
Quantifiers in Comparatives^{*}

Sveta Krasikova
University of Tübingen

svetlana.krasikova@uni-tuebingen.de

1 Introduction

One of the puzzling and recently much debated issues in the semantic literature on comparatives are the apparent scope interactions of the comparative operator with some other elements within the comparative sentence. It has been observed that quantifiers seem to be able to interact with the comparative even over the ‘than’ clause boundary. The adequate semantic treatment of such cases is considered a crucial ingredient in the interpretation of clausal comparatives. The goal of this paper is to provide a semantic analysis for the comparatives in English that accounts for the behaviour of different quantifiers inside ‘than’ clauses.

Schwarzschild and Wilkinson (2002) among others conclude that universal quantifiers embedded in ‘than’ clauses usually appear to take scope over the comparative, as shown in (1). However, the ‘clause-boundness’ of quantifier raising along with other restrictions they discuss make an analysis based on the scoping strategy impossible. This motivates S&W to make a shift to the interval-based interpretation of comparatives. The analysis they propose treats the comparative complement in (1a) as the set of intervals that cover the heights of every girl. Comparing John’s height to the maximum from this set derives the correct meaning.

- (1) a. John is taller than every girl.
 $\forall x: \text{girl}_@(x) \rightarrow \text{Height}_@(j) > \text{Height}_@(x)$
= John is taller than the tallest girl.
- b. John is taller than I predicted.
 $\forall w \in \text{Acc}_@: \text{Height}_@(j) > \text{Height}_w(j)$
= John is taller than my maximal prediction.

It turns out that not all universal quantifiers follow the pattern in (1). Schwarzschild (2004) and Heim (2006) discuss a group of necessity modals that behave as if they

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didn't outscope the comparative. In (2) 'have to', in contrast to 'should', triggers the so called more-than-minimum reading that corresponds to the narrow scope of the modal. Obviously, (2b) is a problem for S&W's analysis that is tailored to account for the apparent wide scope of the modal or the more-than-maximum reading.

- (2) a. John is taller than he should be.
 $\forall w \in \text{Acc}_@: \text{Height}_@(j) > \text{Height}_w(j)$
 = John is taller than the maximally permitted height.
- b. John is taller than he has to be.
 $\text{Height}_@(j) > \max(\{d: \forall w \in \text{Acc}_@: \text{Height}_w(j) \geq d\})$
 = John is taller than the minimally required height.

Embedded existential quantifiers do not behave uniformly either. Possibility modals, like 'be allowed', result in the more-than-maximum interpretation, which can be represented by assigning the existential modal narrow scope with respect to the comparison, cf. (3a). This option is also exploited by nominal indefinites all of which appear in the form of polarity sensitive items, like 'anyone', cf. (3b).

- (3) a. John is taller than allowed.
 $\text{Height}_@(j) > \max(\{d: \exists w \in \text{Acc}_@: \text{Height}_w(j) \geq d\})$
 = John is taller than the maximally permitted height.
- b. John is taller than any girl is.
 $\text{Height}_@(j) > \max(\{d: \exists x: \text{girl}_@(x) \& \text{Height}_@(x) \geq d\})$
 = John is taller than the tallest girl.

We do not seem to be able to interpret indefinites like 'a girl' or 'some student' under the comparative. They invariably produce wide-scope or generic interpretations. Epistemic modals like 'might' escape the scope of the comparative as well.

- (4) a. It is warmer today than it might be tomorrow.
 $= \exists w \in \text{Acc}_@: \text{Temp}_@(today) > \text{Temp}_w(tomorrow)$
 = It is possible that it will be colder tomorrow than it is today.
- b. He did better than a student from his course.
 $\exists x: \text{student from his course}_@(x) \& \text{Grade}_@(he) > \text{Grade}_@(x)$

To conclude, an adequate analysis of comparatives needs to derive the observed readings and explain why than clauses license any terms, but cannot host other existential quantifiers.

The paper is structured in the following way: section 2 gives an overview of the existing analyses and the difficulties they face; section 3.1. concerns the properties of universal modals that can trigger the more-than-minimum reading; in section 3.2. I propose an analysis couched in an interval-based semantics that deals with universal cases; section

3.3. is devoted to ‘than’ clauses with embedded existential quantifiers; section 4 sums up the results.

2 Challenges to Scope and Selection Strategies

The transition to the interval semantics of comparatives undertaken by Schwarzschild and Wilkinson (2002) and re-implemented in Heim (2006) successfully solves the problem of the apparent wide scope of universal quantifiers. Shifting from points to intervals allows to derive the more-than-maximum reading – comparison with the maximum of the degrees associated with the domain of the quantifier – without moving the quantifier outside the subordinate clause. (5b) is the shifted meaning of the comparative clause of (1b) repeated below in (5a).

