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Seuren/Rullmann ambiguities as plural comparisons*

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Abstract This paper reexamines ambiguous comparatives of a kind made famous in Rullmann's (1995) dissertation, e.g. *The helicopter was flying less high than a plane can fly*. There is some disagreement in the semantic literature regarding whether the ambiguity is limited to *less* or also shows up in *more*-comparatives. Accordingly, the analyses suggested differ substantially, ranging from structural to pragmatic. My primary goal is to provide a more solid empirical basis for building semantic theories of the phenomenon. I report the results from a series of questionnaire studies that show (i) that the difference between *more*- and *less*-comparatives is not clear cut, and (ii) that we need to make more fine-grained distinctions among *less*-comparatives. I propose an analysis in terms of plural predication that captures the major effects found in the studies, and I begin to approach the more subtle data points.

Keywords: comparatives; plurals; questionnaire study

1 Introduction

1.1 The issue

The topic of this paper are data like (1) (from Heim 2007; the observation goes back to Seuren 1979 and has become prominent in the semantics literature since Rullmann 1995). The sentence can be understood in two different ways in the context given, permitting both reading (2a) (an apparent comparison to a maximum) and (2b) (a comparison to a minimum). I refer to such data as Lucinda examples.

(1) (This highway has a required minimum speed of 35mph and a speed limit of 50mph.)
Lucinda was driving less fast than allowed.

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(2) a. Lu was driving below max(λd.Lu is allowed to drive d-fast) = Speed(@)(Lu)<50mph MAX
"Lucinda was driving below the speed limit."
b. Lu was driving below min(λd.Lu is allowed to drive d-fast) = Speed(@)(Lu)<35mph MIN
"Lucinda was driving below the minimum speed."

It is surprising that the comparative is ambiguous, because normally comparatives unequivocally make a comparison to the maximal element described by the *than*-clause (von Stechow 1984). Accordingly, analyses of (1) have not proposed a choice between comparing to the maximum vs. the minimum element in the *than*-clause. The proposals made are more abstract. After looking at a prominent recent representative (Heim 2007) in the next subsection, I formulate research questions concerning the data and analysis. Importantly, I think that the empirical foundation for our semantic analyses is less clear than would be desirable. I present in section 2 two studies that aim at providing us with a more solid empirical basis. The major result from these studies is that the data exemplified by (1) are not a clear case of ambiguity at all. Many examples are not perceived to have two readings. Section 3 develops an analysis that captures the prominence of one of the two conceivable readings. Section 4 addresses some open questions and concludes the paper.

1.2 Existing analyses

Analyses of the ambiguity in (1) have been proposed (to my knowledge) by Rullmann (1995), Meier (2002), Heim (2007), Büring (2007) and Krasikova (to appear). I present below Heim's analysis, which represents an approach that locates the source of the ambiguity at the syntax/semantics interface and analyses it as a structural ambiguity. Heim sees the cause of the ambiguity in the presence of *less*. *Less* is the comparative form of *little*, so *less fast* is the combination of *fast* + *little* + *-er*. The three ingredients can be combined in different ways. For the *than*-clause, in particular, Heim suggests the two Logical Forms in (3a) and (3b). They differ in terms of the relative scopes of *little* and *allowed*. *Little* contributes negation, therefore (3a) describes degrees that Lucinda is not allowed to reach (degrees above the speed limit), while (3b) describes degrees that Lucinda is allowed to not reach (degrees above the minimum speed required).

(3) a. than [little [allowed [Lu drive_fast]]] [Heim 2007]
than [Lu not allowed to drive fast] = degrees above the speed limit
b. than [allowed [little [Lu drive_fast]]] [Heim 2007]
than [Lu allowed to drive slowly] = degrees above the minimum speed
c. *less fast* = *-er* + *little* + *fast*; *little* = *not*

Without going into further details about the composition, we will imagine that (3a) ends up making a comparison to 50mph, the maximum, while (3b) makes a comparison to 35mph, the minimum. The ambiguity is analyzed as a scope ambiguity in the *than*-clause. At LF, the ellipsis in the *than*-clause can be resolved in two different ways. Other researchers have disagreed with the idea that structure is responsible for the two interpretations of (1). Meier (2002) for example suggests that two interpretations are available in *more*-comparatives as well as in *less*-comparatives. Therefore the source of the two readings cannot lie in the complexity introduced by *less*. She develops an analysis based on the contribution of the modal instead. Her example is given in (4). The judgement that a more-than-minimum interpretation is possible in (4) is, however, controversial.

(4) a. (This highway has a required minimum speed of 35mph and a speed limit of 50mph. Chuck is transporting eggs. In order not to break too many, he needs to drive as slowly as possible. But he doesn't want to get a ticket.) Chuck was driving faster than allowed. [Meier 2002]

b. Chuck was driving above min(λd.Chuck is allowed to drive d-fast) = Speed(@)(Chuck)>35mph MIN

There is a theoretical question attached to the structural aspect of Heim's analysis as well. Note that *little* in (3) has the meaning of negation. It is well-known that overt regular negation in the environment it is placed in in (3a) is not acceptable. This is the negative island effect in comparatives (von Stechow 1984, Rullmann 1995). The question is, then, why the structure in (3a) is acceptable while the one in (5b) is not acceptable. We can see this as a different aspect of the question about the role of *less* in this type of data.

(5) a. *Lucinda was driving faster than no boy was.

b. than [not [a boy was driving _ fast]]

1.3 Research questions

The empirical situation sketched above merits a more systematic empirical investigation than has been conducted so far. I formulate below two research questions that have guided the empirical studies described in the next section.

RQ1.1: Does the ambiguity depend on the presence of LESS or does it exist in ordinary MORE comparatives as well?

