Equatives, measure phrases and NPIs*

Jessica Rett

UCLA; 3125 Campbell Hall, Los Angeles, CA 90095; `rett@ucla.edu`

Abstract. Standard semantic accounts of the equative ascribe it an 'at least' meaning, deriving an 'exactly' reading when necessary via scalar implicature. I argue for a particular formulation of this scalar implicature account which considers that (i) equatives license NPIs in their internal arguments, and (ii) equatives whose internal arguments are measure phrases (MPs) are, in contrast to clausal equatives, ambiguous between 'at most' and 'exactly' interpretations. The analysis employs particular assumptions about MPs, scalar implicature and the notion of set complementation to enable 'at least' readings to be sensitive to the direction of a scale, thereby becoming 'at most' readings in certain constructions.

1 Introduction

1.1 Equatives and MPs

It's been observed that equatives are ambiguous. These two possible meanings are reflected in the two felicitous responses to (A) in (1). In (B), John's being taller than Sue is incompatible with (A) (on the 'exactly' reading); in (B′), John's being taller than Sue is compatible with (A) (on the 'at least' reading).

(1) (A) John is as tall as Sue is.
(B) No, he's taller than Sue is. (B′) Yes, in fact he's taller than Sue is.

To be exactly as tall as Sue is to be at least as tall as Sue, which means that the 'exactly' interpretation of an equative entails its 'at least' interpretation (but not vice-versa). Drawing a parallel with other scalar implicature phenomena, we can identify the 'exactly' reading as the strong one and the 'at least' reading as the weak one, and derive the former from the latter via scalar implicature where context allows (Horn, 1972; Klein, 1980; Chierchia, 2004). This suggests an analysis in which the equative looks something like (2).

(2) $[\![\text{as}]\!] = \lambda D' \lambda D.\textsc{Max}(D) \geq \textsc{Max}(D')$

Equatives with measure phrases or numerals in their internal argument ('MP equatives') present a challenge to this account. Whereas an equative like *John is as tall as Sue is* is ambiguous between an 'at least' and 'exactly' reading, an equative like (3) is ambiguous between an 'at most' and 'exactly' reading.

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(3) John biked as far as 500 miles yesterday.

(3) is consistent with John having biked 500 miles yesterday (the 'exactly' reading); it's also consistent with John having biked 450 miles yesterday (the 'at most' reading). It is not however consistent with John having biked 550 miles yesterday (the 'at least' reading). Although MP equatives are slightly more marked than other equatives (and than their MP construction counterparts), this important distinction between possible readings of MP equatives and other equatives poses a challenge to a comprehensive account of the meaning of the equative.

My proposal for a semantics of equatives accounts for this variation. I argue that: (1) while the internal argument of (positive antonym) clausal equatives denotes a downward-monotonic scale, the internal argument of MP equatives denotes an upward-monotonic scale; and (2) equatives invoke a mechanism of comparison that is sensitive to the directions of the scales being compared.

1.2 Background assumptions

I'll start by outlining some basic assumptions about the semantics of degrees and comparative constructions. First, I follow many others in assuming that gradable adjectives denote relations between individuals and degrees.

(4) $[\![\text{tall}]\!] = \lambda x \lambda d.\mathsf{tall}(x, d)$

The order of arguments in (4) is consistent with Schwarzschild's observation that MPs like *5ft* in e.g. *John is 5ft tall* function as predicates of scales (ordered, dense sets of degrees), rather than arguments of the adjective. I assume that numerals denote degrees (type $\langle d \rangle$) and combine with measure expressions (like *inch*) to form these predicates via a null measure function μ, which also enables numerals to combine with other common nouns like *cats* (Cartwright, 1975; Nerbonne, 1995; Schwarzschild, 2002, 2006).

I also assume that positive and negative antonyms (like *tall* and *short*) differ in their ordering, which is observable in their behavior in comparatives (Seuren, 1984; von Stechow, 1984, a.o.). Positive antonym scales are downward-montonic, with open lower bounds of zero and closed upper bounds (5a). Negative antonym scales like *short* are upward-monotonic, with closed lower bounds and closed upper bounds of infinity (5b).