- (5) a. John is taller than I predicted.
 b. $\lambda D. \forall w \in \text{Acc}_@: \text{Height}_w(j) \in D$
 = the set of intervals that include John’s height in the prediction worlds

The interpretation of modals triggering the more-than-minimum reading, see (2b), deontic possibility modals and indefinites like ‘anyone’ presents a difficulty for this type of approach. In general, one needs an additional mechanism to treat the apparent narrow scope of quantifiers under an interval analysis. To account for these cases Schwarzschild (2004) and Heim (2006) introduce the Pi operator that shifts the standard degree-based meaning of the adjective to intervals and can be moved to different scope sites inside the comparative clause. Thus, the apparent narrow scope reading of quantifiers is derived by assigning the relevant quantifiers narrow scope w.r.t. the Pi operator and the apparent wide scope reading corresponds to the narrow scope of the Pi w.r.t. the quantifiers.

In the following subsection I will present the details of Heim’s (2006) analysis based on the interaction of the Pi operator with the embedded quantifier and discuss the difficulties that such an approach faces. Then an alternative proposal in Beck (2007) pursuing the so called selection strategy will be introduced and tested against the problematic set of data.

2.1 Scope of Pi

Heim (2006) addresses the availability of readings corresponding to the narrow scope of the quantifier by making the shift from degrees to intervals directly in the syntax and allowing the shifter to enter scope interactions with the quantifiers. She suggests that the adjective expresses a relation between a degree and an individual, see (6b), and the shifter from points to intervals (Pi), defined in (6b), can lift its type to a relation between an interval and an individual. (7b-c) show the derivation of the ‘than’ clause of (7a). The Pi-phrase originating in the degree argument position of the adjective undergoes short movement and abstracting over its interval-denoting argument makes the subordinate clause to a generalised quantifier over degrees.

- (6) a. $[[\text{tall}]] = \lambda w. \lambda d. \lambda x. \text{Height}_w(x) \geq d$
 b. $[[\text{Pi}]] = \lambda w. \lambda D. \lambda D'. \max(D') \in D$
- (7) a. Peter is taller than Mary.
 b. $[\lambda 2 [\text{Pi } 2] [\lambda 1 \text{ Mary } 1\text{-tall}]]$
 c. $\lambda w. \lambda D. \text{Height}_w(m) \in D = \text{the set of intervals including Mary's height}$

The meaning of the main clause that is also derived by the movement of the Pi-phrase, given in (8b), is then quantified into the subordinate clause to give the correct interpretation of the sentence, see (8c).

- (8) a. $[\text{than-clause}] [\lambda 2 [\text{Pi er } 2] [\lambda 1 \text{ Peter } 1\text{-tall}]]$
 b. $\lambda w. \lambda d. \text{Height}_w(p) > d = \text{the set of degrees exceeding Peter's height}$
 c. $\lambda w. \text{Height}_w(p) > \text{Height}_w(m)$

It is further assumed that Pi can be moved to different available scope sites. Crucially, in the presence of another operator we have two scope possibilities for the shifter. It either undergoes a short movement remaining within the scope of the other operator, see (9) or moves over it taking wider scope, see (10). In the latter case, we get the more-than-minimum reading. A subordinate clause with 'be allowed' would also require scoping Pi above the modal to get the set of intervals including the maximally permitted height.

- (9) a. John is taller than he should be.
 b. $[\lambda 2 \text{ should } [\text{Pi } 2] [\lambda 1 \text{ John } 1\text{-tall}]]$
 c. $\lambda w. \lambda D. \forall w_2 \in \text{Acc}_w: \text{Height}_{w_2}(j) \in D$
 $= \text{the set of intervals } D \text{ s.t. John's height in every accessible world is in } D$
- (10) a. John is taller than he has to be.
 b. $[\lambda 2 [\text{Pi } 2] \text{ has to } [\lambda 1 \text{ John } 1\text{-tall}]]$
 c. $\lambda w. \lambda D. \max(\lambda d. \forall w_2 \in \text{Acc}_w: \text{Height}_{w_2}(j) \geq d) \in D$
 $= \text{the set of intervals } D \text{ s.t. John's minimally required height is in } D$

The scope strategy of this kind is successful in deriving correct readings but obviously the scope sites of Pi need to be restricted in every given case. It turns out that not all universal modals can split the scope of Pi and produce the more-than-minimum reading and those that can do not always do that.

The contrast between 'have to' and 'should' illustrated in (2) does not seem accidental. Cross-linguistically we find modals that favour either one reading or another which suggests that we do not deal with the genuine scope ambiguity in these cases. The following pairs from German and Russian display the same properties as their English counterparts in (2).

- (11) German:
- a. Peter war vorsichtiger als er zu sein brauchte.
 P. was cautious-ER than he to be needed
 'Peter was more cautious than he had to be.'
- b. Peter war vorsichtiger als er hätte sein sollen.
 P. was cautious-ER than he had be should
 'Peter was more cautious than he should have been.'
- (12) Russian:
- a. Petja byl oštorožnee čem neobxodimo.
 P. was cautious-ER than necessary
 'Peter was more cautious than he had to be.'
- b. Petja byl oštorožnee čem emu sledovalo byt'.
 P. was cautious-ER than him obligatory was
 'Peter was more cautious than he should have been.'

