D)$

For a non-quantificational *than*-clause like *than Bill is tall* this yields all the sets of degrees that contain Bill's height. For *than every girl is* it gives all the sets of degrees that contain the heights of every girl. Beck now assumes that the final denotation of the *than*-clause comes about in two steps:

(15) Step 1—Select the most informative sets in the set of sets of degrees
Step 2—Select the highest degree out of these most informative sets

Step 1 is implemented by defining a function *min* that picks those sets from a collection of sets that do not contain subsets that are themselves a member of the collection, and combines these into a single new set:

(16) $min(\mathcal{D}) = \cup\lambda D.D \in \mathcal{D} \wedge \neg\exists D'[D' \in \mathcal{D} \wedge D' \subset D]$

Step 2 is now a regular maximality operator that pick the highest value from the set $min(\mathcal{D})$. Thus, the two steps select the maximal point of all the minimal interval(s). The results of this selection procedure are illustrated with the following examples:[2]

(17) a. $[\![\text{than Bill is tall}]\!] = \{D \mid D \text{ contains Bill's height}\}$
b. $min([\![\text{than Bill is tall}]\!]) = \{\text{Bill's height}\}$
c. $max(min([\![\text{than Bill is tall}]\!]) = \text{Bill's height}$

(18) a. $[\![\text{than every girl is tall}]\!] = \{D \mid D \text{ contains the heights of each girl}\}$

[2]To understand the derivations, it helps to keep in mind that D is an interval (if two points a and b are in D then all points between a and b are in D, too). In contrast, the set created by the application of *min* is just a set of points and does not need to satisfy the mentioned condition. The restriction of D to intervals is commonly held in the interval strategy (see Schwarzschild and Wilkinson 2002, Beck 2010). Heim (2006) takes D to be just a set of points (degrees) but for her this choice is just a matter of simplicity (sets are in a way more primitive than intervals) and, as she acknowledges, it is not empirically driven. To preview our own account, we will argue that there are empirical reasons to think that *than* clauses involve non-dense sets (or, rather, pluralities) of degrees.

b. $min([\![\text{than every girl is tall}]\!])$ = the set containing the height of the shortest girl, the height of the tallest girl and all the degrees in-between

c. $max(min([\![\text{than every girl is tall}]\!]))$ = the height of the tallest girl

(19) a. $[\![\text{than Bill and Peter are tall}]\!] = \{D \mid D$ contains both Bill's and Peter's height$\}$

b. $min([\![\text{than Bill and Peter are tall}]\!])$ = the set containing Bill's height, Peter's height and all the degrees in-between

c. $max(min([\![\text{than Bill and Peter are tall}]\!]))$ = the height of whoever is tallest from Bill and Peter

(20) a. $[\![\text{than Bill or Peter are tall}]\!] = \{D \mid D$ contains Bill's height or Peter's height or both$\}$

b. $min([\![\text{than Bill or Peter are tall}]\!])$ = the set containing just Bill's height and Peter's

c. $max(min([\![\text{than Bill or Peter are tall}]\!]))$ = the height of whoever is tallest from Bill and Peter

All these calculations yield the correct result. Below, in section 7, we will look at some further details of this selection mechanism and turn to cases where the result is less clearly favourable. Let us for now, however, focus on the merits of Beck's theory. Via the selection mechanism, Beck has done away with any scopal ambiguity, making clear predictions which reading surfaces where. In the following section we will build further on Beck's approach. Before we do so, we need to point out an important detail of her selection mechanism.

The selection procedure we discussed above is two-tiered. This allows *than*-clauses, which are originally assigned type $\langle\langle d, t\rangle, t\rangle$, to yield the degree (type d) to which the matrix-clause degree is compared. In this way, Beck's analysis is a combination of the approaches operating with sets of intervals and the interval approaches: the composition inside the *than*-clause is done along the lines of the former accounts, while the final object is just a single degree, as in the latter accounts. Beck sees this as advantage because, in her words, "it remains a strength [of the interval approaches] that degree operators combine directly with expressions referring to degrees, and that differentials in particular [as in *John is 2 inches taller than Bill is*] can be accounted for in a direct and straightforward way." We agree with Beck that differentials are far from straightforward in the approaches working with sets of intervals and they are particularly problematic for negation accounts. However, we disagree with her conjecture that *than*-clauses should therefore yield one degree. As we remarked above, differentials like (21) entail that all the girls have the same height. If the than-clause expresses a single degree (say, that of the tallest girl's height) there is no hope to derive this entailment.

(21) John is exactly two inches taller than every girl.

In the next section, we will develop an analysis of *than*-clauses within a framework of degree pluralities. We will argue that this approach simplifies the selection mechanism to a single operation (since there is no need any more for *than*-clauses to yield a single degree), yet it can straightforwardly deal with differentials. Crucially, all this can be achieved with the standard machinery of the semantics of pluralities.

4 A framework for degree pluralities

We would now like to propose a minimal variation on theories operating with sets of intervals, one which incorporates a notion of *degree plurality*. As we will argue extensively in the sections below, the shift from an interval theory to an analysis revolving around plurals improves the empirical coverage.

The idea is first of all to extend the domain of degrees to contain degree sums in addition to degree atoms. For the domain of entities it is standard to assume that it has the structure of the powerset of the domain of atomic entities, with the empty set removed. One can see this as the requirement that the domain is closed under sum formation: it is the smallest set that contains all the atoms and all possible sums that can be formed using these atoms (Link (1983), Landman (1996); see Nouwen (2015) for an overview of plural semantic frameworks.) Some useful notions borrowed from the literature on plurality:

(22) a. We will use $a \sqcup b$ (the *sum* of a and b) to represent the plural individual that has a and b as its parts.
b. We will use * to represent closure under sum of a set, we will refer to this as *predicate cumulation*: $*X :=$ the smallest set such that $*X \supseteq X$ and $\forall x, y \in *X[x \sqcup y \in *X]$.
c. We will use ** to represent closure under sum of a binary relation, we will refer to this as *relation cumulation*: $**R :=$ the smallest set such that $**R \supseteq R$ and $\forall x, x', y, y'[\langle x, x'\rangle, \langle y, y'\rangle \in **R \rightarrow \langle x \sqcup y, x' \sqcup y'\rangle \in **R]$.
d. We will use $\sqsubseteq$ as the part-of relation: $a \sqsubseteq b \;:\Leftrightarrow a \sqcup b = b$
e. We will use *Atom* to return the atoms in a set of pluralities: $Atom(X) \;:=\; \lambda x.X(x) \wedge \neg\exists y[y \sqsubsetneq x]$.

For the domain of degrees $\mathcal{D}$, we now make exactly the same assumptions. $\mathcal{D}$ contains all the atomic degrees, as well as all sums you can form on the basis of that. And it contains nothing else.

Atomic degrees are scalar in nature. This scale, however, is still only defined on atoms: $S = \langle Atom(\mathcal{D}), > \rangle$. So, if d and d' are in $\mathcal{D}$ we can only guarantee that $d > d'$ makes sense if both d and d' are atomic. That is, a statement like $a \sqcup b > c$ is undefined. Nevertheless, in parallel to the mechanisms we use in the nominal domain, we can form a plural version of $>$ by using the double star operator. Let us illustrate how this works by the following example. Say that both $x > z$ and $y > z$ and both $z > v$ and $z > w$. In that case, $x \sqcup y$ $^{**}>$ z and z $^{**}>$ $v \sqcup w$, but also $x \sqcup y$ $^{**}>$ $v \sqcup w$. Slightly less straightforwardly, if we have a linear order $w > x > y > z$, then $w \sqcup y$ $^{**}>$ $x \sqcup z$, since for each part in $w \sqcup y$ there is a part in $x \sqcup z$ that is lower in the ranking, and for each part in $x \sqcup z$ there is a part in $w \sqcup y$ that is higher in the ranking. In this way, $>$ is parallel to many, if not all, lexical predicates applying to entities, which are commonly treated as partial functions, applicable to atoms only, unless they are pluralized (Landman 1989; Kratzer 2003).