(5) Context: John is 5ft tall.

a. $\lambda d.\mathsf{tall}(\mathsf{john}, d) = (0,5]$ b. $\lambda d.\mathsf{short}(\mathsf{john}, d) = [5,\infty]$

2 Comparatives

Following Hankamer (1973), I will use the terms **target** and **correlate** to refer to the subordinate and matrix material in comparatives, respectively (6a).

(6) a. John is taller than Sue is.
correlate **target**

b. John is taller than [$_{\text{CP}}$ Op_d Sue is ~~d-tall~~]

Following Bresnan (1973), I assume that comparatives and equatives with overt tense morphology are clauses that have undergone elision along the lines of (6b). I follow Pancheva (2006) in using the term 'phrasal' to refer to comparatives and equatives whose target cannot have overt clausal material (7), and 'clausal' to refer to those whose target is either clausal or has a plausible clausal source.

(7) a. John is taller than 6ft (*is).
b. No man is stronger than himself (*is). (Hoeksema, 1983, 405)

Based in part on arguments in Schwarzschild (2008), I adopt the 'A-not-A' account of the comparative in (8) (McConnell-Ginet, 1973; Kamp, 1975; Hoeksema, 1983; Seuren, 1984, a.o.). An important consideration of this theory is the fact that NPIs are licensed in the targets of (clausal) comparatives (9).

(8) $\lambda D' \lambda D \exists d[D(d) \wedge \neg D'(d)]$

(9) a. He would rather lose his honor than so much as a dime.
b. She is happier now than ever before.

This generalization comes with two caveats, one significant and the other less so. Less significant is that the *any* licensed in comparative targets (e.g. *John is taller than anyone in his class*) is modifiable by *almost* and thus appears to instead be a free-choice *any* (Hoeksema, 1983). More significantly is the issue of how NPIs could possibly be licensed in comparatives given the apparent lack of superset-to-subset entailment in the target ((10); Seuren, 1984; von Stechow, 1984; Hoeksema, 1983, 1984; Heim, 2003).

(10) Cheetahs are faster than lions. $\nrightarrow$ Cheetahs are faster than speedy lions.

What these sorts of tests – common in discussions of NPIs in comparatives – overlook is that the comparative is a degree quantifier, not an individual one. Testing for subset-to-superset entailment of degree sets (instead of individual sets) shows that the targets of comparatives are in fact downward-entailing.[1]

(11) Context: Mary is 6ft tall, John is 5ft tall, Sue is 4ft tall.
a. Mary is taller than John. $\rightarrow$ Mary is taller than Sue.
b. Mary is taller than Sue. $\nrightarrow$ Mary is taller than John.

(A side note: The problem with using individual sets to test for monotonicity in degree quantifiers isn't just that tests like (10) predict the targets of comparatives aren't DE. It's that they predict that **all** arguments of **all** degree quantifiers are non-monotonic. Degree quantifiers differ from individual quantifiers in containing an individual predicate – the one that adjoins to the quantifier, *fast* in

[1] It's possible that those NPIs licensed in DE degree contexts are different from those licensed in DE individual contexts, which would explain the *any* data discussed above (as well as the distribution of Dutch *ook maar* discussed in Hoeksema, 1983).

(10) – in addition to the set-denoting predicates that can occur in their arguments. As a result, there is always at least one subset/superset pair with which the additional predicate can interfere, thus making it impossible to reliably infer from **all** subsets to supersets (and vice-versa). In other words, testing the monotonicity of the arguments of degree quantifiers using sets of individuals predicts that all arguments of degree quantifiers are non-monotonic, because interference with the comparative predicate will always prevent entailment in every case.)

To sum up: NPIs appear to be licensed in the targets of comparatives, and entailment patterns between supersets and subsets of degrees (11) confirm that the targets of comparatives are downward-entailing (DE). These facts are appropriately captured by the 'A-not-A' analysis in (8) because it properly characterizes the target of comparatives as DE. Before ending this discussion, I would like to point out Hoeksema's (1983) observation that the definition in (8b) is equivalent to the one in (12) that invokes set complements (written as $\overline{D}$).