Let us first convince ourselves that comparatives with 'should'-like universal modals and with 'be allowed' can only be parsed with the narrow scope of P_i relative to the modal. To see this, one can consider a scenario that excludes the more-than-maximum reading, i.e. a situation in which comparison with the upper limit of the accessible interval would be infelicitous. In (13) I describe a scenario of this kind that we can use to test the pair of sentences in (14).

- (13) John was to take care of the alarm while his friends were robbing a bank. John was only instructed not to switch on the alarm before 1 a.m. so that his friends could complete their robbery task.
- (14) a. John switched on the alarm later than he had to / was required / necessary.
 b. John switched on the alarm later than he should have / was supposed to / was allowed to.

(14b) is not felicitous in the given context, which strongly suggests that it cannot have the more-than-minimum reading, i.e. it cannot describe John's switching of the alarm later than 1 a.m., after the required earliest time. It rather states that John's action occurred after the latest permissible time, which is not consistent with the facts in (13). (14a), on the other hand, describes a state of affairs that could well obtain given (13). Thus, manipulating the context does not have any effect on the interpretation of modals in (14b), which leads us to the conclusion that they can only result in the more-than-maximum reading.

What about 'have to'-like modals? It turns out that they are less consistent in this respect. (15) and (16) are examples of the more-than-minimum and the more-than-maximum readings respectively.

- (15) Peter leaves his office 30 min later than necessary to miss rush hour.

- (16) He was coming through later than he had to if he were going to retain the overall lead. ... The time flashed up above the finish line: 36:53. Almost a minute back. (Google)

The apparent wide scope reading corresponding to the more-than-maximum interpretation obtains with ‘have to’ quite frequently in comparatives with negative-pole adjectives. On its natural reading the sentence (17) describes the situation in which Peter’s height does not reach the required minimum. At first glance, it seems that we need to reproduce the scope configuration in (10) and interpret the modal below Pi. However, in this case, if we follow Heim’s negation theory antonymy and decompose ‘short’ into ‘negation + tall’, see (18), we can only get comparison with the permitted maximum as shown in (19).

- (17) (Suppose that John wants to be a pilot. Pilots need to be between 1,70 and 1,80.) John is shorter than he has to be.
- (18) $[[\text{short}]] = \lambda w. \lambda d. \lambda x. \text{Height}_w(x) < d$
- (19) a. $[\lambda 2 [\text{Pi } 2] \text{ has to } [\lambda 1 \text{ John } 1\text{-short}]]$
 b. $\lambda w. \lambda D. \max(\lambda d. \forall w_2 \in \text{Acc}_w: \text{Height}_{w_2}(j) < d) \in D$
 = the set of intervals D s.t. John’s maximally permitted height is in D

The desired meaning could be derived under the standard approach by scoping ‘have to’ over the comparative as represented in (20a). However, the interval-based approach cannot account for this case without additional assumptions about the interpretation of antonyms¹. If the modal is scoped above Pi, the maximality operator integrated into the meaning of Pi ends up undefined on Peter’s degrees of shortness, cf. (20b)².

- (20) a. $\forall w_2 \in \text{Acc}_w: \{d \mid \text{Height}_{w_2}(j) < d\} \subset \{d \mid \text{Height}_w(j) < d\}$
 b. $\lambda w. \lambda D. \forall w_2 \in \text{Acc}_w: \max(\lambda d. \text{Height}_{w_2}(j) < d) \in D$ (undefined)

Negative-pole adjectives do not always result in this problematic reading. We also find examples of ‘than’ clauses that the interval-based approach can deal with by moving Pi to a position above the modal. Consider the following sentences from Google that feature comparison with the upper bound of the accessible interval.

- (21) a. “Buck’s text is much shorter than necessary, running only 153 pages in all. He could easily have added 30 pages under the rules of the series.”
 b. “Shelf-life requirements for processed foods are far shorter than necessary to preserve freshness...”
 c. “Germany, France and Denmark found that their industries’ emissions were lower than required.”

¹See Buring (2007) for an analysis that could offer a solution to this problem.

²We run into the same problem when interpreting the matrix clause. If it does not contain any modal Pi is moved locally and max has to be applied to an open interval.

To summarise this section, Heim’s (2006) analysis treating ‘than’ clauses as generalised quantifiers over degrees is flexible enough to account for all readings of embedded quantifiers. However, I presented some evidence that restricting the scope sites of Pi , which this theory crucially relies on, is a non-trivial task. A class of modals including ‘have to’ indeed trigger readings corresponding to the wide and narrow scope of Pi . But ‘should’ and other modal expressions of its type never allow Pi to split its scope – they always seem to sit above the shifting operator. Another challenge for an interval-based approach like Heim (2006) is the interpretation of comparatives with antonyms. Introducing Pi that is based on the maximality operator is in conflict with the negation theory of antonymy.