RQ1.2: Does the ambiguity depend on a *than*-clause (with a modal verb and potential for ambiguous ellipsis) as opposed to plural degree denoting DP?

The first research question emerges directly from Meier's data and proposal. The second question targets the structural aspect of Heim's analysis. By a degree denoting DP, I mean a *than*-phrase that directly refers to a degree, such as (6a) (this may be a simplification; I trust that it is harmless for the purpose at hand). In (6b), we similarly have a degree denoting DP as our *than*-phrase, only this time it is plural. Imagine (6b) in the same context as the original Lucinda example. The permissible speeds refers to [35mph, 50mph]. The second research question asks whether the sentence allows the same two readings argued to be present in (1). The pertinent difference between (1) and (6b) is that in (6b), there is not plausibly ellipsis involved. Hence, there is no way to introduce *little* = negation and no ambiguity at LF. If (6b) is judged ambiguous, the source of the two readings must be something else.

(6) a. Lu was driving less fast than *the speed limit.* (degree DP)
b. Lu was driving less fast than *the permissible speeds.* (plural DegDP)

2 Studies I and II

I describe below two questionnaire studies conducted on Lucinda-type examples in German, the second being a small follow-up study to the first.[1] We begin with Study I.

2.1 Method

Study I tested comparative sentences following the pattern in (7). The material contained MORE-comparatives as well as LESS-comparatives, and *than*-clauses as well as plural degree denoting DPs. Each example was tested for a maximum as well as a minimum interpretation, leading to a total of 8 conditions tested, according to a $2 * 2 * 2$ factorial design. In order to test the availability of a particular interpretation, the comparative was put into a short text. The text unambiguously fixed the interpretation, in the sense that it was only consistent under one interpretation. For example, the text in (8), embedding a LESS-comparative with a *than*-clause, is only consistent under the less-than-maximum interpretation. So (8) is a test item for the condition LESS;CP;MAX.

(7) Katrin drove {faster/less fast} than allowed/
than the permissible speeds.
MORE/LESS; CP/DP; MAX/MIN – 8 conditions

1 I am very grateful to Polina Berezovskaya, Michaela Meder and Konstantin Sachs for running the questionnaire studies reported in this paper, as well as for their comments and suggestions.

(8) On the highway between Schusselheim and Sonderlingen there is a required minimum speed of 50kmh and a speed limit of 80 kmh. Yesterday, Katrin was in a hurry because she had an important appointment. Still she observed the traffic rules. She drove *less fast than allowed*. So she couldn't get a ticket.
LESS; CP; MAX

Participants were asked for a judgement of consistency. If they judged a given text as consistent, it was inferred that the relevant interpretation was available. There were five series of example types like (7), (8), making a total of $5 \times 8 = 40$ experimental texts. Translations of the other 4 series are given below. For further illustration, (13) gives another example translation of an embedding text.

(9) The board is {wider/less wide} than the wall can be deep/
than the possible depths of the wall.

(10) We were {more/fewer} people than can form a soccer team/
than the possible numbers of players.

(11) M. got a {longer/less long} jail sentence than the law permits/
than the permitted sentences.

(12) The sound produced by this whistle is {higher/less high}
than audible for humans
than the audible frequencies.

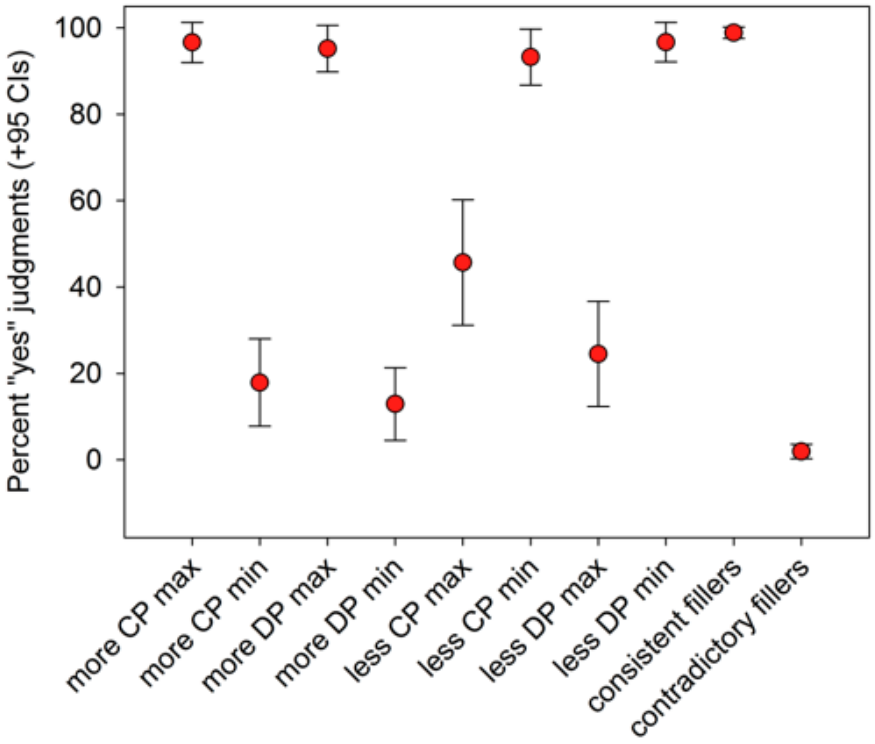
(13) At the annual charity soccer event, you can join with teams of 5, 7 or 11 players. Last year our Nordic Walking group wanted to participate. But it turned out that hardly anybody wanted to play. So we were fewer people than can form a soccer team, and we couldn't participate.
LESS; CP; MIN

In addition to the 40 test items, the material contained 10 filler texts (5 consistent, 5 contradictory). Each participant gave a consistency judgement plus verbal explanation for 10 test items and 10 filler texts as distractors. Each participant was only asked about two items from a given series (one MORE- and one LESS-comparative), to avoid too much repetition. A total of 52 participants was consulted. For each test item, 13 judgements were collected, 65 ($= 13 \times 5$) judgements per condition. The task was explained to the participants with the help of several practice items. If a participant made more than 2 mistakes with the filler items, that participant was excluded (this occurred only once). Participants were asked for a spontaneous response of the form "this text is consistent"/"this text is contradictory". They were then asked to explain their answer. If their explanation revealed that the judgement was based on a misunderstanding or a mistake, the judgement was not considered

in the quantitative evaluation (this concerned 8% of the judgements given). The participants were all monolingual adult native speakers of German.