We propose that adjectives are interpreted as relations between degree pluralities and entities. So rather than (13) (repeated here), we assume (23):

(13) $[\![\text{tall}]\!] = \lambda D_{\langle d,t\rangle}.\lambda x_e.x\text{'s height} \in D$

(23) $[\![\text{tall}]\!] = \lambda d_d.\lambda x_e.x\text{'s height} \sqsubseteq d$

In other words, *tall* relates individuals to all the degree pluralities that have the individual's height as an atomic part. This creates spuriously large pluralities and, in parallel to Beck's analysis, sets of degree pluralities will have to be reduced to more informative subsets. We do this by defining a minimality operator that operates on pluralities. Whereas Beck proposes (16) (repeated here), we propose (24).[3]

(16) $min(\mathcal{D}_{\langle\langle d,t\rangle,t\rangle}) = \cup\lambda D.D \in \mathcal{D} \wedge \neg\exists D'[D' \in \mathcal{D} \wedge D' \subset D]$

(24) $min(D_{\langle d,t\rangle}) = \sqcup\lambda d.d \in D \wedge \neg\exists d'[d' \in D \wedge d' \sqsubseteq d]$

It should be clear that we are simply implementing ideas of interval approaches within a framework in which intervals have been replaced by pluralities. There are, however, some interesting nuances that differ, as we will see shortly. First, however, let us illustrate how the plural framework works by focusing on the simplest example that we discussed above. We will also use this opportunity to be as specific as possible about all the steps in the analysis, which should make it easier to understand more complex examples as we proceed.

(25) John is taller than Bill is.

We assume, as is standard, that the adjective *tall* is elided in the *than*-clause and will be recovered in interpretation.

The semantically annotated syntactic structure for (25) is given in Figure 1. We assume that the comparative morpheme forms a constituent with its

[3] This requires generalising the sum operator to: $\sqcup X := \iota x.{}^*X(x) \wedge \forall y[{}^*X(y) \rightarrow y \sqsubseteq x]$.

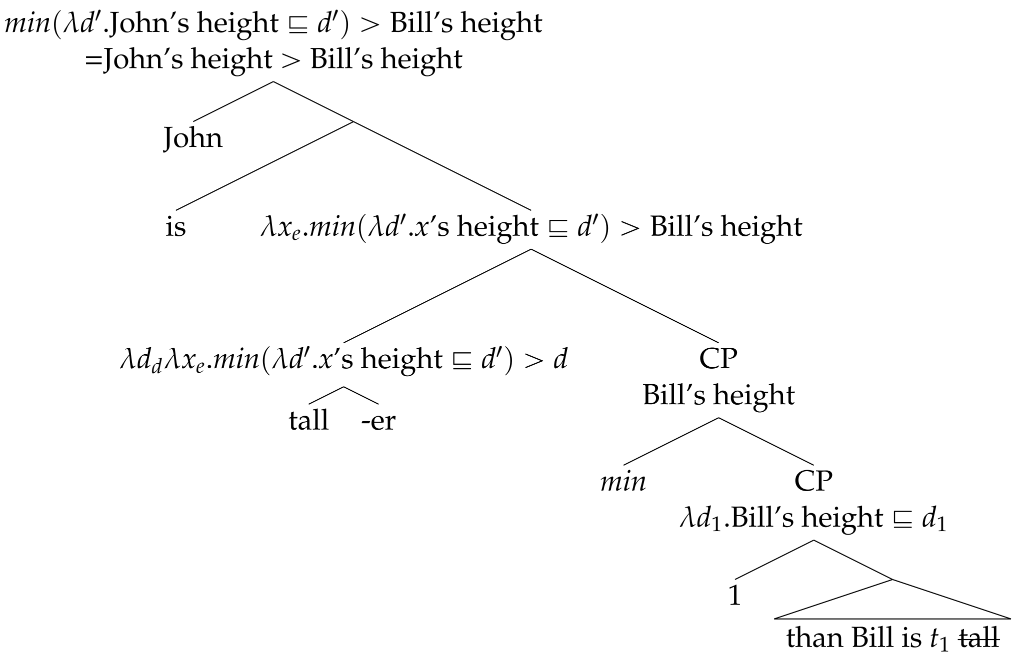


Figure 1: Syntax and interpretation of (25)

adjective although we are aware of the fact that two traditions exist. One postulates the same constituency in this respect as we do (Larson 1988; Kennedy 1997; Kennedy 2002; Alrenga and Kennedy 2014). Alternatively, the comparative morpheme might form a constituent with the *than*-clause and only later combine with the adjective (Bresnan 1973; Carlson 1977; von Stechow 1984; Heim 2000; Bhatt and Pancheva 2004). The choice is largely orthogonal to our study but the former option makes the combination of degree and plural semantics slightly easier, hence our choice, which leads us to the following interpretation of the comparative:

(26) $[\![\text{-er}]\!] = \lambda g_{\langle d,\langle e,t\rangle\rangle}\lambda d_d \lambda x_e.min(\lambda d'.g(d',x)) > d$

Turning our attention to the interpretation of the *than*-clause, we note that its semantic composition includes operator movement (Chomsky 1977), resulting in lambda abstraction over degrees, and, as in Beck's analysis, the *min* operator. Unlike Beck, we dispense with the second selection step (her *max* operator). Notice that the *than*-clause of Figure 1 is going to collect all pluralities that contain Bill's height. So, this is a set that has among its members, spurious plural individuals like "Mary's height⊔Bill's height", or the individual that contains everyone's height. Applying the minimality operator *min* yields a single individual, namely Bill's height. Similarly, the matrix adjective would be true of spurious plural individuals that include, among its members, John's height. Here again, applying *min* yields a single individual, John's height. Thus, *min* selects the most informative plurality both in the matrix clause, as well as in the *than*-clause, and can be compared to the work of *min* and *max* operators selecting the most informative element in a set, commonly used in comparatives (von Stechow 1984; Heim 2006; Beck 2010).

In the example above, there is no reason to apply plurality semantics to degrees since the matrix clause and the *than*-clause denote atomic individuals. Things change once we turn to quantified examples:

(27) John is taller than every girl is.

In (28), we give the interpretation of *than every girl*

(28) $\lambda d.\forall x[\text{girl}(x) \rightarrow x\text{'s height} \sqsubseteq d]$

This is the set of pluralities that contain at least the heights of every girl. So, if there are three girls who are respectively 150, 160 and 190 centimetres tall, then this set contains $150 \sqcup 160 \sqcup 190$ and all sums that contain this particular sum as a proper part. Minimality reduces this set to the individual $150 \sqcup 160 \sqcup 190$ itself:

(29)
$$
\begin{aligned}
[\![min(than\ every\ girl)]\!] &= min(\lambda d.\forall x[girl(x) \rightarrow x\text{'s height} \sqsubseteq d]) \\
&= 150 \sqcup 160 \sqcup 190
\end{aligned}
$$

If we proceeded with composition in the same way as in Figure 1, the sentence would end up meaning (30).

(30) John's height $> 150 \sqcup 160 \sqcup 190$ (undefined)

(30) is undefined because $>$ only relates atomic entities. Previous accounts avoid this meaningless comparison in various ways, as discussed above. They postulate quantifier raising of *every girl*, so that John's height will be compared pairwise to atomic entities (heights of individual girls), or alternatively, a special selection mechanism is used (Beck 2010), which selects just one degree, so that the comparison can go through. We could follow suit and use some sort of maximality operator to select the highest atom in the plurality denoted by the *than* clause, in which case the truth-conditions for (27) will correctly become John's height$>$ 190.