2.2 Selection Strategy

Beck’s (2007) proposal also features a shift to intervals, however, it follows what we will refer to as the selection strategy. Drawing on the recent analysis of temporal clauses in Beaver and Condoravdi (2003) she bases her analysis on the selection of the item of comparison from the interval denoted by the subordinate clause by a maximality operator. Specifically, it is assumed that the shifting operator, if introduced at the LF, can move only locally. As in Heim (2006) ‘than’ clause is interpreted as a generalised quantifier over degrees, see (22):

- (22) a. John is taller than anyone else.
 b. $[\lambda 2 \exists \lambda x [\text{Pi } 2] [\lambda 1 x \text{ 1-tall}]]$
 c. $\lambda D. \exists x: \text{Height}_@(x) \in D$
 = the set of intervals that include the height of at least one individual.

The set denoted by the subordinate clause is passed to a *min* operator that returns the set of the smallest interval(s) contained in it. Then the selection step follows: the specially defined maximality operator applies the set returned by *min* and picks the maximal degree from the interval that extends highest on the relevant scale. Suppose that the salient individuals in the context of (22) are x_1 , x_2 and x_3 with their heights arranged as in (23a). Then the derivation of the truth conditions of this sentence in the given scenario is demonstrated in (23b-d).

- (23) a. |-----x1-----x2-----x3-----J----->
 b. $\min(\lambda D. \exists x: \text{Height}_@(x) \in D)$
 = $\{\{\text{Height}_@(x_1)\}, \{\text{Height}_@(x_2)\}, \{\text{Height}_@(x_3)\}\}$
 c. $\max(\{\text{Height}_@(x_1)\}, \{\text{Height}_@(x_2)\}, \{\text{Height}_@(x_3)\}) = \text{Height}_@(x_3)$
 d. $[[\text{er}]](\max(\min(\text{than-clause}))) (\max(\min(\text{matrix-clause})))$
 = $\text{Height}_@(\text{John}) > \text{Height}_@(x_3)$

For the sentences with embedded universal quantifiers this analysis makes the same predictions as Schwarzschild and Wilkinson (2002). It is easy to verify that in these cases the subordinate clause denotes a set whose minimal interval is the region covering

the relevant degrees of every accessible world or every individual in the restriction of the quantifier. Comparison with the maximum of this interval results in the more-than-maximum reading as desired.

The advantage of the selection strategy over S&W is that it accounts for the more-than-maximum reading of possibility modals and universal readings of embedded ‘any’ terms. This is achieved without having to scope Π non-locally and introduce strict restrictions on this move. However, as it stands Beck’s (2007) proposal cannot deal with Heim’s cases of Π scoping over universal modals, i.e. the more-than-minimum reading of modals like ‘have to’.

In the following sections, I will modify the semantics of a class of embedded universal modals and develop an analysis that accounts for the more-than-minimum reading building on the interval approaches discussed above. My ultimate goal is to demonstrate that one can get over the stipulative part of the scope approach by keeping the scope of the shifting operator local, as the selection strategy does it, and at the same time retain the predictive power of this kind of analysis.

3 Dispensing with the Wide Scope of Π

The discussion of the scope and selection strategies leads us to the following conclusions. On the one hand, most cases of embedded quantifiers involve comparison with the maximum. This interpretation appears unproblematic within an interval-based approach even with existential quantifiers as Beck’s selection analysis proves. One can derive it without resorting to the non-local movement of the Π operator. On the other hand, the existence of the more-than-minimum reading with a certain class of universal modals pushes the scope theory to the latter extreme measure and as a consequence strict restrictions on the scope of Π need to be introduced.

The purpose of this section is twofold. First, we argue that the more-than-minimum reading results from the degree semantics of the involved necessity modals and does not require any comparative specific operations, like wide scoping of Π . Second, we show that the universal reading of the disjunction and ‘any’ terms and the more-than-maximum reading of some possibility modals can be derived as a free choice effect.

3.1 Universal Scope-Splitters

In this section we will have a closer look at the properties of necessity modals that give rise to the more-than-minimum reading under the comparative. I demonstrated in the previous section that the availability of this reading, cf. (2b), depends on the choice of the modal. Universal modals have been shown to fall into two classes: ‘should’-like modals always result in the more-than-maximum interpretation, whereas ‘have-to’-like modals,

termed scope-splitters in Schwarzschild (2004), allow comparison with the minimum as well as with the maximum of the span corresponding to the accessible worlds.

One of the common properties of the universal scope-splitters, like ‘have to’, is their behaviour under ‘only’. Unlike ‘should’ they can participate in the sufficiency modal construction exemplified in (24), see von Stechow and Iatridou (2007). When embedded under ‘only’ they give rise to the sufficiency inference.