(12) $[\![\text{-er}]\!] = \lambda D' \lambda D \lambda d. d \in D \wedge d \in \overline{D'}$

(12) additionally differs from (8b) in not existentially binding the differential degree d. This allows for further modification by e.g. *much* and *3 inches* in *John is much/3 inches taller than Sue.* I assume that, in the absence of a differential modifier, the differential argument d is bound via existential closure.

3 Equatives

I'll begin this section by discussing the MP equative data more indepthly. My claim is that all of the equatives in (13) are ambiguous between an 'exactly' and 'at most' reading, and can never have an 'at least' reading.

(13) a. (I think) John biked as far as 500 miles yesterday.
b. (I heard that) the DOW dropped as much as 150 points yesterday.
c. The moon is as far as 240,000 miles away.
d. The waves reached as high as 6ft.
e. GM plans on laying off as many as 5,000 employees.

For instance, (13e) is true if GM is planning on laying off 4,500 employees, but not if they're planning on laying off 5,500. This is in distinct contrast with the truth conditions of the clausal equative *GM plans on laying off as many employees as Chrysler (did)* in a context in which Chrysler laid off 5,000 employees.

Importantly, the distribution of MP equatives is restricted relative to clausal ones. They are licensed when: (a) their value is significantly high given the context (is 'evaluative'; Rett, 2008); and (b) the value of the correlate is indeterminate. This second restriction is manifested in a variety of ways: the speaker can be unsure of the amount at issue (13b), the measure need not be precise in the context (13c), or the correlate can denote a range, either via a plurality (13d), or a modal (13e). These restrictions on the distribution of MP equatives seem directly related to their being more marked than their (intuitively synonymous) MP construction counterparts (e.g. *John biked 500 miles yesterday*).

Nouwen (2008, *to appear*) makes a similar point about the distribution of what he calls 'Class B' comparative quantifiers (e.g. *at most 6ft*, *up to 6ft*). He argues that they can only quantify over ranges, and that they equate the maximum of that range to, say, 6ft. It's not clear to me whether MP equatives fall under this description. On the one hand, the correlates in (13a) and (13b) don't appear to be ranges, and (13c) seems to be acceptable in a context in which the moon is 200,000 miles away. The fact that e.g. (13b) is unacceptable in a situation in which the DOW dropped a mere 5 points can be attributed to the evaluativity of MP equatives, which we already know provides a lower bound (a contextually valued standard s), and which is perhaps a result of their competition with less marked MP constructions.

On the other hand, the MP equatives which **do** involve clear ranges, like (13d), seem to pattern like Nouwen's Class B quantifiers. (13d) seems false if the highest wave only reached $5\frac{1}{2}$ feet. It's possible, then, that the MP equatives in (13a) and (13b) involve ranges, too (manifested as a range of epistemic possibilities). If this is the case (if all MP equatives associate the maximum value of the correlate range with the measure denoted by the MP), then it's more appropriate to characterize MP equatives as having only an 'exactly' interpretation.

Still, there is a stark contrast between clausal and MP equatives: in *GM plans on laying off as many employees as Chrysler*, the **minimum** value in the range of employees laid off by GM is that of Chrysler's. In (13e) it's the **maximum** value that measures 5,000. Regardless of the precise nature of the semantics of MP equatives, we need an account that explains this contrast.

3.1 MPs and scalar implicatures

The equatives in (13), of course, all have in common that their targets are MPs. They have other things in common: they're all evaluative, for instance. But some clausal equatives (*John is as short as Sue*) are evaluative without having an 'at most' reading. I argue that the equatives that are 'at most'/'exactly' ambiguous are those and only those whose targets are MPs because MPs (and numerals) are themselves scalar. The traditional SI account of sentences like *John has 3 children* assigns the numeral an 'at least' semantics (≥ 3), deriving the 'exactly' interpretation via scalar implicature, where appropriate (contra Geurts, 2006).

