The dead ends of language: The (mis)interpretation of a grammatical illusion

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Abstract
This paper[1] explores the so-called 'comparative illusion' or 'dead end' experimentally – a pseudo-elliptical, seemingly grammatical, but ill-formed sentence, e.g. *More people have been to Paris than I have*. Repeatability of the event and choice of quantifier (*more* vs. *fewer*) do not affect acceptability significantly, whereas plurality of the *than*-phrase subject does. The illusion is fast and (superficially) easy to parse, suggesting that it is (mis)interpreted directly, not via ellipsis resolution or syntactic reanalysis of some intermediate representation. (Mis)interpretation neither leads to a single representation, nor does it rely on broad superficial heuristics, but falls into a small set of possibilities. Furthermore, even when people are told that such examples may in fact be meaningless, they are still tricked, showing that the effect is very robust.

1. Introduction

There are many examples of fully grammatical structurally complex sentences that people find unacceptable. This paper focuses on a specific instance of the opposite phenomenon, namely, the comparative illusion – a type of ungrammatical but acceptable sentence – and on how this linguistic illusion is (mis)interpreted.

[1] Thanks to the hundreds of participants for their patience. I am also grateful to Johanna Wood, Sten Vikner, and Johannes Kizach (Aarhus University, DK), Douglas Saddy (University of Reading, UK), and Colin Phillips (University of Maryland, USA) for discussions and/or comments. Also thanks to two anonymous reviewers for constructive critique of a previous and unpublished version of this paper. Finally, thanks to an anonymous reviewer for very insightful and helpful comments on an early version of the present paper.

Sten Vikner, Henrik Jørgensen & Elly van Gelderen (eds.): ***Let us have articles betwixt us – Papers in Historical and Comparative Linguistics in Honour of Johanna L. Wood.***
Dept. of English, School of Communication & Culture, Aarhus University,
pp. 129-160, © The author(s), 2016.

Language is full of ambiguity, but not all ambiguities are problematic, and in many cases, they go undetected. For instance, there are many examples of lexical ambiguity where individual words have more than one meaning, e.g., *bat*, *rock*, *mean*, etc. Furthermore, many sentences, such as (1), contain local structural ambiguities:

(1) Which dessert would Mary like the artist to paint?

The fronted *wh*-phrase, *which dessert*, is temporarily interpreted as the object of the matrix verb *like* and subsequently reinterpreted as the object of the verb *paint* in the embedded clause (Christensen, Kizach & Nyvad 2013a; Christensen, Kizach & Nyvad 2013b). Other sentences, such as those in (2) below, are globally ambiguous and have more than one meaning, each with its own sentence structure:

(2) a. She met a man who once talked to Elvis at the airport.
(Which event took place at the airport?)
b. He preferred American music and movies to politics.
(Do the movies also have to be American?)

All these ambiguities are normally unproblematic, at best giving rise to amusement. There are, however, also ambiguities that are difficult or impossible to parse:

(3) a. The doctor told the patient he was having trouble with to leave.
b. Without her contributions would be impossible.

The sentences in (3), taken from Pritchett (1992:5, 23), are so-called garden path sentences. For a sentence to be a garden path, it must contain a local structural ambiguity; in addition, there must be a preference for one interpretation, which gives rise to a strong tendency to parse the sentence erroneously. In other words, the sentence is assigned a wrong and globally impossible structure and has to be reanalyzed, which is very difficult, if not impossible – very unlike the effortless shift between the two structures in (2) above (Ferreira, Christianson & Hollingworth 2001; Frisch et al. 2002; Mason et al. 2003; Osterhout, Holcomb & Swinney 1994; Pritchett 1992). Garden path sentences are often used to illustrate the difference between linguistic competence (what you tacitly know about your language(s))

and linguistic performance (how this knowledge is put to use). It should be noted that garden path sentences are most often only problematic in writing; when presented orally, prosody usually helps to disambiguate and recover from the garden path (try adding a pause after *with* in (3)a) or to avoid it completely (e.g. by adding stress to *her* in (3)b).