2.2 Results

The graph below summarizes the judgements collected in study I.[2]



There are four interpretations that come close to the judgements collected for the consistent filler items, i.e. close to an acceptance rate of 100%. In MORE-comparatives, those are the MAX-interpretations with both CPs and DPs. In LESS-comparatives, those are the MIN-interpretations with both CPs and DPs. The other four interpretations received much lower acceptability ratings. In MORE-comparatives, the MIN-interpretation got 18% in the CP condition and 13% in the DP condition. With LESS-comparatives, the MAX-interpretation got 47% in the CP condition and 23% in the DP condition.

The data were analysed using a Logit Mixed Effects model including MIN vs. MAX, LESS vs. MORE and CP vs. DP as fixed effects and participants and items as

2 I am greatly indebted to Oliver Bott for the statistical evaluation of the data, and for his comments and suggestions on the empirical side of this project in general.

random effects (as suggested by Jaeger (2008)). Statistical analysis revealed that there were two main effects: LESS-comparatives were judged better overall than MORE-comparatives and MAX-interpretations were judged better overall than MIN-interpretations. More importantly, the analysis revealed that the interaction between MORE vs. LESS and MIN vs. MAX is significant (estimate = 8.03; z-value = 7.60; $p < .01$), in that the MAX-interpretation is good in MORE-comparatives while the MIN-interpretation is not good, and the other way around in LESS-comparatives. An additional effect was found regarding the LESS; CP; MAX condition: as the graph suggests, this interpretation was judged better than the other three dispreferred readings. In particular, in a Logit Mixed Effect model analysing only the LESS; CP; MAX and the LESS; DP; MAX condition, the difference turned out to be significant (estimate = -1.13; z = -2.40; $p < .05$). All four dispreferred interpretations were judged significantly better than the contradictory filler items ($p < .01$ by Fisher Exact Test).

The verbal responses elicited from the participants in study I revealed some problems with certain test items. For example, the subcomparative structure in (9) seemed in retrospect to be unnecessarily complex. The soccer example was also suboptimal because the participants had a strong independent conviction that 11 is the right number of players for soccer, which the context specified in the study did not always successfully override (this effect is responsible for a substantial portion of the judgements not considered, see above). Since the differences between the four dispreferred readings are relatively subtle, a small follow-up study was conducted testing just those four interpretations, fixing some of the problems with the material that Study I revealed. I give in (14)-(17) translations of the new comparative structures tested. The procedure was identical to the one used in Study I. A total of 21 participants was consulted. In (18) are the percentages of acceptance for the four dispreferred readings collected in Study II. We see that the pattern among the dispreferred interpretations from Study I is essentially repeated.

(14) They were {more/fewer} people than can play "Ambiquest"/
than the possible numbers of players.

(15) The door is {wider/less wide} than the hallway can be wide/
than the possible widths of the hallway.

(16) Beate's talk was {longer/less long} than allowed/
than the permitted lengths.

(17) The sound produced by this whistle is {higher/less high} than audible for humans/
than the audible frequencies.

(18) MORE; CP; MIN: 4% LESS; CP; MAX: 33%
MORE; DP; MIN: 0% LESS; DP; MAX: 12%

2.3 Discussion

The results from studies I and II are unexpected in that they fail to establish Lucinda examples as clearly ambiguous. The original pattern exemplified by (1), a LESS-comparative with a *than*-clause, gets less than 50% acceptance on the MAX interpretation. That is, despite the fact that the context is constructed so as to make that interpretation maximally prominent, fewer than half of the examples were accepted. Research questions RQ1.1 and RQ1.2 are thus revealed to be presupposition failures. It is at this point unclear that Lucinda examples are in fact ambiguous. The major effect revealed by studies I and II is that MORE-comparatives prefer a MAX-interpretation while LESS-comparatives prefer a MIN-interpretation. In addition, the studies show the more subtle effects (19A-C) below.

(19) A. LESS is more ambiguous than MORE

B. CP is more ambiguous than DP

C. Much depends on choice of example.

That is, the dispreferred reading in LESS-comparatives seems a little easier to get than in MORE-comparatives, and in CP-comparatives than in DP-comparatives. To illustrate finding (C), consider the translated test item below:

(20) The Osterwelle company produces various kinds of whistles, including the new dog whistle 'GuidoExpress'. Dogs can perceive very high frequencies. Most dog whistles make use of this fact and work with frequencies that humans cannot perceive. However, the sound that this whistle produces is *less high than a human can hear*. The whistle is not as useful as one might hope, because we can hear it. (0/10 acceptance; vs. 6/12 for (8))

I conclude from the results of studies I and II that we want an analysis that derives the four clearly available interpretations for these comparatives, and leaves some leeway to coerce them into a second, dispreferred interpretation. Note that the empirical results do not support a theory that analyses LESS-comparatives are ambiguous while MORE-comparatives are not, or that *than*-clauses are ambiguous while *than*-DegPs are not. In section 3, I propose a new analysis, including an explanation of finding (B). Open questions regarding (A) and (C) will be discussed afterwards.