- (24) You only *have to* go to the North End to get good cheese.
→ Going to the North End suffices for getting good cheese.

It turns out that the ability of a necessity modal to form an SMC is directly related to the availability of the more-than-minimum reading of this modal under the comparative. Below we use the ‘only’ test to demonstrate this correlation for a number of modals:

- (25) a. You only *need* to go to the North End to get good cheese. (SMC)
b. [[John left later than he *needed* to] in order to miss rush hour].
- (26) a. You are only *required* to go to the North End to get good cheese. (SMC)
b. [[John left later than *required*] in order to miss rush hour].
- (27) a. You *should* only go to the North End to get good cheese. (#SMC)
b. John left later than [he *should* have in order to miss rush hour].
- (28) a. You only *ought to* go to the North End to get good cheese. (#SMC)
b. John left later than [he *ought to* have left in order to miss rush hour].

On the one hand, the *a* variants of (25) and (26), in contrast to the *a* variants of (27) and (28), trigger the sufficiency inference. On the other hand, the modals used in them, i.e. ‘need’ and ‘be required’, can produce the more-than-minimum interpretation (‘John stayed longer than minimally required with the goal to avoid rush hour’). The modals that do not result in the SMC under ‘only’ can only trigger the more-than-maximum interpretation (‘John left later than the latest possible time before rush hour’). Interestingly, in (27) and (28) ‘in order to’ clause can only be attached at the level of the comparative clause. This is the only construal that is compatible with the more-than-maximum interpretation. Thus, the contrast between (25)-(26) and (27)-(28) suggests that the mechanism responsible for the selection of modals in the SMC also determines the behaviour of these modals in the comparative clause.

In the context of ‘only’ the uttered necessity statement refers to the minimal sufficiency point on the effort scale, see Krasikova and Zhechev (2006). The same effect arises in the comparative context as well when we are dealing with the more-than-minimum reading. Let us consider the pilot scenario described in (17) and repeated here in (29a). The minimal required height, 1,70m, that is picked as the standard of comparison on the more-than-minimum reading is precisely the minimal sufficiency degree in this case.

- (29) a. Suppose that John wants to be a pilot. Pilots need to be between 1,70 and 1,80.
 b. |-----1,70-----1,80----->
 necessary \neg necessary

One can conclude that the necessity scale prominent in the SMC is at work in the comparatives with ‘have to’-like modals as well. I suggest that this scale is associated with the relevant necessity modals that need to be analysed as degree predicates of propositions. Following Villalta (2006), that offers a degree semantics for emotive predicates in Spanish and argues that they compare their complements to other alternatives on different kinds of lexically determined scales, I propose that ‘necessary’ and other predicates that occur in the SMC relate propositions to degrees of their comparative possibility in a given world, see Lewis (1973). Thus, ‘necessary’ defined in (30) expresses a relation between a proposition and an interval on the scale of likelihood. I stick to the interval-based semantics of degree constructions and assume a lexical shift to intervals, which is equivalent to the introduction of the shifting operator like Pi , cf. Heim (2006).

- (30) $[[\text{necessary}]] = \lambda w. \lambda D \subseteq S_{P,w}. \lambda q. P_w(q) \in D$,
 where $\forall w_s, q_{st}: P_w(q) =$ the likelihood degree of p in w ,
 and $S_{P,w}$ is a scale that ranks propositions according to their likelihood in w .

The degree operator that binds the degree argument in an unmarked positive sentence like (31a) is the positive operator defined in (32), see von Stechow (2006). POS relates its interval argument to the contextually provided standard of comparison N . I assume that N corresponds to the likelihood degrees of the ‘in order to’ clause of a necessity statement. In this sense, ‘in order to’ clause acts as a context setter like ‘compared to’ phrases. In other words, the POS is restricted by the degrees of likelihood that should be reached in the goal worlds. The *min* operator that is defined to pick the unique minimal interval from a given set provides an appropriate argument for the positive operator, as in the selection approach.

- (31) a. It is necessary for John to be 1,70 m tall (in order to become a pilot).
 b. $\text{POS}_N \text{ min } [\lambda D [\text{necessary } D] \text{ John } 1,70 \text{ m tall}]$
 c. $[[\text{min}]] = \lambda w. \lambda Q. \iota D: D \in Q \ \& \ \forall D': D' \in Q \rightarrow D \subseteq D'$

- (32) $[[\text{POS}_N]]^g = \lambda w. \lambda D. \max(g(N)) \leq \max(D)$,
 where N is a contextually given standard interval of comparison.

Let us identify the likelihood scale with the reversed height scale, i.e. it is more likely to be short for height than too tall. Then in the scenario (29), the value of N is fixed as in (33b) and the sentence is predicted true iff the likelihood of John’s height being 1,70 m is greater or equal to the likelihood that corresponds to 1,70 m, which is satisfied.