This means that the denotation of an MP target (in a positive-antonym equative, like those in (13)) is an upward-monotonic set of degrees, with a lower bound of d (for a d-denoting numeral) and an upper bound of ∞. In a context in which Sue is 5ft tall, the target of the equative *John is as tall as Sue (is)* denotes the degrees to which Sue is tall (14a), which is downward-monotonic. The target of the equative *John could be as tall as 5ft*, on the other hand, denotes the degrees greater than or equal to 5ft (14b), which is upward-monotonic.

(14) a. $[\![\text{Op}_d \text{ Sue is } \cancel{d\text{-tall}}]\!] = \lambda d.\mathsf{tall}(\mathsf{sue},d) = (0,5]$
b. $[\![\text{5ft}]\!] = \lambda d.d \geq \text{5ft} = [5,\infty]$

This particular characterization of MPs wouldn't be an issue if it wasn't for the independent observations tying it to SIs in DE contexts. Chierchia (2004) claims that SIs (a) can be calculated sub-sententially, and (b) are calculated differently in DE contexts.

I'll illustrate this point as Chierchia does, independently of equatives and MPs. *Or* is typically characterized as scalar (on a Horn scale with *and*), ambiguous between a weak reading (A or B or both) and a strong reading (A or B but not both). The strong reading is then characterized as coming about, where pragmatically possible, as a result of scalar implicature (15a). In DE environments, though, this SI is affectively cancelled; (15b) cannot be used to negate the claim that Sue didn't meet both Hugo and Theo (and is therefore incompatible with Sue having met both). Chierchia's explanation is that SIs are calculated in terms of informativity, and what counts as the most informative in upward-entailing contexts is actually the least informative in DE contexts (and vice-versa).

(15) a. Sue met Hugo or Theo. b. Sue didn't meet Hugo or Theo.

Extending this generalization to equatives, whose targets are DE, means that the targets of MP equatives always (across all contexts) have their weak meaning.

3.2 A more sensitive semantics

The crux of the analysis that follows is a reformulation of the equative morpheme, motivated by the fact that NPIs are licensed in the targets of equatives, too:

(16) a. He would just as much lose his honor as he would a dime.
b. She is as happy now as ever before.

We thus need a semantics of the equative in which its target, too, is DE. Drawing on the set-complement definition of the comparative (12), I propose (17).[2]

(17) $[\![\text{as}]\!] = \lambda D'\lambda D[\textsc{Max}(D) \in \widehat{\overline{D'}}]$, where
$\widehat{\overline{D}} =_{def}$ the smallest D' such that $\overline{D} \subseteq D'$ and D' is a closed set.

This definition invokes the notion of a 'closure of the complement', the smallest superset of the complement with closed bounds.[3] It is downward-entailing in its target (D'), correctly predicting the licensing of NPIs.

(18) Context: Mary is 6ft tall, John is 5ft tall, Sue is 4ft tall.
Mary is as tall as John. → Mary is as tall as Sue. *is true iff*
$\textsc{Max}(\ (0,6]\ ) \in \widehat{\overline{(0,5]}} \rightarrow \textsc{Max}(\ (0,6]\ ) \in \widehat{\overline{(0,4]}}$ *is true iff*
$6 \in [5,\infty] \rightarrow 6 \in [4,\infty]$ ✓

[2] The definition in (17) is a simplified version of $= \lambda D'\lambda D\lambda d[d = \textsc{Max}(D) \wedge d \in \widehat{\overline{D'}}]$, which is required for an account of modified equatives (see §4).

[3] Direct application of (17) will result in some scales having a closed lower bound of zero. This is formally unattractive but actually harmless, assuming that it is infelicitous to predicate a gradable property of an individual if that individual doesn't exhibit that property at all (cf. #*That couch is intelligent*). We could alternatively reformulate the definition of a closure of a complement to omit this possibility.

Positive-antonym MP equatives differ from positive-antonym clausal equatives in that their target is upward-monotonic. The definition in (17) allows the 'greater than' relation we implicitly associate with the 'at least' reading of the equative to be sensitive to the ordering on the target scale; it affectively employs a different relation ('at least', 'at most') based on the direction of the target scale.