3 Analysis

Before we proceed with the semantic analysis of the Lucinda examples themselves, I introduce the background assumptions I make about the interpretation of comparatives in section 3.1. Section 3.2 provides a derivation of the four preferred

interpretations of the structures investigated above, and section 3.3 turns to the four dispreferred interpretations.

3.1 Background assumption: maximal informativity (m-inf)

I assume essentially a classical analysis of comparatives, and of *than*-clauses in particular (von Stechow 1984, Heim 2001; a recent exposition can be found in Beck to appear). An example is provided in (21) (imagine that we are talking about the men's 4×100m relay race at the Olympic Games).

(21) a. Jamaica has a faster athlete than the US do.
b. [-er [$_{<d>}$ than **max** [2[the US do ~~have a t_2 fast athlete~~]]]]
c. $[\![-er]\!] = \lambda d_d.\lambda d'_d.d' > d$
d. $[\![-er]\!](\max(\lambda d.$the US have a d-fast athlete$)) =$
$\lambda d'_d.d' >\max(\lambda d.$the US have a d-fast athlete$)$
degrees exceeding the maximal degree d such that the US have a d-fast athlete

(22) $\max(D) = \iota d.d \in D \;\&\; \forall d' \in D : d > d'$

Note that I assume that the comparative operator requires as its first argument a type $< d >$ category. When we have a *than*-clause, this is derived by selecting an element from the denotation of the *than*-clause. A type $< d >$ argument is provided directly in degree denoting *than*-phrases, (23). I make one change to this analysis: instead of choosing from the set of degrees denoted by the *than*-clause the maximal element, as is standardly done and indicated in (21), I propose that the maximally informative element is chosen. Maximal informativity is defined in (24). The definition as well as the general idea follows Fox & Hackl (2007).

(23) a. Lucinda ran faster than the world record.
b. $[\![$the world record$]\!]$ = 10.49s/100m
c. $[\![-er]\!](10.49\text{s}/100\text{m}) = \lambda$d.d > 10.49s/100m

(24) $\text{m\_inf}(w)(p_{<s,<d,t>>}) =$
$\lambda d.p(w)(d) \wedge \neg\exists d'[p(w)(d') \wedge d \neq d' \wedge [p(w)(d') \rightarrow p(w)(d)]]$

the maximally informative degrees in a description of degrees are those whose presence in the description could not be inferred from the presence of any other element in the description.

Maximal informativity usually returns a singleton. Applied to our example in (25), we get the same result as under a classical analysis.

(25) a. Jamaica has a faster athlete than the US do.
b. [-er [$_{<d>}$ than **the m-inf** [2[the US do ~~have a t_2 fast athlete~~]]]]

(25′) a. Suppose that the fastest US athlete runs 100m in 9.5 s.
b. $[\![-er]\!]$ (the m-inf (λd.the US have a d-fast athlete)) = $[\lambda d_d.\lambda d'_d.d' > d](9.5s/100m) = [\lambda d'_d.d' > 9.5s/100m]$
c. degrees exceeding the maximally informative degree d such that the US have a d-fast athlete

(26) The US have an athlete who can run 100m in 9.5s $\Longrightarrow$
The US have an athlete who can run 100m in 9.6s etc., but not vice versa

The predicate in (25) is what Beck & Rullmann (1999) call a downward scalar predicate. Such predicates permit valid inferences from larger degrees to smaller degrees, as illustrated for the example. Hence the maximally informative degree is the maximal degree. Not all degree predicates are downward scalar. (27) gives an example of an upward scalar degree predicate. We see that the most informative degree described by this *than*-clause is not the maximum, but the minimum. Intuitively, the comparison made in (27) is with this minimum. This motivates the replacement of maximality by maximal informativity.

(27) a. I have more flour than is sufficient to bake this cake.
b. I have more flour than the minimal amount of flour that suffices to bake this cake.
c. #I have more flour than the maximal amount of flour that suffices to bake this cake.

(27′) a. I have more flour than is sufficient (to bake this cake).
b. [-er [$_{<d>}$ than **the m-inf**[2 [t_2 much flour is sufficient]]]]

(28) a. Suppose that you can bake this cake if you have at least 500g of flour.
b. $[\![-er]\!]$ (the m-inf($\lambda d.d$-much flour is sufficient)) = $[\lambda d_d.\lambda d'_d.d' > d](500g) = [\lambda d'_d.d' > 500g]$
c. degrees exceeding the minimum amount sufficient to bake this cake
d. To bake this cake it is sufficient have 500g of flour $\Longrightarrow$ To bake this cake it is sufficient to have 600g of flour

3.2 Non-scalar predicates and pluralities of degrees

Beck & Rullmann (1999) identify a third kind of degree predicate, namely the ones that permit neither upward nor downward inferences. Maximal informativity when

applied to such a non-scalar predicate does not return a unique degree. Take our soccer example from above:

(29) Suppose that the numbers of people that can form a soccer team are 5, 7, 11.
m-inf(λd. d-many people can form a soccer team) = {5,7,11}

It is, I suggest, the crucial property of Lucinda examples that they involve non-scalar degree predicates. Therefore maximal informativity returns not a singular degree, but a set of degrees. In example (1), that is the interval between 35mph and 50mph. (31) illustrates that the degree predicate in the *than*-clause is intuitively non-scalar. We will come back to why that is the case in section 4. Note here that it is a defining property of Lucinda examples that the *than*-clause describes a particular span on the degree scale. This is how a MIN and a MAX interpretation are intuitively possible at all, as Rullmann (1995) observes.