But there is no need for such and other mechanisms. Examples completely parallel to (30) are bread and butter of semanticists working on pluralities, and several operations have been developed to deal with cases in which a plurality combines with a predicate restricted to atoms. One of them is to pluralise the predicate roughly corresponding to *John is taller*. The pluralization then results in:

(31) $^*\lambda d.min(\lambda d_2.\text{John's height} \sqsubseteq d_2) > d$

(31) can straightforwardly combine with $150 \sqcup 160 \sqcup 190$. Given the nature of * and the atomic requirement of $>$, the resulting interpretation is true iff each of the atoms of $150 \sqcup 160 \sqcup 190$ is smaller than John's height, that is, John is taller than any of the girls.[4] The semantic composition of this derivation assumes nothing beyond standard mechanisms of semantics of pluralities, and is shown in Figure 2. The only difference from Figure 1 is that now, we also have to postulate movement of the *than*-clause, so that a predicate is created to which the $*$-operator can be applied. This step is not postulated *ad hoc*: in the semantics of pluralities, this kind of movement is generally required for distributive readings of any arguments other than subjects (but see (Lasersohn 1998) for an account of distributivity that dispenses with this movement, which we do not follow here to keep semantics relatively simple).

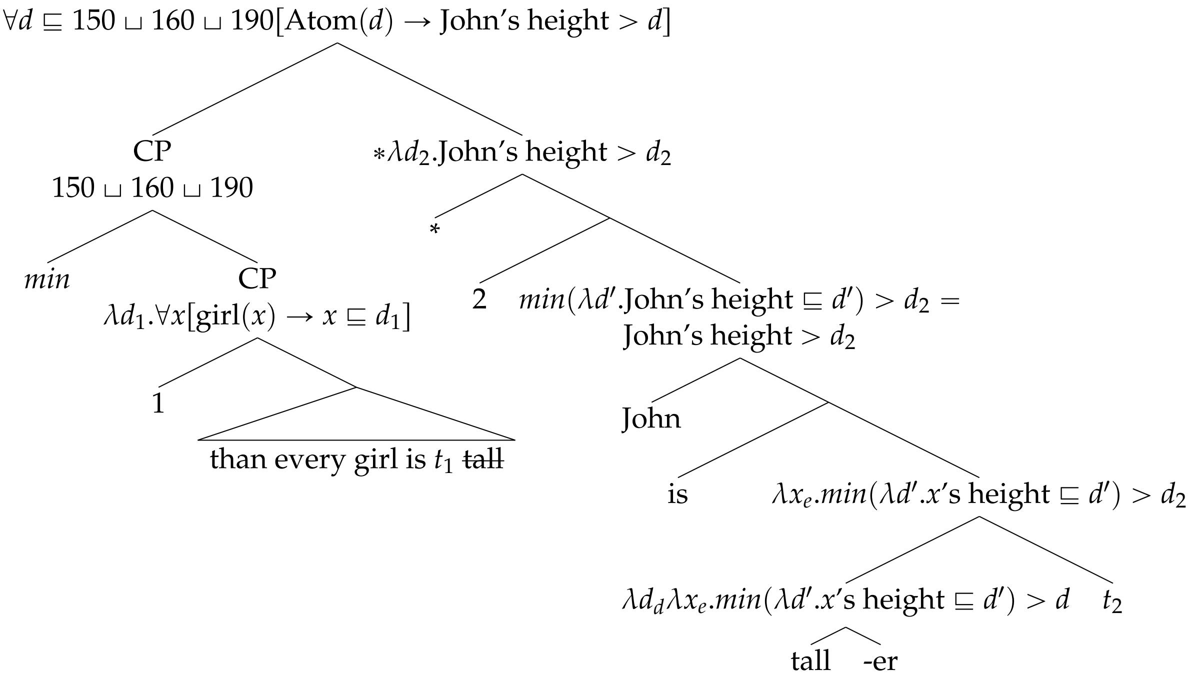


Figure 2: Syntax and interpretation of (25)

Another option is to pluralise relations, not predicates. In our scenario, this boils down to pluralising the comparative after it applied to the adjective.

[4]Our analysis is reminiscent of that of Beck (2012), who also introduces a mechanism of distributive quantification over atoms in a degree plurality. However, Beck only uses this mechanism for cases involving existential quantifiers (in particular, existential modals), where her selection mechanism yields a set of minimal intervals, rather than a single atomic minimal interval. In effect, apart from a superficial similarity between the used mechanisms, there is no overlap whatsoever in the analyses we offer for particular cases. In particular, Beck does not aim to provide an extensive argument in favour of a plural semantics, which we do aspire to here.

(This means we would analyse the sentence as *John is **(tall er) than every girl*.) This yields the following statement:

(32) $\langle 150 \sqcup 160 \sqcup 190, \text{John}\rangle \in {}^{**}\lambda d_d \lambda x_e.min(\lambda d'.\text{x's height} \sqsubseteq d') > d$

Since John is an atomic individual, (32) is equivalent to (33), which in turn is the interpretation of the root node of Figure 2.

(33) $150 \sqcup 160 \sqcup 190 \in {}^{*}\lambda d_d.min(\lambda d'.\text{John's height} \sqsubseteq d') > d$

Note that (32) and (33) are equivalent to (34), which captures a truly cumulative interpretation of the comparative relation.

(34) John's height $^{**}> 150 \sqcup 160 \sqcup 190$

In summary, our plural degrees framework provides two natural and equivalent interpretations for (27), one where the *than* clause plurality is the subject of a distributive predicate and one where it enters in a cumulative comparison relation with the subject. In both derivations, John has to be taller than the *tallest* girl. This is exactly as is required, and this is exactly the result of the accounts discussed in Section 2. However, we got the correct interpretation without postulating an island-violating QR. In contrast to Beck, we moreover did not need to assume that there is a combination of a minimality operator (*min*) and a maximality operator (*max*, picking the top degree in an interval). Instead we used minimality in tandem with an independently motivated pluralisation operator. In this sense, our approach is simpler, since it does away with the two-tier selection procedure of Beck's in favour of a single informativity-optimising operation. By leaning on Beck's selection innovation, we also do not face the problem of the negation approaches discussed in Section 2 how to exclude a missing interpretation since we derive a single, unambiguous reading.

So far, we have only offered a conservative variation on interval approaches to comparatives that simplifies them in a natural way, namely by saying that the work done by a special mechanism (the second selection step in Beck's account, long-distance QR) can be substituted with an independently required pluralization operation. However, as we will show in the sections that follow, our relatively minimal alterations have profound consequences regarding the predictions of the framework. First of all, if the comparative may indeed express cumulative relations like (32), then we expect to see more outlandish readings involving plural subjects. In particular, we expect to see cases where the cumulative and distributive reading are truth-conditionally distinct. We will present a careful argument in section 6 that there exist examples that require a cumulative interpretation and that these examples are highly problematic for frameworks that lack reference to degree pluralities. We will start, however, with a second advantage: our framework improves the semantics of differentials considerably.

5 Differentials

Beck discusses a problem with her theory with respect to sentences like (35) (Beck 2010, section 3.4). The intuitive interpretation is as in (36).

(35) John is exactly 2″ taller than every girl is.

(36) For every girl x: John is exactly 2″ taller than x.

That is, (35) entails that the girls all have the same height. This does not follow from Beck's analysis, however. The reason is that on that account, the *than* clause selects the maximum degree out of the individual girls's heights. John's height is then compared to that degree, irrespective of the height of the other girls. If the girl's heights are 150, 160 and 190:

(37) John is exactly 2″ taller than $max([150 \ldots 190])$

The result is that there is no hope for this analysis to predict an entailment that the girls in question have the same height. The potential of our theory is clearly better. Pseudo-formally, the semantics we predict will be along the lines of (38).

(38) $150 \sqcup 160 \sqcup 190 \in {}^{*}\lambda d.$John is exactly 2″ taller than d

If the girls have different heights, as in this scenario, (38) can clearly never be true, and so we predict that differentials such as (35) entail that the girls have equal height. Or, in other words, we predict that such sentences can only be true if the *than* clause denotes an atomic degree.

Let us see in somewhat more detail how we derive this result. We follow Schwarzschild (2008) in assuming: (i) measure phrases express predicates over intervals (type $\langle\langle d,t\rangle,t\rangle$); (ii) the differential construction applies the measure phrase to the gap between the matrix and *than*-clause degree. If d and d' are two degrees, then we write $d \rightarrow d'$ for the interval that spans from d upwards to d': $d \rightarrow d' := \{d'' \mid d \leqslant d'' \leqslant d'\}$. (Note that the interval is empty if $d > d'$.)