- (33) a. $\max(g(N)) \leq \max(\min(\lambda D. P_{@}(\lambda w. \text{Height}_w(j) \in [1,70, 1,70]) \in D))$
 b. $g(N) = [P_{@}(1,80), P_{@}(1,70)]$,
 where $P_{@}(n)$ stands for the likelihood of John being n tall in $@$

One can verify that any alternative sentence of the form ‘It is necessary for John to be n tall’ with $n \leq 1,70$ m, is predicted true under this analysis. This prediction is welcome and the fact that the likelihood degree of the uttered alternative is usually perceived as sufficient can be derived as a scalar implicature if we strengthen the meaning by a covert ‘only’. Embedding under an overt ‘only’, as in the SMC, produces the same effect: the likelihood degrees greater than the likelihood of the uttered complement of ‘necessary’ are said to lie within the goal interval, i.e. the uttered alternative is sufficient.

To summarise this section, I demonstrated that there is correlation between the ability of a necessity modal to trigger the more-than-minimum reading in comparatives and produce sufficiency inference under ‘only’. I proposed that this is a result of the degree-based semantics of the relevant group of necessity expressions. In the following section I will use the proposed meaning for the ‘have to’-like modals to derive the more-than-minimum interpretation under the comparative.

3.2 Deriving More-Than-Minimum Reading

Let us apply the semantics for ‘have to’ developed in the previous section to derive the truth conditions of the comparative sentence (34).

- (34) John is taller than he has to be.

I will follow the selection strategy of Beck (2007) and make use of the coercion operators in order to reduce intervals to points. However, this choice is not dictated by the assumptions I made above. It can be shown that the present analysis can also be implemented in Heim’s (2006) theory.

The comparative operator compares the maxima of the intervals obtained from the comparative and the main clause, see (35a). The *min* operator defined in (31c) reduces the generalised quantifier type of the main and the embedded clause to the interval type, as sketched in (35b).

- (35) a. $[[er]] = \lambda w. \lambda D. \lambda D'. \max(D') > \max(D)$
 b. $[[er]]([[min]]([[than\ clause]]))([[min]]([[main\ clause]]))$

Under the assumption that ‘have to’ denotes a gradable predicate like ‘necessary’ defined in (30), the analysis of the embedded clause proceeds as in (36). According to (36b), we obtain a set of intervals D on the height scale, s.t. the likelihood of John’s height being in D is greater than or equal to the maximal likelihood of the neutral interval.

- (36) a. $\lambda D \text{ POS}_N \min [\lambda D2 [\text{have to } D2] \text{ John } D \text{ tall}]$
 b. $\lambda D. \max(g(N)) \leq \max(\min (\lambda D2. P_{@}(\lambda w. \text{Height}_w(j) \in D) \in D2))$

I follow the assumptions made in the previous section and identify the likelihood ordering with the reversed height scale. The neutral interval is set to the height in the ‘goal’ worlds, i.e. $[P_{@}(1,80), P_{@}(1,70)]$. It can now be calculated that the set (36b) consists of intervals whose upper bound does not exceed 1,70.

The *min* operator cannot pick the unique minimal interval from this set. To fix this, I propose to embed the necessity clause in (36a) under a covert *exh* operator following the pragmatic program defended in Fox (2007) that allows to insert a covert exhaustification operator anywhere in a structure if this step strengthens the ordinary meaning. The final LF for the embedded clause is given in (37).

- (37) $\lambda D \text{ exh}_C \sim C [\text{POS}_N \min [\lambda D2 [\text{have to } D2] \text{ John } D_F \text{ tall}]]$

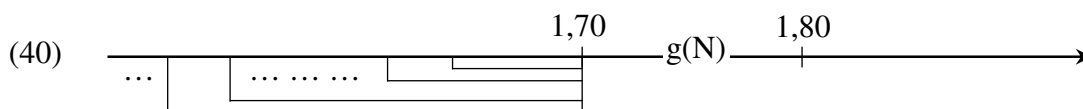
To calculate the extension of (37) in the scenario at hand we need to understand the contribution of *exh*. Simplifying Fox’s (2007) definition, let us assume that *exh* projects the truth of the prejacent and negates all stronger alternatives from its restriction set *C*, see (38a). As indicated in (37), the set *C* is restricted by the focus anaphor introduced by the \sim operator and the focus falls on the interval argument of the gradable predicate. This gives us the definition of *C* in (38b).