(30) a. Lu was driving less fast [than [1[was allowed [~~Lu drive t_1 fast~~]]]
b. Suppose the minimum speed is 35mph and the speed limit 50mph.
[λd. it was allowed that Lu drive d-fast] = [35mph-50mph]
c. m-inf(*than*-clause) = [35mph-50mph]

(31) it was allowed that Lu drive 40mph $\not\Rightarrow$ it was allowed that Lu drive 41mph
it was allowed that Lu drive 40mph $\not\Rightarrow$ it was allowed that Lu drive 39mph

The question is how a *than*-clause with such a plural denotation is integrated into the further composition. We begin with the step from the compositionally simplest example (32) to a plural counterpart (33). I propose that the comparative operator does not combine directly with a plurality of degrees. Instead we use plural predication parallel to the distributive predication in (34). In (34) I employ Link's (1983) star operator. A preliminary definition is given in (35). Hence the LF in (34b) is assigned the truth conditions in (34c).

(32) a. Lucinda drove faster than the speed limit.
b. $[\![$the speed limit$]\!]$ = 50mph
c. $[\![-er]\!]$(50mph) = λd.d > 50mph

(33) a. Lucinda drove faster than the permissible speeds.
b. $[\![$the permissible speeds$]\!]$ = [35mph-50mph]

(34) a. Lucinda graded these papers.
b. [[these papers] [*[1[Lucinda graded t_1]]]]
c. $\forall x \in [\![$these papers$]\!]$: Lucinda graded x

(35) $[*P](X) = 1$ iff $\forall x \in X : P(x) = 1$

We proceed in a parallel way in (33), as illustrated below. The resulting interpretation is that Lucinda drove faster than all the permissible speeds. Hence she drove faster

than the speed limit. This looks like a comparison with a maximum, but note that it is simply the universal quantification brought about by distributive predication.

(36) a. Lucinda drove faster than the permissible speeds.
b. [[the permissible speeds] [*[1[[-er t_1] [2[Lu drove t_2 fast]]]]]]
c. $\forall s \in [\![$the permissible speeds$]\!]$: Lu drove faster than s MAX!

Let us turn to the corresponding LESS-comparative, given in (37). Assuming that *less* is simply the inverse of *-er* leads to the derivation in (37b), (37c). The same distributive predication this time looks like a comparison to a minimum.

(37) a. Lucinda drove less fast than the permissible speeds.
b. [[the permissible speeds] [*[1[[less t_1] [2[Lu drove t_2 fast]]]]]]
c. $\forall s \in [\![$the permissible speeds$]\!]$: Lu drove less fast than s MIN!

(38) $[\![\text{less}]\!] = \lambda d_d.\lambda d'_d.d > d'$

We now have all the ingredients required for the analysis of the original Lucinda structure. The operator m-inf derives for the *than*-clause a denotation that is the same (in the context provided) as that of the *than*-phrase in the previous example. Thus we derive the same interpretation, an apparent comparison to the minimum speed.

(39) a. Lucinda was driving less fast than was allowed.
b. [m-inf [than was allowed]] [*[1[[less t_1] [2[Lu drove t_2 fast]]]]]
c. $\lambda s \in$ m-inf($[\![$than was allowed$]\!]$): Lu drove less fast than s MIN!

The corresponding MORE-comparative is of course interpreted in a parallel way to (33), deriving the more-than-maximum reading. This semantics thus derives the four clearly attested interpretations as the semantic readings of the Rullmann sentences. What about the four dispreferred interpretations?

3.3 Weaker readings: covers as contextual restrictions

Notice that the dispreferred readings of our data are weaker than the ones derived above. That is, if Lucinda drove less fast than all permissible speeds – less-than-MIN, then she also drove less fast than the speed limit – less-than-MAX. And vice versa for MORE-comparatives. Therefore, given the analysis above in terms of plural predication, we should ask if there is a place in the analysis of plural predication that could derive weaker readings. It turns out that there is – namely the use that Brisson (1998) put the cover variables from Schwarzschild 1996 to. Consider (40a). Our analysis of the distributive reading of (40a) at the moment derives the truth conditions represented in (40b). This, Brisson observes, is not quite right. (40a) contrasts with

(41) since in (41), it must indeed be the case that absolutely all children are involved. In (40a) on the other hand, we would be prepared to accept the sentence as true even if some child or other was not in fact part of the raft building. That is, we tolerate exceptions in (40a) but not (41).

(40) a. The children built a raft.
b. $\forall x[x \in [\![\text{the children}]\!] \rightarrow x \text{ built a raft}]$

(41) All the children built a raft

To capture this, Brisson makes use of the contextual constraint on distributive predication that Schwarzschild (1996) introduces. Plural predication is sensitive to covers. A contextually given cover provides the salient subgroups in the context. The truth conditions of (40a) on the distributive reading are more accurately represented in (42a). Now suppose that there is a child which is not an element of the cover. This child will not be required to build a raft now. The additional restriction leads to weaker truth conditions. We revise the definition of the * operator as in (43) and can derive (42a) with the help of the LF in (42b).

(42) a. $\forall x[x \in [\![\text{the children}]\!] \ \& \ x \in \text{Cov} \rightarrow x \text{ built a raft}]$
(where Cov contains the contextually relevant subgroups)
b. [[the children] [* Cov[1[t_1 built a raft]]]]

(43) $[*\text{Cov } P](X)=1 \text{ iff } \forall x[x \in X \ \& \ x \in \text{Cov} \rightarrow P(x) = 1]$

Let us implement this improvement also in our analysis of the comparative data. A representation of the truth conditions of example (1) now looks as in (44a). What this means depends on the value of the cover variable. If the cover contains all relevant speeds, we derive the same truth conditions as before. Suppose however that the cover does not contain all permissible speeds. We then get a weaker reading. The extreme case would be one in which the cover contains, of the permissible speeds, only the speed limit. In this case, we would get an apparent comparison with the maximum.