Based on this mechanism, we propose the semantics of differential comparison in (40). Compare this to the original entry for comparative morphology in (39).[5]

(39) $[\![\text{-er}]\!] = \lambda g_{\langle d,\langle e,t\rangle\rangle}.\lambda d_d.\lambda x_e.min(\lambda d'.g(d',x)) > d$

[5] Crucially, (39) and (40) are related in the following way: $[\![\text{-er}]\!](g)(d)(x) \Leftrightarrow \exists m[m \neq \varnothing \wedge [\![-er_{\text{diff}}]\!](g)(d)(m)(x)$ (under a few natural assumptions for m, the measure phrase). This is because if $min(\lambda d'.g(d',x)) > d$ then $d \rightarrow min(\lambda d'.g(d',x))$ is non-empty. Assuming that m, the measure phrase, can be of any size, it follows that $m(d \rightarrow min(\lambda d'.g(d',x)))$ is true for some m. Similarly, if $m(d \rightarrow min(\lambda d'.g(d',x))$ is true for some non-empty m, which can be of any size but greater than zero, it follows that $d \rightarrow min(\lambda d'.g(d',x))$ is not empty. Since m is non-zero, it follows that $d \rightarrow min(\lambda d'.g(d',x))$ has at least two end points, and consequently $min(\lambda d'.g(d',x)) > d$.

(40) $[\![\text{-er}_{\text{diff}}]\!] = \lambda g_{\langle d,\langle e,t\rangle\rangle}.\lambda m_{\langle d,t\rangle}.\lambda d_d.\lambda x_e.m(d \rightarrow min(\lambda d'.g(d',x)))$

The basic structure we assume is that in Figure 3. Here, the CP corresponding to the *than*-clause has moved out. This is not strictly necessary, but it is if we assume that the comparative is read distributively.

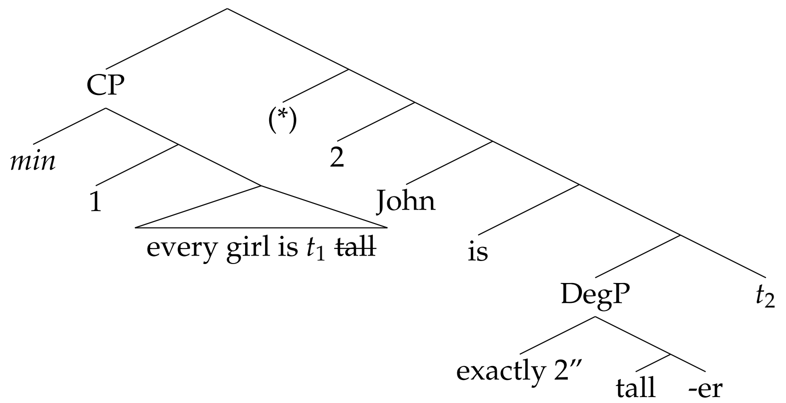
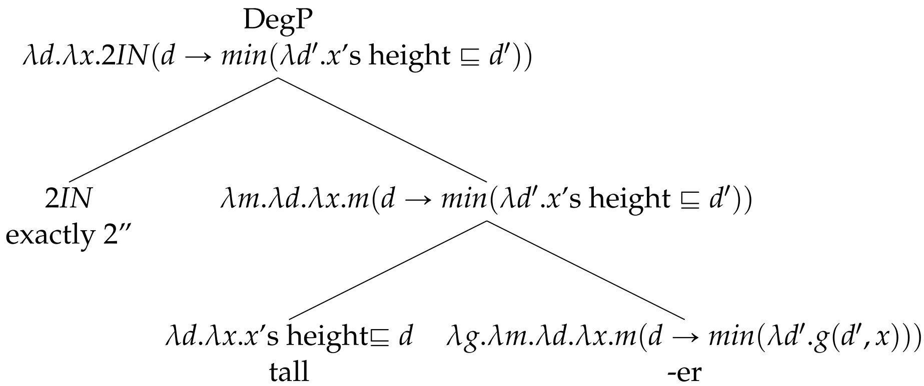


Figure 3: Structure of (35)

Let 2*IN* express a predicate over degree intervals such that it returns true if and only if the end points of the interval are 2 inches apart. This will be how we interpret the measure phrase. Correspondingly, the DegP is interpreted as follows:

(41)



Note that DegP only makes sense if x is an atom. This is because $min(\lambda d'.g(d',x))$ may return a non-atomic degree plurality if x is a plural entity. The interval constructor $\rightarrow$, however, is not defined on plural degrees. Effectively, this means that if the subject of the differential is plural, one would need to cumulate the predicate it combines with. In this sense, differentials are inherently distributive predicates, just like comparatives are. (Alternatively, we could say they are inherently cumulative.)

The next step in the derivation is to combine the DegP with the trace of the *than* clause and then fill in the subject slot. Let d_{th} be the degree plurality denoted by the *than* clause, then the end result is:

(42) $d_{th} \in {}^*\lambda d.2IN(d \rightarrow min(\lambda d'.\text{John's height} \sqsubseteq d'))$
$\equiv d_{th} \in {}^*\lambda d.2IN(d \rightarrow \text{John's height})$

This is only true if all the atoms in d_{th} are exactly 2 inches below John's height. In other words, this is only true if d_{th} is itself an atom. In turn, that is only possible if the girls in question all have the same height, namely John's height minus 2 inches.[6]

We have now shown that our proposal significantly improves on the analysis of non-monotonic differentials. This is not the only kind of differential where our account provides a natural solution to so far unaccounted for data. To show this, let us first characterise the data a bit clearer.

As we claimed above, just like normal comparatives give the impression of wide scope quantification by the quantifier in the *than* clause, so do differentials. This is irrespective of the kind of measure phrase we find in the differential slot, as can be seen by the wide-scope paraphrases in (46)-(48) of the respectively upward, non-monotonic and downward monotone differentials in (43)-(45).

(43) John is more than 2 inches taller than every girl.

(44) John is exactly 2 inches taller than every girl.

(45) John is less than 2 inches taller than every girl.

(46) Every girl is such that John is more than 2 inches taller than her.

(47) Every girl is such that John is exactly 2 inches taller than her.

(48) Every girl is such that John is less than 2 inches taller than her.

In our approach so far, we have accounted for (44) not by quantifying over girls, but rather by distributing over the plural degree slot corresponding to the *than* clause. Importantly, this analysis extends to the other cases. That is, (43) is interpreted in our account as (49), while (45) is interpreted in our account as (50). Here, $>2IN$ and $<2IN$ express the set of intervals of which the end-points are respectively more than 2 inches and less than 2 inches apart.

(49) $[\![$*than* clause$]\!] \in {}^*\lambda d.\ {>}2IN(d \rightarrow \text{John's height})$

[6] As in the previous section, since there is but one plural argument in the -er relation, the distributive and cumulative reading collapse. This means we could, in principle, arrive at the same result assuming cumulation of -er. However, since differentials require a three-place comparison relation, we would need to assume an operator that cumulates three-place predicates: $^{***}R$ is the smallest superset of R such that if $\langle a,b,c\rangle \in {}^{***}R$ and $\langle a',b',c'\rangle \in {}^{***}R$, then also $\langle a \sqcup a', b \sqcup b', c \sqcup c'\rangle \in {}^{***}R$. (An independent example where we may need such an operator would be: *John, Bill and Mary are exactly 2, exactly 4 and exactly 6 inches taller than their mothers*.)