- (38) a. $[[\text{exh}]] = \lambda w. \lambda C. \lambda p. p(w) \ \& \ \forall q \in C: q \subseteq p \rightarrow \neg q(w)$
 b. $C = \{\lambda w. \max(g(N)) \leq \max(\min (\lambda D2. P_w(\lambda w2. \text{Height}_{w2}(j) \in D) \in D2): D \subseteq S_{\text{Height}})\}$

Obviously, the stronger alternatives are the ones, that involve a greater height interval. One can verify that for any two intervals *D'* and *D* s.t. $D' > D$ the statement that John’s height has to be in *D'* implies that it has to be in *D*. Therefore the structure in (37) defines the following set of intervals:

- (39) $\lambda D. \max(g(N)) \leq \max(\min (\lambda D2. P_{@}(\lambda w. \text{Height}_w(j) \in D) \in D2)) \ \& \ \forall D3: D3 > D \rightarrow \max(g(N)) > \max(\min (\lambda D2. P_{@}(\lambda w. \text{Height}_w(j) \in D3) \in D2))$

(39) restricts the definition in (36) by the requirement that any height interval greater than *D* be below the neutral interval on the likelihood scale, i.e. below the likelihood degree of 1,70m. Since the likelihood ordering is the converse of the height scale this implies that the set in (39) contains intervals whose upper bound is 1,70, as illustrated on the following scheme:



The minimum from this set is [1,70, 1,70]. Comparing John's height in the actual world to this interval gives us the desired more-than-minimum reading.

An important consequence of this analysis is the dependence of the interpretation of comparatives with embedded 'have to' on the likelihood ordering in the given context. The availability of more-than-minimum and more-than-maximum reading in these cases follows from the fact that the item of comparison is fixed with respect to the scale of the modal – it is the minimal compliance amount on the likelihood scale. Let us consider examples (15) and (16) repeated below in (41).

- (41) a. Peter leaves his office 30 min later than necessary to miss rush hour.
 b. He was coming through later than he had to if he were going to retain the overall lead.

In (41a), the more-than-minimum case, the item of comparison is the earliest allowed leave for the day. As in the pilot scenario above, the adjective scale is the converse of the likelihood scale, i.e. it is more likely that you leave your office too early than too late. In contrast, in (41b) two scales are unidirectional – the later you reach the finish line the more likely it is. Therefore the latest point from the time span corresponding to the goal ("you retain the overall lead") is picked as the standard of comparison and we get the more-than-maximum reading. Thus, the present analysis correctly predicts that the item of comparison is the maximum from the 'goal' interval, i.e. the original accessible interval, with respect to the likelihood scale.

I conclude this section with a short discussion of a sentence with an antonym. Remember that (17) repeated in (42) cannot be captured in Heim's (2006) theory, the problem being the negation in the definition of the antonym that results in the undefinedness of the Pi operator. In order to deal with this one can redefine Pi in order to suit such cases. I will consider a different strategy the motivation of which I will leave for a different occasion. Assume that antonyms are associated with different orderings on the same kind of objects. As shown in (43), 'tall' relates an individual to a set of heights ordered on the scale of tallness, whereas 'short' takes a set of height intervals ordered on the reversed shortness scale.

- (42) John is shorter than he has to be.

- (43) a. $[[\text{tall}]] = \lambda w. \lambda D \subseteq S_{\text{tall}}. \lambda x. \text{Height}_w(x) \in D$
 b. $[[\text{short}]] = \lambda w. \lambda D \subseteq S_{\text{short}}. \lambda x. \text{Height}_w(x) \in D$

To derive the truth conditions of (42) we consider the same scenario we used for the analysis of its counterpart with 'tall'. Crucially, we do not change our assumptions about the direction of the likelihood scale. The reader can verify that (42) is predicted true in this scenario iff John's actual height exceeds the minimal required height on the scale of shortness, i.e. iff John is shorter than 1,70 m, which is a welcome result.

3.3 Free Choice ‘Any’

In this section I will argue that existential quantifiers triggering the quasi universal interpretation, see (3), do not present a problem for an analysis that disallows the non-local scope of the Pi operator. To give a preview, the analysis I am going to develop is based on strengthening of the embedded clause by a free choice implicature.

Let us consider a comparative sentence with an embedded disjunction.

(44) Peter is taller than John or Bill.

On one of its readings the sentence conveys the meaning that Peter’s height exceeds the height of the tallest person out of John and Bill. We have seen in section 2 that this reading is derivable in the scope as well as in the selection approach. In the former case, Pi is scoped above the disjunction, which mimics von Stechow’s (1984) analysis that keeps the disjunction in the scope of the comparative operator. In the latter case, the specially defined *max* operator picks the height of the tallest person as the item of comparison. I propose an alternative way to derive the more-than-maximum reading of (44). Let us consider the analysis of the embedded clause of (44) within the interval-based approach I used above:

(45) $\lambda D. \text{Height}_{@}(j) \in D \wedge \text{Height}_{@}(b) \in D$
 = the set of intervals D, s.t. D contains John’s height or Bill’s height.

Interestingly, (46) creates the kind of environment that has been argued to trigger the free choice effect, namely disjunction under an existential quantifier. To see this, consider the parallel between (46a) equivalent to (45) and (46b) that represents the sentence ‘You may eat the cake or the ice-cream’ implying among other things that you are free to choose between the two options.