(44) a. $\forall s[s \in \text{m-inf}([\![\text{than allowed}]\!]) \ \& \ s \in \text{Cov} \rightarrow \text{Lu drove less fast than } s]$
b. If $[\![\text{the permissible speeds}]\!] \subseteq$ Cov, MIN results.
c. If Cov $\cap$ $[\![\text{the perm. speeds}]\!]$ = {the speed limit}, MAX results.

While it is generally accepted that the cover need not contain all individuals in the domain, one may wonder how plausible it is to limit the cover to such an extreme extent. I conjecture that such a move is not completely excluded – perhaps (45) on the team credit reading from Gillon 1984, is an example – but neither is it a normal value for the cover variable. Such a value assignment should be dispreferred and require heavy contextual pressure.

(45) The soldiers of F-troop spotted the Indians.

Looking back at the data considered above, for example Chuck, the egg truck driver, this is precisely what happens. To the extent that the dispreferred reading is possible, it arises under severe contextual pressure which makes just one particular speed relevant. Furthermore, it should be easier to get such a reading with CPs than with DPs. This is because the latter are plural marked; we would first explicitly talk about a plurality ("the permissible speeds") and then assume a value for the cover that in fact identifies exactly one relevant speed. This seems odd. In case of a CP, on the other hand ("than allowed"), no such plural marking occurs and contextual reduction does not conflict with overt material.

To sum up, the semantics suggested derives the four readings that the studies from section 2 showed to be there. The crucial property of Lucinda examples that this analysis relies on is that they involve non-scalar degree predicates as the denotations of the *than*-clauses. The m-inf operator applied to a non-scalar degree predicate yields a plurality of degrees. Thus plural predication is required to combine the *than*-clause with the comparative operator. This derives more-than-maximum and less-than-minimum readings. The analysis leaves some room through plural predication and contextual restriction of the domain of quantification for weaker interpretations, in the extreme case the four dispreferred interpretations. Since they come about as dispreferred values of a free variable, the dispreferred status of these interpretations is predicted. The analysis agrees well in this respect with the general finding from the two studies. It also captures finding (B). However, it has nothing to say about findings (A) and (C): MORE- and LESS-comparatives should behave in a parallel way, and variation between examples is not yet accounted for. Section 4 includes a discussion of finding (C).

4 Further considerations

4.1 Not emerging from the quantitative data: ambiguity intuitions

The analysis in the preceding section seems a good overall fit for the data collected in the empirical studies. However, there is an interesting mismatch between quantitative data and intuitions: I have a pretty clear intuition about several examples that they are indeed ambiguous, and obviously, so do other people. Some of our participants also expressed this intuition. I provide below translations of some of the comments collected (translations of the texts commented on are also included for

better understanding).

(46) Beate is getting a PhD in a well-known Tübingen graduate program. Her topic is 'Structural Ambiguity in Elisabeth Gaskell's Work'. Next week, her program has its annual doctoral guidance day. All graduate students have to present their thesis work. Each talk has to be between 10 and 15 minutes long. Beate is very well prepared, but she is concerned that she might take too long. This morning, she has given a practice talk to her roommate. She has taken exactly 14 minutes. *Beate's talk is less long than allowed*. It can stay like this.

Participant's comment on the crucial sentence: This can refer to the 10 minutes or to the 15 minutes. If it refers to the 10 minutes, it is not consistent. And with 15 it is consistent. I would assume 15, then it would be consistent.

(47) On the highway between Schusselheim and Sonderlingen there is a required minimum speed of 50kmh and a speed limit of 80 kmh. Yesterday, Sarah had a box of glasses in her trunk and wanted to drive very carefully. She drove *less fast than allowed*. So she got a ticket.

Participant [judged the text contradictory]
Experimenter's question: How fast did Sarah drive?

Participant: Sarah drove between 50 and 80. But one could also take it to mean that she drove less fast than the minimum speed and got a ticket for that. In that case, she would have driven below 50. Then the text would be consistent.

Thus, for some of the examples, there does seem to be an intuition that they permit two interpretations. I would like to examine this intuition in connection with the observation that there was considerable variation between examples – observation (C) above. The connection is that the unconvincing overall results for the ambiguity hypothesis might arise from the effect that while some examples do permit a MAX- and a MIN-interpretation, many do not – that is, that only a proper subset of the Lucinda structures are in fact ambiguous. For this purpose, I report below selected results from a third questionnaire study that was conducted to follow up on this issue as well as on a particular prediction of the analysis from section 3. (I report selected results only because Study III, groping about in the dark for promising factors to distinguish example types, included some data that I consider unenlightening.)
Study III asks the following research questions:

RQ2.1: Does context play the expected role for the availability of the dispreferred

reading? I.e. in a context that provides Min and Max, is it possible to make one more salient and thereby facilitate a dispreferred reading?

RQ2.2: Can we pin down finding (C), that there are significant differences between examples? Does the (un-) availability of dispreferred readings depend on the nature of the scale?

Material and procedure were parallel to the two earlier studies. A total of 30 participants was consulted. The factors varied included context and scale nature. To illustrate the first, consider the triple of test items given below.

(48) Irene is renovating her garden shed. She wants to replace a rotting window sill. In her basement she discovers a good board. Unfortunately she forgot to measure the old board. But she knows that it has to be between 15cm and 25cm wide.

(a) She is afraid that the new board might be too wide.
When she measures it, she finds that it is 23cm wide. (MAX prominent)
(b) She hopes that the new board will fit. (neutral)
(c) She is afraid that the new board might be too narrow.
When she measures it, she finds that it is 17cm wide. (MIN prominent)

Since the new board is *less wide than the old one can be*,
she may be able to use it.