(50) $[\![$*than* clause$]\!] \in {}^*\lambda d.\ {<}2IN(d \rightarrow \text{John's height})$

While other accounts have no problems with (43), the downward-monotone differential in (45) is generally outside the empirical reach of existing accounts. We refer to (Fleisher 2014) for an extensive exposé of the issues all corners of the current theoretical landscape run into. We will here briefly emphasise how differentials constitute an area where our relatively conservative variation on Beck's theory yields an altogether different set of predictions. As we showed, the quirky interpretation of differentials follows neatly from our approach. The reason for this is that, contrary to Beck's analysis, we have not assumed that *than* clauses contain a maximality operator. The problem created by such an operator is that in sentences like (43)-(45), John's height is going to be (differentially) compared to a single degree. As seen by the paraphrases in (46)-(48), the data are different, though. John needs to be in the differential relation expressed by the measure phrase to all entities in the domain of quantification, not just to its maximal, minimal or any other specific individual. That Beck's approach fares well in (43) is a happy coincidence, due to the fact that if John's height exceeds the height of the tallest girl by at least some measure, his height will also exceed the height of any of the other girls by at least that measure. In contrast, our account can accommodate all examples (43)-(45) because the *than* clauses keep the information about every girl's height.

6 Cumulative comparison

The plural machinery we adopt creates the prediction that we find a variety of plural-related readings. In particular we predict that genuine cumulative readings exist – that is, cumulative readings that are not equivalent to distributive construals in the way we saw above. In this section, we show that this prediction is correct.

We start with the note that some mention of such readings already appears in previous literature (Scha and Stallard 1988; Schwarzschild 1996; Matushansky and Ruys 2006). For instance, Scha and Stallard give the following example, which does not require that every frigate was faster than any carrier; it suffices that every frigate was faster than some carrier, and every carrier was slower than some frigate. In other words, this is a cumulative reading. (See Schwarzschild 1996, p89, for further discussion on this reading.)

(51) The frigates were faster than the carriers.

One could potentially analyse (51) as a cumulative relation between two plural *entities*, viz. the frigates and the carriers. This is indeed what Scha and Stallard (1988), Schwarzschild (1996), and Matushansky and Ruys (2006) do.

However, we can now offer an analysis in terms of a cumulative relation between degrees. The idea is that the sentence will yield a degree plurality made up of all and only the speeds of the individual frigates, call this plurality f, while the *than* phrase denotes the sum of all the carrier speeds, c. The sentence (51) is now true if and only if f $^{**}\!> c$. What this means is that for each atomic speed in f, there is an atomic slower speed in c, and for each atomic speed in c there is an atomic speed in f that is faster. This is equivalent to saying that the frigates and carriers stand in the cumulative relation $^{**}\lambda x.\lambda y.x$'s speed $> y$'s speed.

The fact that there is an equivalence between an analysis of (51) in terms of a cumulative relation between degrees and one in terms of a cumulative relation between entities makes it that we cannot use such examples as an argument that our approach is on the right track. Clearly, one does not need to assume the existence of degree pluralities to account for examples like (51). However, as we will show now, there exist examples that, if we are right, can only be analysed using the kind of framework we are proposing.

We start by considering a minimal variation on (51), namely its clausal comparative counterpart.

(52) The frigates were faster than the carriers were.

For such a clausal comparative, an interpretation using a cumulative relation between entities is problematic. The reason is that the only way to get at such an interpretation is by quantifier raising the subject of the *than* clauses, as in (53). For a number of reasons, which we will explain in more detail below, such a derivation goes against normal assumptions on movement.

(53) [The frigates [the carriers [**[1[were faster than t_1 were fast]]]]]

A way out would be to deny that (52) is cumulative in the first place. We could follow the reasoning in Winter (2000) for other purported cumulative readings and claim that (52) is a distributive reading where the definite description *the carriers* functionally depends on quantification over the frigates. Informally:

(54) The frigates EACH$_i$ were faster than the carriers$_i$ were.

The idea would be that (54) allows a reading where each frigate is only faster than *its* carriers. The possessive relation could then be specified in pragmatics (it could, for example, mean that each frigate is faster than the carriers in the area of the frigate, which is the cumulative reading discussed in Schwarzschild 1996). Thus, this would create the illusion of a cumulative relation. As Winter extensively argues for the examples in his paper, such an analysis is not unlikely, given the fact that examples like (55) exist. Here, the most salient reading is one in which each student hands in only the essays that (say) he or she wrote.

(55) Each student managed to hand the essays in on time.

So, although (52) has a cumulative-like reading and although it is impossible to derive that reading as a cumulative relation between frigates and carriers, this is still not enough to argue for the need of a cumulative comparison relation between degree pluralities, for it could simply be that the proper interpretation for such sentences is a Winter-style dependency analysis. To support our approach, we should therefore be on the lookout for examples that have cumulative-like readings, but for which a dependency analysis is unavailable. We believe (56)[7] is such an example.

(56) The state economies of Ireland, the Netherlands and Australia all scored higher than they each did in the mid-1980s.

In the relevant reading, the state economy of Ireland scored higher now than it did in the 80's, the state economy of the Netherlands showed similar improvement as compared to the mid 80's, and so did Australia's economy. Crucially, on this reading the three economies are not compared to each other, so it could be that Ireland's state economy now does not score higher than Australia's economy in the mid 80's, etc.

What makes this sentence interesting is that a dependency analysis, as in (57), is out of the question.

(57) The state economies of Ireland, the Netherlands and Australia EACH_i scored higher than they_i each did in the mid-1980's.

The problem with (57) is the occurrence of *each* in the *than* clause. In the relevant reading, *they* will refer to a singular economy (bound by distributive quantification over the matrix subject) and so *each* is vacuous and infelicitous. One can see this effect by looking at examples that resemble the analysis in (57).

(58) a. The boys all think they won the race
b. #The boys all think they each won the race
c. The boys all think that they each failed the course

The example in (58-a) has a dependent reading: each boy thinks that he won the race. This reading disappears once we add the distributive quantifier *each*. In fact, the only reading available for (58-b) is one in which the boys each have the contradictory thought that each of them is the winner of the race. A similar observation can be made for (58-c). The reading that *is* available is one in which the boys all have the same thought: all the boys failed. What is missing is a dependent reading, in which each boy only thinks of himself that he has failed the course.

[7]Simplified from www.oapen.org/download?type=document&docid=340206

Given these observations, we can conclude that the cumulative-like reading of (56) cannot be due to a dependent interpretation of the plural pronoun, but that this sentence is genuinely cumulative. Given that, once more, at no point in the composition there is a cumulative relation between entities, we conclude that (56) is an instance of a cumulative relation that involves a degree plurality, namely the one corresponding to the denotation of the than clause.[8]

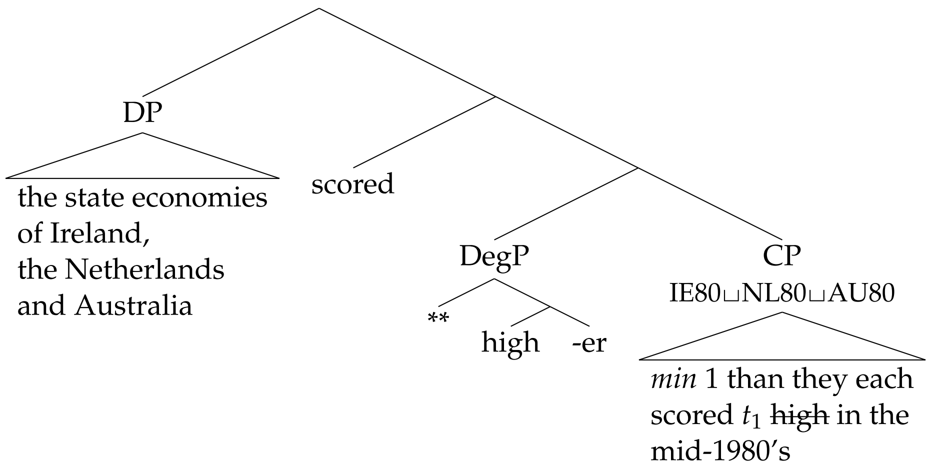
Let us now see what our analysis of example (56) is in detail. Its *than* clause (prior to applying minimality) is interpreted as follows.

(59) λd. the state economies of Ireland, the Netherlands and Australia each scored d-high in the mid-1980's.