(19) John is as tall as Sue. (John's height = 5ft; Sue's height = 5ft; **true**)
$\textsc{Max}(\ (0,5]\ ) \in \widehat{(0,5]} \quad \rightsquigarrow 5 \in [5,\infty]$ ✓

(20) John is as tall as Sue. (John's height = 6ft; Sue's height = 5ft; **true**)
$\textsc{Max}(\ (0,6]\ ) \in \widehat{(0,5]} \quad \rightsquigarrow 6 \in [5,\infty]$ ✓

(21) John is as tall as Sue. (John's height = 5ft; Sue's height = 6ft; **false**)
$\textsc{Max}(\ (0,5]\ ) \in \widehat{(0,6]} \quad \rightsquigarrow 5 \in [6,\infty]$ ✗

(22) The waves reached as high as 6ft. (waves' height = 6ft; **true**)
$\textsc{Max}(\ (0,6]\ ) \in \widehat{[6,\infty]} \quad \rightsquigarrow 6 \in [0,6]$ ✓

(23) The waves reached as high as 6ft. (waves' height = 5ft; **true**)
$\textsc{Max}(\ (0,5]\ ) \in \widehat{[6,\infty]} \quad \rightsquigarrow 5 \in [0,6]$ ✓

(24) The waves reached as high as 6ft. (waves' height = 7ft; **false**)
$\textsc{Max}(\ (0,6]\ ) \in \widehat{[6,\infty]} \quad \rightsquigarrow 7 \in [0,6]$ ✗

(17) works just as well for negative-antonym equatives, whose clausal arguments are upward-monotonic (see (5b)). I assume a definition of the maximality operator in which it is sensitive to the direction of the scale (Rett, 2008).

(25) John is as short as Sue. (John's height = 5ft, Sue's height = 5ft; **true**)
$\textsc{Max}(\ [5,\infty]\ ) \in \widehat{[5,\infty]} \quad \rightsquigarrow 5 \in [0,5]$ ✓

(26) John is as short as Sue. (John's height = 4ft, Sue's height = 5ft; **true**)
$\textsc{Max}(\ [4,\infty]\ ) \in \widehat{[5,\infty]} \quad \rightsquigarrow 4 \in [0,5]$ ✓

(27) John is as short as Sue. (John's height = 5ft, Sue's height = 4ft; **false**)
$\textsc{Max}(\ [5,\infty]\ ) \in \widehat{[4,\infty]} \quad \rightsquigarrow 5 \in [0,4]$ ✗

To extend the analysis to negative-antonym MP equatives (like *The temperature dropped as low as 2° Kelvin*), we must recall that the target also involves a negative antonym (e.g. 2° low, rather than 2° high). This is consistent with Bresnan's (and Kennedy's (1999)) assumptions about the syntax of comparatives and equatives ((28), cf. (6b)).

(28) John has fewer children than Sue.
-er ([Op'_d Sue has d'-few children]) ([Op_d John has d-few children])

MP targets of negative-antonym equatives are thus in fact downward-monotonic, which results in the correct truth conditions.

(29) The temperature dropped as low as 2°Kelvin. (highest temp = 2^o; **true**)
$\textsc{Max}(\ [2,\infty]\ ) \in \widehat{(0,2]} \quad \rightsquigarrow 2 \in [2,\infty]$ ✓

(30) The temperature dropped as low as 2°Kelvin. (highest temp = 3^o; **true**)
$\textsc{Max}(\ [3,\infty]\ ) \in \widehat{(0,2]} \quad \rightsquigarrow 3 \in [2,\infty]$ ✓

(31) The temperature dropped as low as 2°Kelvin. (highest temp = 1^o; **false**)
$\textsc{Max}(\ [1,\infty]\ ) \in \widehat{(0,2]} \quad \rightsquigarrow 1 \in [2,\infty]$ ✗

4 Extensions and conclusions

Equative modifiers. Importantly, this analysis calls for a semantics of superlative modifiers like *at least* and *at most* that are not sensitive to the direction of the scale. This is because *at least* can modify MP equatives, forcing them to have an 'at least' interpretation (32a), and *at most* can modify clausal equatives, forcing them to have an 'at most' interpretation (32b).

(32) a. John biked at least as far as 500 miles yesterday.
b. John is at most as tall as Sue (is).