The plural predication analysis formulated above predicts that the less-than-maximum interpretation should be better when the maximum is given contextual prominence. This expectation is confirmed in Study III. Study III contained three triples. Each participant was consulted about one element of each triple. Besides the one whose translation is given above, it contained similar triples for examples (8) and (46). The results for acceptance of LESS; CP; MAX are given below. Contextual prominence

plays the role we would expect under the plural predication analysis.

	MAX prom.	neutral	∅ (neutral, MIN prom)
Speed:	50%	20%	30%
Width:	100%	70%	65%
Length of time:	70%	30%	50%

Study III also contained a pair of minimally different examples that received strikingly different acceptability ratings. Both were judged by 30 participants.

(49) a. The helicopter was flying
less high than a plane can fly. (LESS; CP; MAX 87% acc.)
b. The sound that the whistle produces is
less high than a human can hear. (LESS; CP; MAX 37% acc.)

The two *than*-clauses are quite parallel. They contain the same modal (German *kann* 'can'), with a circumstantial modal base both times) and even the same adjective. I conclude from the different acceptability ratings that the content of the sentence, what is talked about, plays a role.

A revised view of the empirical situation after studies I-III is this: the ambiguity is nowhere near as widespread and systematic as we first thought (not even under circumstances that should allow both a MIN and a MAX interpretation). We need to identify a class of examples that works fairly well – let's call them the fairly ambiguous examples – from the rest, which are not easily perceived as ambiguous. Let's call the latter the fairly unambiguous examples. I find the plural predication analysis convincing for the fairly unambiguous examples – i.e. the ones in which the dispreferred reading is really clearly dispreferred. The idea that a free variable needs to assume a value that it would not assume under ordinary circumstances fits well in my opinion with the intuition about the dispreferred reading that well, if you really have to, maybe you can coerce the sentence into that meaning. I think that we are missing an analysis that derives the somewhat dispreferred reading in the fairly ambiguous examples. Plural predication is in my opinion unsuitable because it makes the dispreferred reading too strongly dispreferred. However, at this stage, I concede that this seems to be a matter of personal opinion. The quantitative data show differences between example types, but we don't seem to be in a position to draw definitive conclusions about analysis from these differences. It would be good to increase the informational content of quantitative results, so that an acceptance rate of, say, 37% has implications for semantic theory. That said, I will go with the above described personal intuition.

4.2 A first idea about different example types

In order to try to understand the two types of examples, I will take a closer look at the internal composition of the *than*-clauses they involve. All *than*-clauses involved predicates that were non-scalar in the relevant contexts. But how does the non-scalarity of the predicate arise compositionally? I tentatively suggest that this may differ between the two kinds of examples, and have to do with the nature of the scale associated with the adjective. Considering the two examples with *high* (German *hoch*), in (49a), the scale is altitude. This scale has a natural zero point: intuitively, zero altitude is ground level. In (49b), the scale is frequency. This is not a scale with an intuitive zero point (that would be a tone that is perceived as having no height). Compare Sassoon 2009. This difference may play a role in distinguishing the two examples. I list below those examples from the three studies for which the acceptability rating of the dispreferred LESS; CP; MAX reading is at least 50% (when two values are given, this means the structure was tested repeatedly). They all involve scales with a natural zero point. I conjecture that a zero point scale associated with the adjective is a prerequisite for a fairly ambiguous example.

(50) "fairly ambiguous"examples ($\geq$50% acc. in studies I, II, III):

a.	less high than a plane can fly (87%)	altitude
b.	less wide than the old one can be (100%) less wide than the doorway can be (60%)	width
c.	less long than it is allowed to be (70%; 64%) less long than the law permits (72%)	length of time
d.	less fast than allowed (50%; 50%)	speed

The analysis of adjectives I adopted assumes that the denotations of adjectives are monotonic, in the sense of (51). An example is (52a). If something reaches an altitude of, say, 100m, then it also reaches all altitudes below that. I hypothesize that not all adjectives are monotonic. A scale with a zero point also has a natural direction. Such scales are the denotation domains of monotonic adjectives. Adjectives that relate to non-zero-point scales, however, are not monotonic. I suggest that they have an 'exactly' semantics instead as in example (52b).

(51) $\forall d, d'[\text{Adj}(d)\ \&\ d' < d \rightarrow \text{Adj}(d')]$

(52)

a.	high (altitude):	$\lambda d.\text{Altitude}(x) \geq d$
b.	high (frequency):	$\lambda d.\text{Freq}(x) = d$

One immediate positive consequence of this is that Lucinda structures with non-monotonic adjectives give rise straightforwardly to non-scalar degree predicates. If it is possible for a human to hear a sound with a frequency of, say, 300Hz, nothing

follows about 299Hz or 301Hz. Note that the degree predicate is irrevocably non-scalar, this being grounded in the basic contribution of the adjective. The plural predication analysis is the only way to combine it with the comparative operator. Such adjectives should lead to strongly preferred more-than-maximum and less-than-minimum intuitions, i.e. provide fairly unambiguous examples.

(53) a. than a human can hear_high tones
b. $\lambda d.\exists w \exists x[w\text{Acc@} \ \&\ \text{human}_w(x)\ \&\ \exists y[\text{tone}(y)\ \&\ \text{Freq}_w(y) = d\ \&\ x \text{ hear } y]$

What about possible negative consequences of this move? The strongest argument in favour of monotonic adjective meanings that I am aware of concerns data like (54). The sentence permits a reading according to which 15pp specifies the minimum requirement length of the paper. This is the length that the paper reaches in all worlds compatible with the rules. Suppose that the rules specify that the paper needs to be between 15 and 20pp long. Then there is no unique length that the paper has in all worlds compatible with the requirements. An 'exactly' semantics for the adjective would be unable to derive reading (54b). A monotonic semantics makes the desired predictions. Let us compare the natural zero point adjective *high* with its tone frequency counterpart in this respect. My intuition is that while (55a) can specify a minimum altitude required, it is extremely difficult to read (55b) in such a way. Perhaps this can be seen as an argument for a non-monotonic semantics.