This is the set of degree pluralities that at least contain the three economies' scores in the mid-1980's. For ease of exposition, let's write IE, NL and AU for the three state economies in question and IE80, NL80 and AU80 for the respective scores in the mid-1980's (as well as, accordingly IE15, NL15, AU15 for the current scores). That is, (59) is $\lambda d.\text{IE80}\sqcup\text{NL80}\sqcup\text{AU80} \sqsubseteq d$. Applying minimality gives us the plurality that contains nothing but the three scores: $min(\lambda d.\text{IE80}\sqcup\text{NL80}\sqcup\text{AU80} \sqsubseteq d) = \text{IE80}\sqcup\text{NL80}\sqcup\text{AU80}$.

The structure of the rest of the derivation is now:

(60)



The cumulative relation in DegP expresses:

(61) $**\lambda d_d \lambda x_e.min(\lambda d'.x\text{'s height} \sqsubseteq d') > d$

and so we get the following truth-conditions for (56):

[8]The kind of example in (56) is not rare; (i) provides two more examples.

(i) a. The students earned less than each of them hoped they would
b. The Baltimore Ravens scored more points than each of their opponents did

(62) $\langle$IE$\sqcup$NL$\sqcup$AU, IE80$\sqcup$NL80$\sqcup$AU80$\rangle \in {**}\lambda d_d \lambda x_e.min(\lambda d'.x\text{'s height} \sqsubseteq d') > d$

which in turn is equivalent to:

(63) IE15$\sqcup$NL15$\sqcup$AU15 **> IE80$\sqcup$NL80$\sqcup$AU80

The most salient state of affairs that makes (63) true is in case IE15 > IE80, NL15 > NL80 and AU15 > AU80, which coincides with the intended reading for (56). One could object at this point that the truth-conditions in (63) are very weak, weaker than intuitions would let us believe are appropriate for such sentences, since there are many alternative situations that make (63) true as well. As we will show below, this is a general issue with cumulative readings and we will argue that with the right kind of pragmatic strengthening in place, our predictions are on target. Before we turn to this, however, let us first explore how other theories of the comparative would fare with examples like (56) that require cumulative relations involving degrees.

Cumulating degrees is not possible in the other accounts of comparatives, the interval strategy and the negation strategy. Take, for example, Beck's selection approach. In that analysis, the *than* clause of (56) yields only a single degree, the highest of {IE80, NL80, AU80} and the only available reading is that IE15, NL15 and AU15 are all higher than the highest score of the mid-1980's economies. In the negation strategy, the *than* clause is interpreted as the interval that goes upward from the highest score in {IE80, NL80, AU80} (see Section 2). Here again, the end result of the *than* clause destroys the information regarding individual degrees, IE80, NL80, AU80, and the ** operator cannot be successfully applied.

There is one possibility open to the previous accounts of comparatives, namely cumulating directly on plural entities, following Scha and Stallard (1988), Schwarzschild (1996) and Matushansky and Ruys (2006). We already noted that this strategy should not be used in (56). Let us discuss its problem in more detail now. To capture the reading, one could let *they each* move to the matrix clause, so the following cumulative relation between entities is obtained:

(64) ${**}\lambda x_e.\lambda y_e.min(\lambda d'.x\text{'s score} \sqsubseteq d') > min(\lambda d.y\text{'s 1980-score} \sqsubseteq d)$

This cumulative relation can then combine with the pair $\langle$IE $\sqcup$ NL $\sqcup$ AU, they each$\rangle$. If *they each* was interpreted in the same way as the first argument, the formula would yield the correct truth conditions.

There are two problems with this analysis. First, *they each* would have to move out of an island, the *than* clause. Allowing this would nullify the whole research on comparatives since (von Stechow 1984), which got rid of such syntactically illicit transformations in the interpretation of *than* clauses. (See also Beck and Sauerland 2000 for evidence that DPs cannot move out of an island to enter cumulative readings).

Second, it is not clear how the analysis can deal with the floating *each* in the *than* clause. Above, we assumed that *each* moves together with *they*. But then, how should it be interpreted? The floating *each* is commonly treated as a predicate modifier, specifying that the predicate is interpreted distributively (Dowty and Brodie 1984; Link 1987; Roberts 1987; Schwarzschild 1996; Champollion 2010). Here, however, *each* would have to combine with a cumulative relation, which is normally prohibited. Notice, for example, that (65) lacks the cumulative reading that John lifted one sofa and Mary lifted another sofa.

(65) John and Mary each lifted two sofas.

Alternatively, *each* could be stranded in the *than* clause. This is problematic, too: the *than* clause in (64) has an atomic subject, y. Since distributive and non-distributive predicates behave alike with atomic subejcts, *each* modifying the predicate in the *than* clause would become vacuous. But vacuous quantification of *each* is normally prohibited (see, e.g., Roberts 1987; Hoeksema 1996):

(66) *Every boy/John each left.

To sum up, cumulation on degrees seems unavoidable. Examples like (56) strongly support our point that *than* clauses should yield not just a single degree, or a degree interval, but a degree plurality. It is a virtue of an account working with degree pluralities that it correctly derives the most salient reading of (56).

As we hinted at above, a careful reader might have noticed that our analysis derives more than the salient reading. All we require is that (67) is true. Given the definition of **, this is true if each state scored higher now than it did in the mid-1980's. But there are other possibilities. For instance, the sentence would be true in this situation: IE15 > AU80, AU15 > NL80 and NL15 > IE80. But this is definitely not the reading that the writer of (56) had in mind.

(67) $\text{IE15} \sqcup \text{NL15} \sqcup \text{AU15} \ {**}{>} \ \text{IE80} \sqcup \text{NL80} \sqcup \text{AU80}$

It is not specific to our analysis of comparatives that we predict weaker interpretations than the sentence seems to have. Consider the variant of our example in (68-a). In this case again, the most salient interpretation is that each state economy improved between the mid-1980's and now. Using ** to cumulate on *improve* derives this reading, but it makes the sentence true in other scenarios, including the (unlikely) situation noted above. A similar fact is true for (68-b), which relates two plural individuals (state economies and images).

(68) a. The state economies of Ireland, the Netherlands and Australia improved their mid-1980's scores.
b. The state economies of Ireland, the Netherlands and Australia improved their images.

A common solution to strengthening the cumulative reading is to restrict ** by a pair-restrictor (cf. the paired-cover in Chapter 5 of Schwarzschild 1996), and we use it here. First, we have to modify the application of the cumulative operator, as follows: it does not apply directly to the relation *R*; it applies to ($R \cap$ **PR**), that is, the relation further restricted by **PR**.

Second, we have to define **PR**, a pair-restrictor, (69).[9] Notice that the definition leaves it relatively open which pairs will appear in **PR**. Schwarzschild (1996) argues at length that further specification is pragmatically driven and should be left open in the semantic definition.

(69) *T*, a set of pairs, is a pair-restrictor (**PR**) (of the domain *D*) iff:
1.$T \subseteq D^2$
2.$\forall x \in D \exists y \in D[\langle x, y \rangle \in T]$
3.$\forall y \in D \exists x \in D[\langle x, y \rangle \in T]$

The example in (68-a) should now be analyzed as follows:

(70) $\langle \text{IE} \sqcup \text{NL} \sqcup \text{AU}, \text{IE80} \sqcup \text{NL80} \sqcup \text{AU80} \rangle \in {}^{**}(\text{improve} \cap \mathbf{PR})$

We derive the most likely interpretation if we assume, following the idea of Schwarzschild (1996), that the **PR** by context and world knowledge has, among its members, pairs as ⟨IE,IE80⟩, ⟨NL,NL80⟩, ⟨AU,AU80⟩, but not, crucially, elements like ⟨IE,AU80⟩ etc. This derives that the state economies improved their own scores, and it would be false if each economy improved compared to the economy of some other state in the mid-1980's. The same **PR** would correctly restrict the interpretation of (67), yielding the right truth conditions for (56) in our account.