(46) a. $\lambda D. \exists d \in D: \text{Height}_{@}(j) = d \vee \text{Height}_{@}(b) = d$
 b. $\exists w_2 \in \text{Acc}_w : \text{you eat the cake in } w_2 \vee \text{you eat an ice-cream in } w_2$

I suggest that the mechanism that is responsible for the free choice effect of (46b) applies in the comparative case as well and results in the universal interpretation. To demonstrate this, I follow the proposal in Fox (2007) that derives the free choice implicature by embedding (46b) under two *exh* operators. I assume Fox’s entry for *exh* in (47) and the standard definition of the set of alternatives for disjunction, see (48).

(47) $[[\text{exh}]]^w(A_{(\text{st})t})(p_{\text{st}}) = \lambda w. p(w) \ \& \ \forall q \in I\text{-E}(p,A): \neg q(w)$, where $I\text{-E}(p,A) = \bigcap \{A_2 \subseteq A \mid A_2 \text{ is a maximal set in } A, \text{ s.t. } \{\neg r: r \in A_2\} \cup \{p\} \text{ is consistent}\}$

(48) $A = \{\lambda w. \exists d \in D: \text{Height}_w(j) = d \vee \text{Height}_w(b) = d;$
 $\lambda w. \exists d \in D: \text{Height}_w(j) = d \wedge \text{Height}_w(b) = d;$
 $\lambda w. \exists d \in D: \text{Height}_w(j) = d; \lambda w. \exists d \in D: \text{Height}_w(b) = d\}$

One can verify that embedding the statement in (46) under the *exh* restricted by the *A* in (48) results in the following extension of the comparative clause:

- (49) $\lambda D. \exists d \in D: \text{Height}_{@}(j) = d \vee \text{Height}_{@}(b) = d \ \&$
 $\neg \exists d \in D: \text{Height}_{@}(j) = d \wedge \text{Height}_{@}(b) = d$
 = the set of intervals *D*, s.t. *D* contains John's height or Bill's height but does not contain a degree corresponding to the height of both.

Following Fox, I pass the statement in (49) to the second *exh* restricted by the set of exhausted alternatives in (50). (51) is the resulting meaning of the 'than' clause. The last exhaustification step adds the requirement that both the height of Bill and the height of John be included in *D*. This derives the superlative interpretation of (44). It can be shown that this analysis makes the same predictions for (3a-b).

- (50) $A^{\text{exh}} = \{[[\text{exh}]]^W(A)(p): p \in A\} =$
 $\{\lambda w. \exists d \in D: \text{Height}_w(j) = d \vee \text{Height}_w(b) = d$
 $\ \& \ \neg \exists d \in D: \text{Height}_w(j) = d \wedge \text{Height}_w(b) = d;$
 $\lambda w. \exists d \in D: \text{Height}_w(j) = d \ \& \ \neg \exists d \in D: \text{Height}_w(b) = d;$
 $\lambda w. \neg \exists d \in D: \text{Height}_w(j) = d \ \& \ \exists d \in D: \text{Height}_w(b) = d\}$

- (51) $\lambda D. \exists d \in D: \text{Height}_{@}(j) = d \vee \text{Height}_{@}(b) = d \ \&$
 $\neg \exists d \in D: \text{Height}_{@}(j) = d \wedge \text{Height}_{@}(b) = d \ \&$
 $\exists d \in D: \text{Height}_{@}(j) = d \ \& \ \exists d \in D: \text{Height}_{@}(b) = d$

The results obtained in this section allow Heim's scope analysis to do without the long movement of Pi in all cases of embedded existential quantifiers. The selection analysis can now use a simpler definition of coercion operators that makes them pick either an interval or a point from a set of such, e.g. (31c). I leave out the discussion of 'some' indefinites and epistemic modals under the selection approach for reasons of space. Their treatment would presumably require some mechanism that generates wide scope or generic interpretations in non-comparative contexts as well.

4 Conclusion

In this paper I attempted to show that the availability of different interpretations in the comparatives with embedded quantifiers is not a matter of the relative scope of the involved operators. I contrasted 'should'-like modals, universal quantifiers over individuals, any-terms and non-epistemic possibility modals with a relatively small group of 'have to'-like modals. I argued that the behaviour of the former does not support the flexibility of the scope approach – these expressions always result in the more-than-maximum reading. The latter class can indeed lead to different interpretations. To account for this pattern I proposed a degree-based semantics for necessity modals like 'have to' and demonstrated that the observed readings under the comparative is a consequence of the interplay be-

tween the likelihood ordering introduced by the modal and the scale of the adjective. I further argued that the quasi universal interpretation of some existential quantifiers in the comparative context is due to the free choice implicature that strengthens the meaning of the embedded clause. I hope to have shown that the existing approaches to the analysis of comparatives do not have to resort to comparative-specific scope mechanisms.

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