(54) a. The paper has to be exactly 15pp long.
b. $\max(\lambda \text{d}.\forall w[w\text{Acc@} \rightarrow \text{Length}_w(\text{the\_paper}) \geq d]) = 15\text{pp}$
15pp is the minimum requirement length for the paper.

(55) a. The plane has to fly exactly 2000m high.
b. The tone has to be exactly 2500 Hz high.

Back to the helicopter example and the monotonic adjective *high*. It is an interesting question how the 'span' interpretation that the context requires is actually reached. Note that a monotonic semantics derives a downward scalar predicate, (56b). This is not what we want. The ambiguity in the helicopter example stems from the fact that inferences like (57) are not valid.

(56) a. than a plane can fly_high
b. $\lambda d.\exists w \exists x[w\text{Acc@} \ \&\ \text{plane}_w(x)\ \&\ \text{Altitude}_w(x) \geq d]$

(57) a. a plane can fly 100m high $\not\Rightarrow$ a plane can fly 90m high
b. a plane can fly 100m high $\not\Rightarrow$ a plane can fly 110m high

I propose that downward scalarity may be destroyed in these examples by a hidden exhaustifying operator (Fox 2006, Chierchia, Fox & Spector to appear; see also

Krasikova to appear). The resulting semantics is computed in (58b) and yields a non-scalar degree predicate as the denotation of the *than*-clause. Including the covert operator EXACTLY is a way to incorporate the context information that there is delineated interval of height degrees that the plane can reach.

(58) a. than a plane can fly EXACTLY_high
b. $\lambda d.\exists w \exists x[w\text{Acc@} \;\&\; \text{plane}_w(x) \;\&\; \text{EXACT}_C\text{Altitude}_w(x) \geq d] = \lambda d.\exists w \exists x[w\text{Acc@} \;\&\; \text{plane}_w(x) \;\&\; \text{Altitude}_w(x) = d]$
c. $\text{EXACT}_C(p) = 1$ iff $p \;\&\; \forall q \in C : \neg(p \rightarrow q) \rightarrow \neg q$
g(C) = $\{\text{Altitude}_w(x) \geq d \mid d \in D_{<d>}\}$

This way, we can capture intuitions about lack of inferences in the relevant contexts. In terms of further composition, we are at this point in the same situation as with the non-monotonic adjectives: expecting use of plural predication and predicting less-than-minium and more-than-maximum interpretations. But we got there differently, via a more complex derivation.

We are still looking for a way to derive less-than-maximum readings (outside of the strongly dispreferred cover choice). Our reasoning so far suggests that there may be a second LF without the covert operator. Then there needs to be a second way to incorporate the contextual information about the delineated interval of height degrees. I suggest that alternatively to the EXACTLY-semantics above, we presuppose that the *than*-clause talks about just the contextually relevant degrees. This yields a degree predicate that is in the relevant interval downward scalar. Maximal informativity picks the maximum, and we derive a less-than-maximum interpretation. In contrast to the tone frequency example, the helicopter altitude example with the monotonic adjective has a choice in its interpretation that comes from two ways to incorporate context. If the derivation in (59) is reasonable, this would be a not-so-dispreferred way to get the less-than-maximum reading.

(59) a. than a plane can fly_high
b. $\lambda d : d \in C.\exists w \exists x[w\text{Acc@} \;\&\; \text{plane}_w(x) \;\&\; \text{Altitude}_w(x) \geq d]$
c. g(C) = [50m, 1000m]
d. $\text{m-inf}(\lambda d : d \in C.\exists w \exists x[w\text{Acc@} \;\&\; \text{plane}_w(x) \;\&\; \text{Altitude}_w(x) \geq d]) =$ 1000m

4.3 Further questions

The discussion in the preceding subsection was a first step towards identifying what makes a fairly ambiguous Lucinda example. In addition to the non-zero-scale data, there are fairly unambiguous examples with zero-point-scale adjectives. An example is (14); a discussion of why such examples disprefer a less-than-maximum reading is

left for a future occasion. We should also look at MORE-comparatives again in the light of scalarity properties of different degree predicates; in other words, we haven't seen a discussion of finding (A) yet. The finding about (48) needs to be integrated into the suggestions in this section.

An important larger issue is the different kinds of adjectives I hypothesize in the preceding subsection. Distinctions between gradable adjectives have been proposed in the past, for example dimension adjectives vs. non-dimension adjectives (Bierwisch 1987, Schwarzschild 2010). We can ask whether monotonicity plausibly underlies this distinction.

It is tempting to apply the plural predication idea to *than*-clauses with quantifiers, such as (60a). The denotation in (60b) has been proposed for the *than*-clause – the set of degrees containing the heights of all the girls (see e.g. Schwarzschild & Wilkinson 2002, Heim 2006, Beck 2010). Note that this is another instance of a set of degrees which m-inf cannot reduce to a singleton. Applying plural predication yields the right truth conditions. It would be interesting to see if this generalizes to other quantifiers in *than*-clauses. I hope to approach these issues in future work.

(60) a. John is taller than every girl is.
b. $\lambda D.\forall x[girl(x) \rightarrow Height(x) \in D]$
c. $\forall d[d \in [\![$*than*-clause$]\!] \rightarrow$ John is taller than d]

In more general terms, I have presented a case in which systematic data collection has had interesting implications for semantic theory. The studies presented have revised our empirical picture and revealed the need for more fine-grained analysis. I have also pointed out, though, that it would be desirable to increase the amount of information that can be gleaned from such studies.

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