But why should such **PR** be used here? Why would speakers consider these particular pair-restrictors and not other ones? Obviously, the first and the second element in the pairs of the most salient **PR** share more features (e.g., IE and IE80 involve the same state economy) than the pairs of less salient pair-restrictors. But the matters are relatively complex and not of immediate relevance to the article.[10] What is relevant is the conclusion that pragmatic restrictions are not specific to cumulative comparisons, and there

[9]Schwarzschild (1996) uses a paired-cover, which restricts the members of pair-restrictor to the members of (unary) covers. This is needed in general, but not necessary for our examples, hence we opted for a simplified definition to keep the discussion easier.

[10]See Chapter 5 of Schwarzschild (1996) for many examples on restrictions in paired-covers, and Chapter 3 of Dotlačil (2010) for the specification of some such restrictions in terms of the grouping principles uncovered in the Gestalt psychology.

is no reason to expect that the solution to such cases cannot be extended from plural individuals to plural degrees.

7 Beyond distributive universal quantifiers

We have focused on the predictions that our analysis makes when *than* clauses host distributive universal quantifiers. This contrasts with most research on comparatives, which studies how *any* quantifier (including modals) is interpreted in a *than* clause. It turns out that our analysis makes the same predictions as Beck (2010) regarding the variation in the interpretation of other quantifiers. We shortly summarize the facts here.

A peculiar feature of the max-mechanism in Beck's framework is that in most cases, a *than*-clause like *than Q is/are tall* will end up denoting the height of the tallest individual in the restrictor of Q. In other words, it appears that this mechanism rids the *than*-clause of any quantificational forces that it may contain and instead simply considers the set of entities (and, in particular, their heights) that partake in the quantification.

Downward monotone quantifiers are an exception to this. If the *than* clause contains such a quantifier, the selection mechanism will always return an infinite degree. This, Beck argues, is a good result because it correctly explains why negative quantifiers are ungrammatical in *than* clauses, (71). This is because the sentence can never be true (no degree is taller than the infinite degree).

(71) *John is taller than no girl is.

This result carries over to our analysis, in which the *than* clause of (71) is interpreted as:

(72) $\lambda d.\neg\exists x[\text{girl}(x) \wedge x\text{'s height} \sqsubseteq d]$

This gives us the set of all degrees but the girls' heights (including all degrees exceeding the tallest girl's height), and, after applying *min*, the corresponding plurality. (71) can never be true since John's height would have to be greater than any height.

Aside from the successes, there are also two cases in which the selection mechanism misfires. The first problematic case is represented by modal quantifiers. Non-universal quantifiers (most prominently, indefinites and numerals) are the second problematic case.

We start with the first group. As a background, note that some universal modal quantifiers behave as predicted (by Beck's and our analysis) and that we correctly derive the meaning of *than* clauses with *supposed to be* and *should*. For example, assuming the background in (73), (73-a) and (73-b) will in our analysis mean that John's height exceeds the height of a male model in any world conforming to the conditions, that is John is taller than 190 cm.

(73) Background: John wants to become a model. Male models' height should be between 180 cm and 190 cm.

a. John is taller than he is supposed to be.
b. John is taller than he should be.

However, universal modals *have to* and *required to* are problematic. The examples in (74) (might) convey in the same context that John's height exceeds 180 cm. That is, the degree in the matrix clause has to exceed the minimal degree provided by the *than* clause, not the maximal one. We don't derive this reading. To see this, recall that we let the degrees of the *than* clause distribute over the matrix clause. This necessarily yields the reading that for every degree from 180 cm to 190 cm, John exceeds the degree, i.e., John is taller than 190 cm. The cumulative reading yields the same interpretation.

(74) a. John is taller than he has to be.
b. John is taller than he is required to be.

We hasten to add a caveat. It has been noted repeatedly that the min-reading is more salient with modals *have to* and *required to be* but the max-reading (John's height exceeds 190 cm) is possible, too (Heim 2006; Krasikova 2008; Alrenga and Kennedy 2014). Two naturally occurring examples are below. (75-a), from the Corpus of Contemporary American English (COCA, Davies 2008), expresses the fear of a doctor at an emergency room that a seriously ill person will wait longer than he should (not that there is some minimally required time to stay in an emergency room and a seriously ill patient will wait longer than that). (75-b), found using Google,[11] says that the person exceeded his time to stay. These readings are straightforwardly derived in degree pluralities.

(75) a. I'm always afraid that somebody who's seriously ill has to wait longer than they have to for a physician.
b. He stayed longer than he had to even though he was told he had to leave(.)

That said, we would still need to explain where the salient minimal degree reading in examples like (74) comes from. Here we could follow Beck (2010) in taking up a suggestion made by Krasikova (2008) that the modals that give rise to the more-than-minimum reading are the modals that occur in the so-called sufficiency modal constructions (von Fintel and Iatridou 2005).

[11] http://www.revengeofthebirds.com/2011/6/13/2222685/the-arizona-cardinal-i-would-like-to-meet-larry-fitzgerald

An example of such a construction is in (76). This sentence expresses that you don't have to do anything more difficult than going to the Twijnstraat to reach your goal of getting good cheese.

(76) You only have to go to the Twijnstraat (to get good cheese).

Disregarding (difficult and unimportant) details, we can analyze *only+have to* as in (77-a), where $q \subseteq p$ expresses the relevant ordering of propositions. In this case, the ordering would reflect how much effort one makes to get cheese, i.e. how far one travels. Let us assume that the adressee of (76) is in Utrecht, and that there are various options, ranging from traveling to the closest place to traveling to the most remote place: to Janskerkhof (JK), to the Twijnstraat (TW), to the Haarlemmerstraat (HA) or to North End (NE). The propositions are ordered as NE ⊂ HA ⊂ TW ⊂ JK. The sentence in (76) is true if the Twijnstraat is the nearest location to the addressee that sells good cheese.

(77) a. $[\![\text{only have to}]\!](p) = \Box \cup \{p'|p' \in Alt \wedge p' \subseteq p\} \quad \wedge$
$\neg\Box \cup \{p'|p' \in Alt \wedge p' \subset p\}$
b. $[\![\text{only have to}]\!]([\![\text{you go to the Twijnstraat}]\!])$
$= \Box(TW \vee HA \vee NE) \wedge \neg\Box(HA \vee NE)$

Informally, only+$\Box$ in (77-a) is true of p if and only if (i) in all worlds in which the goal is met either p or something higher on the scale is true; (ii) it is not the case that in all goal worlds propositions higher in rank than p are true. Using (77-a), (77-b) indeed reflects the correct interpretation.

Krasikova (2008) and Beck (2010) assume that the silent counterpart of *only*, EXH, appears in *than* clauses that yield the min-reading and we follow their assumption, arriving at (78-a) as the interpretation for *than he has to be* in (74). As in the previous example, we have to furthermore assume a particular ordering of alternatives, as Beck (2010) does. More concretely, the alternatives have to be ordered by height: tall(j,200) ⊂ tall(j,190) ⊂ tall(j,180) (for discussion of this assumption, see (Beck 2010, p. 36-37)).[12] Assuming that, we can rewrite (78-a) in a more transparent way as (78-b). Given the requirements on male models discussed above, (78) will yield only a singleton set, {180} (John's minimal permissible height if he wants to become a model).

(78) a. $\lambda d.\Box \cup \{p'|p' \in Alt \wedge p' \subseteq (\text{John's height} \sqsubseteq d)\} \wedge$
$\neg\Box \cup \{p'|p' \in Alt \wedge p' \subset (\text{John's height} \sqsubseteq d)\}$
b. $\lambda d.\Box(\exists d' \geqslant d[j\text{'s height} \sqsubseteq d']) \wedge \neg\Box(\exists d' > d[j\text{'s height} \sqsubseteq d'])$

[12] There is another order of alternatives we have to postulate when pluralities enter the picture: they have to be ordered by the part-of relation. For example, tall(j,180 ⊔ 181 ⊔ 182) ⊂ tall(j,180 ⊔ 181) ⊂ tall(j,180). This scale is easy to justify, as it follows entailment relations between propositions.