I argue that such an analysis requires the assumption that pragmatic strengthening is applied to equatives before the equatives are modified. The modifiers therefore take strengthened, 'exactly' equative meanings as their arguments, and add a restricting clause based on an objective scale direction ($\leq$ or $\geq$).

MP comparatives. The assumptions made above about the denotation of MPs in DE contexts doesn't extend straightforwardly to comparatives given the definition in (12). In particular, feeding an upward-monotonic denotation of MPs into (12) erroneously predicts that all MP comparatives are true.

(33) John is taller than 5ft. (John's height = 4ft; **false**)
$\exists d[d \in (0,4] \wedge d \in \overline{[5,\infty]}] \quad \rightsquigarrow \quad \exists d[d \in (0,4] \wedge d \in (0,5)\ ]$ ✓

Instead, it seems that the incorrect truth conditions in (33) underscore the argument in Pancheva (2006) that comparative subordinators are meaningful and differ in their meanings. In fact, some languages employ different comparative subordinators for MP targets than they do for clausal targets (cf. Spanish *de lo que* DP versus *de* MP). One possible way of adopting Pancheva's analysis while holding fixed this particular characterization MPs as denoting their weak meaning in DE contexts is to argue that the comparative morpheme *-er* is a simple quantifier over degrees, while clausal *than* is a function from a set to its complement (thus resulting in the NPI data above), and MP *than* is an identity function over degree sets.

(34) a. $[\![\text{-er}]\!] = \lambda D' \lambda D \lambda d.d \in D \wedge d \in D'$
b. $[\![\text{than}_{clausal}]\!] = \lambda D \lambda d.d \notin D$ b. $[\![\text{than}_{MP}]\!] = \lambda D \lambda d.D(d)$

Slavic languages provide independent evidence that MP targets of comparatives are treated differently from clausal targets of comparatives. ((35) is Pancheva's example from Russian, in which clausal comparatives are formed with the *wh*-phrase *čem*, and phrasal comparatives are formed with a covert subordinator.)

(35) a. ??Ivan rostom bol′še čem dva metra.
Ivan in-height more what two meters
b. Ivan rostom bol′še dvux metrov.
Ivan in-height more [two meters]$_{\text{GEN}}$
'Ivan measures in height more than two meters.'

In effect, this discussion of MPs in comparative and equative targets helps provide an explanation for why languages would employ two different subordinators for clausal comparatives and MP comparatives: the two types of targets denote two different types of scales, and as a result need to be dealt with differently. It is also compatible with the observation that some languages disallow MP equatives entirely (e.g. German, Daniel Büring, p.c.). These languages, at first glance, appear to be those that employ *wh*-phrases as equative subordinators.

DP equatives. Some phrasal equatives have DP rather than MP targets.

(36) a. John can reach as high as the ceiling (*is).
b. This rubber band can stretch as wide as a house (*is).

It appears as though these equatives, too, must be indeterminate, or a range of some sort (37a), but this requirement comes in the absence of any obvious unmarked counterparts ((37b), cf. MP contructions).

(37) a. ??John reached as high as the ceiling.
b. ??John can reach the ceiling's height.

It's not clear to me which of the three readings ('at least', 'at most', 'exactly') DP equatives have. (36a), for instance, seems both compatible with John being capable of reaching lower than the ceiling's height and with John being capable of reaching higher than the ceiling. I suspect that the meaning of these DPs rely heavily on the contextual salience of the DP, not just the measure denoted by the DP. This point is made especially clear by DP equatives like *This train will take you as far as Berkeley*, which is intuitively false if the train will take you somewhere equidistant to Berkeley (but not to Berkeley itself).

Conclusion. Clausal equatives are ambiguous between 'at least' and 'exactly' interpretations, while MP equatives are ambiguous between 'at most' and 'exactly' interpretations. I argue that these phenomena can be assimilated in a neo-Gricean SI framework if we characterize the weak meaning of the equative in a way that is sensitive to the scalar ordering of its internal argument. The account relies on independent observations that numerals (and therefore MPs) are themselves scalar, and that scalar implicature is calculated sub-sententially and differently in downward-entailing contexts (Chierchia, 2004).

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