Applying *min* to this set yields the only element, 180, and (74) is interpreted, correctly, that John exceeds 180, the minimal requirement, not the maximal allowed height. Since the option of applying such EXH should only be open to the class of verbs that participate in sufficiency modal constructions we have an independent restriction for min-readings, which carves out the right class of modal verbs (see Krasikova 2008; Beck 2010 for discussion).

We now turn to the second potentially problematic class of examples that we inherit from adapting Beck's approach, viz. indefinites, numerals and the like. Before we turn to the problems, we would first like to show that three cases of indefinite-like quantification are handled properly in our analysis (and Beck's, for that matter; see Section 3). First up is disjunction, (79-a) says that John is taller than Abby and John is taller than Bill. The set of degrees in our analysis is in (79-b). After applying the min-operator, we get the plurality of Abby's height and Bill's height. This is because the min-operator finds two minimal degrees, Abby's height and Bill's height, and sums them (cf. the definition of the min-operator in (82)). Similarly, (80-a) is interpreted that John exceeds everyone's degree, which is easily derived using degree pluralities. Finally, referential indefinites are entirely unproblematic as is shown in (81). (This naturally goes for any referential DP.)

(79) a. John is taller than Abby or Bill are.
b. $\lambda d.$Abby's height $\sqsubseteq d \vee$ Bill's height $\sqsubseteq d$

(80) a. John is taller than anyone else is.
b. $\lambda d.\exists x(x \neq \text{John} \wedge x$'s height $\sqsubseteq d)$

(81) a. John is taller than some (particular) friend of mine.
b. $\lambda d.f$'s height $\sqsubseteq d$
where f is the particular friend the speaker has in mind

(82) Repeated definition of *min*:
$min(D_{\langle d,t\rangle}) = \sqcup\lambda d.d \in D \wedge \neg\exists d'[d' \in D \wedge d' \sqsubseteq d]$

Problematic cases are in (83). First of all, (83-a) expresses that there is a classmate whose height John exceeds. We derive this meaning if we analyse the indefinite as referential. The problem is that on a non-referential analysis of the indefinite we derive that John is taller than any classmate. The culprit is the sum operator, $\sqcup$ in the definition of *min*. This worked well in the examples above, but here it causes problems. There are many minimal plural degrees d such that one of John's classmates' height $\sqsubseteq d$, one for every classmate. The definition of *min* makes sure that all these individual degrees are summed into one plurality. The effect of this is a more-than-maximum reading: John is taller than each of his classmates. Similarly, (83-b) derives that John is taller than any girl, provided there are at least five girls in the domain. This is yet again caused by the $\sqcup$ in (82), which sums the degrees of any plurality of exactly five girls, forcing John to exceed all such degrees.

(83) a. John is taller than one of his classmates is.
b. John is taller than exactly five girls are.

For (83-b), we can derive the correct meaning by following Beck in assuming that the non-monotone quantifier can scope outside of the *than* clause. This step yields (84), which is the correct interpretation.[13] This analysis rests on the assumption that modified numerals are like indefinites (and unlike universal distributive quantifiers) in that they may escape scope islands. It is not very clear whether this assumption is warranted (Winter 1997).

(84) $\exists! x_{\#5}[\text{girls}(x) \wedge \; min(\lambda d.\forall y \leqslant x[Atom(y) \rightarrow y\text{'s height} \sqsubseteq d]) \in {}^*\lambda d'.\text{John's height} > d']$

The issue both wide scope analyses for the examples in (83) have in common is that they do not get rid of the faulty prediction that in addition to the attested interpretation such examples have a taller-than-everyone-else reading. An alternative would be to get rid of $\sqcup$ in the definition of *min* in (82). More concretely, we could substitute it with a choice function, which picks a random element from the set of degrees, (85). (The choice function is then existentially bound at the matrix level.)

(85) Modified definition of *min*:
$min(D_{\langle d,t\rangle}) = f(\lambda d.d \in D \wedge \neg\exists d'[d' \in D \wedge d' \sqsubseteq d])$

This does not affect our analysis of distributives (and modals) because until the introduction of indefinites, the set of degrees of *than* clauses always consisted of only one plurality. It leads to a slight modification of our explanation why negative quantifiers are banned from *than* clauses, (71): such examples are now trivially true, being totally uninformative. Most importantly, however, (85) has an effect on (83), since (85) effectively amounts to saying that non-universal quantifiers always yield a forced referential-like interpretation. The *than* clause in the a-example of (83) would now yield a single degree, the height of some classmate of John's. In the second example we still have to require that the exhaustivity operator, forced by *exactly* can scope at the matrix level, an assumption we share with negation approaches (Gajewski 2008; Alrenga and Kennedy 2014). However, unlike (Beck 2010), we now can get rid of the wide scope of the quantifier itself. This is a positive result given the reservations we expressed above with respect to

[13] We make two simplifying assumptions in the notation: first, we assume that the whole quantifier undergoes QR into the matrix clause. A choice-functional approach, which is more standard with indefinites, would yield just the same results, as shown in (Beck 2010). Second, we notate the "exactly" meaning using $\exists! x_{\#5}$, which is just an abbreviation for saying that 5 elements satisfy the scope, and no greater number does.

the assumption that modified numerals have wide scope capabilities.

Of course, using (85) would misfire with disjunctions and indefinites like *anyone*, which would now lose their max-readings in *than* clauses. But it is conceivable that these elements give rise to the max-reading in other means. For example, Aloni and Roelofsen (2014) argue that *any* in *than* clauses is interpreted as a free choice item, which would explain why it forces the same interpretation as universal quantifiers.

To step back a bit, we have seen in this section that our analysis fares like Beck's with respect to the interpretation of modals and indefinites. This might look like a disappointing result but we prefer to see this in a positive light. We have seen that our minimal modification of Beck's account leads to improvements in differentials and cumulative readings. In this respect, it is good news that such improvement does not come at a cost of worse coverage in other domains.

We are aware of one analysis which, we think, performs better than Beck's in assigning the correct interpretation to quantifiers in *than* clauses, the so-called *no more* analysis by Alrenga and Kennedy (2014). It is therefore interesting to note that their analysis, clearly superior to ours and Beck's with respect to the cases of this current section, does not seem to be capable of deriving the results that were the main topic of the rest of our paper. This is because the proposal in Alrenga and Kennedy (2014) is a sub-type of negation approaches, and just like other analyses in that tradition, their account destroys the information regarding individual degrees contributed by quantifiers in *than* clauses. Narrowing the gap between our adaptation of Beck's selection strategy and the *no more* analysis will be an interesting task for the future.

8 Conclusion

In her 2006 paper, Heim slightly diverges from the interval theory of comparatives by letting adjectives like *tall* relate an individual and a set of degrees. The difference between her account and similar analyses, (Schwarzschild and Wilkinson 2002; Beck 2010) among others, is that the latter analyses impose an extra condition on arguments of adjectives: sets of degrees must be dense, that is, they must form an interval. But while Heim (2006) drops this restriction, she notes that no empirical facts drive this decision.

It is common to model pluralities as sets, and in that view, our paper can be seen as a defence of Heim's treatment of adjectives. In contrast to Heim (2006), however, we provided arguments that dropping the interval condition is a necessary step forward: the reformulation of an interval theory using degree pluralities allowed us to correctly analyze differentials (Section 5) and cumulative readings of comparatives (Section 6). Furthermore, these cases, we argued, are problematic for other accounts of comparatives. At the same time, using degree pluralities has the same empirical coverage as Beck (2010) regarding the interpretations encountered for the full range of quantifiers in *than* clauses of non-differential comparatives (Section 7).

Over the past three decades, the interpretation of the comparative has proven to be a remarkably difficult puzzle to solve. Progress has been steady, but very slow. The reason for this is probably because the semantics of the comparative conflates a great number of phenomena, ranging from scalarity, ellipsis and scope to (possibly) negation. As we have pointed out, part of the enigmatic nature of the semantics of -er may be explained by recognising that *plurality* is yet another phenomenon inherently tied to the comparative.

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