Grammaticality in the face of unacceptability also occurs with multiple center-embedded ('nested') relative clauses. The problem here is that the parser runs out of working memory (Warren & Gibson 2002):

(4) Cars men women hate buy pollute and rust
(Compare: *Cars that are bought by men who women hate pollute and rust*)

The way the sentences in (2)-(4) are (mis)interpreted suggests that syntactic parsing is automatic (unconscious, fast, and obligatory), and that the parser chooses one structure rather than delivering all possible analyses simultaneously (which would also require extra working memory). Which structure is the preferred (initial) structure depends on various structural and nonstructural factors, including lexical semantics, context, and frequency (Christensen, Kizach & Nyvad 2013a; Christensen, Kizach & Nyvad 2013b; Hofmeister & Sag 2010; Kizach, Nyvad & Christensen 2013). In other words, instead of a 'width' strategy, where all possible analyses are kept open in working memory in parallel, the parser uses a 'depth first' strategy and incrementally builds the most plausible single structure until there is reason to change it.

The opposite of the grammatical but unacceptable syntactic garden path also exists, namely, in the form of what Christensen (2010; 2011) has called a "dead end", elsewhere called a "comparative illusion" (Phillips, Wagers & Lau 2011; Wellwood et al. 2009). Compare (5) and (6):

(5) More people have been to Paris than to Copenhagen.

(6) *More people have been to Paris than I have.

The sentence in (5) is a completely normal elliptical clausal comparative construction. The preposition phrase (PP), *than to Copenhagen*, is the elliptical and right-dislocated complement of *more*, see the structure in Figure 1.

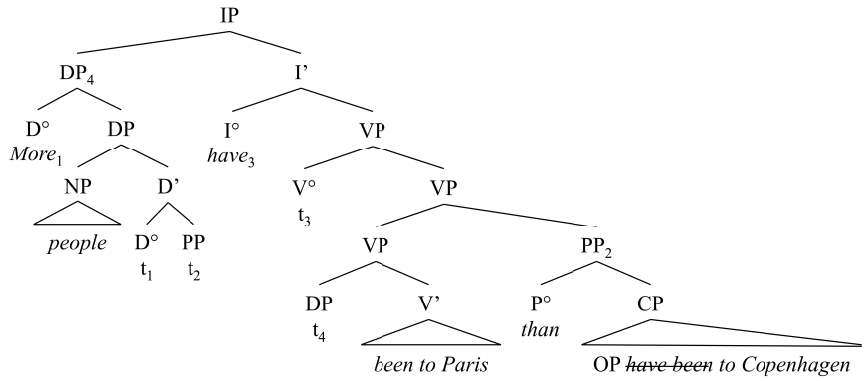

Figure 1: Partial syntactic analysis of the clausal comparative construction in (5). The analysis is based on Larson (2014), slightly simplified for reasons of clarity. In the base-position, t_1, the quantifier *more* selects a preposition phrase (PP) headed by *than* in the position t_2. Subsequently, *more*, raises to the higher D-position where it precedes *people*. In the resulting configuration, *more* is an operator, *people* its restriction, and the *than*-phrase its focus domain (*more* x, x=*people*, *than* x *been to Paris*). The *than*-phrase is right-dislocated and right-adjoined to VP prior to the raising of the DP to subject position. In the PP, *than* takes a clausal complement corresponding to a free relative clause with a silent *wh*-operator OP and elided *have been*.

When parsing a sentence such as (5) with elided elements (illustrated with strike-through in (7) below), we tacitly understand the left-out 'silent' or 'invisible' elements and undo the ellipsis; furthermore, these elements are reconstructed in the structural position where they receive full interpretation (including, e.g., scope relations) (namely at t_2 in Figure 1):

(7) a. More people have been to Paris than to Copenhagen.
(with ellipsis and right-dislocation)
b. More people have been to Paris than ~~have been~~ to Copenhagen.
(ellipsis undone)
c. More people [than ~~have been~~ to Copenhagen] have been to Paris […].
(reconstruction: right-dislocation undone)

The sentence in (6) above is different. It is a dead end, a grammatical illusion: acceptable but ungrammatical. Many people stubbornly maintain that it is indeed acceptable and grammatical, and that it makes perfect

sense – right until they are asked to explain what it means (I return to such potential interpretations below).[2] The sentence in (6) differs from the one in (5) in that the *than*-phrase is pseudo-elliptical. That is, there is no actual elided (unexpressed) material; it only looks or sounds like it. The effect becomes apparent when attempting to undo the ellipsis (which isn't there) and to reconstruct (which is impossible); the result is absurd:

(8) a. *More people have been to Paris than I have.
(pseudo-ellipsis)
b. *More people have been to Paris than I have ~~been to Paris~~.
(pseudo-ellipsis 'undone')
c. *More people [than I have ~~been to Paris~~]
have been to Paris […].
(reconstruction: right-dislocation 'undone')

The structure of (8)a is illustrated in Figure 2:

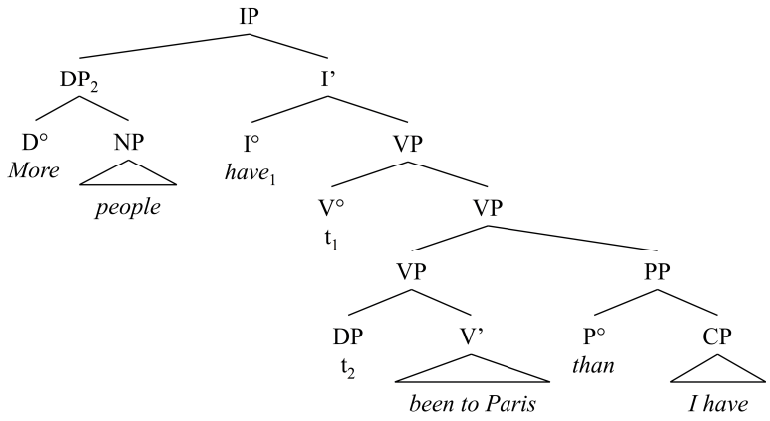

Figure 2: The syntactic structure of the dead end in (6)/(8)a. Note that the PP headed by *than* does not contain elided material and does not originate inside the DP *more people*, cf. (8)b-c.

(There is, in fact, a potential, grammatical but absurd interpretation of (6), where *have* is interpreted as the possessive main verb, namely, *More*

[2] Anecdotally, I have tested translated versions of the sentence in (6) on native speakers of Danish, English, Faroese, German, Icelandic, Polish, and Swedish – always with the same effect.

people than I own have been to Paris. I return to this in section 4 below. The focus in this paper is the interpretation with *have* as an auxiliary.)

The structure of (6), Figure 2, is a linguistic parallel to visual illusions such as the 'Devil's Tuning Fork' in Figure 3. The first part of the sentence, *More people have been to Paris*, is well-formed in itself, and so is the final part, *than I have*; together, however, they do not form a grammatical sentence.

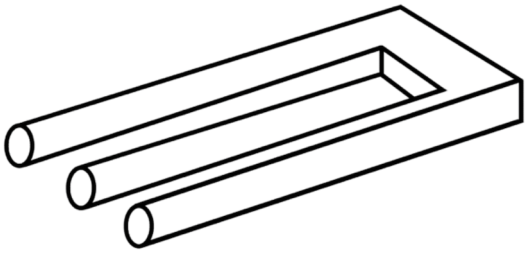

Figure 3: The Devil's Tuning Fork (also called a blivet) is an optical illusion; an impossible (globally incoherent) object consisting of two possible but incompatible parts: three round bars or prongs in one end, two connected square bars in the other.

This seemingly well-formed, yet meaningless (or incongruous) construction is well known in certain linguistic circles (Christensen 2010; Christensen 2011; Myers 2009:7; Hinzen 2006:131; Phillips, Wagers & Lau 2011:165; Saddy & Uriagereka 2004:384; Smith 2005:10; Wellwood et al. 2009; Montalbetti 1984:6). At present, however, empirical studies on the phenomenon are almost nonexistent; the studies by Christensen (2010; 2011) and Wellwood et al. (2009; 2011) are notable exceptions.

Using fMRI (functional magnetic resonance imaging), Christensen (2010) found that activation in the brain correlated with syntactic complexity. In the experiment, participants (19 native speakers of Danish) were asked to read a number of Danish sentence pairs and to judge whether the meaning of the second sentence (the probe) followed from the first sentence (the target). Target sentences included garden paths, dead ends, and normal control sentences, as in (9)-(10). (The probes were simple sentences corresponding (or not) to a sub-part of the corresponding target sentence). The sentence in (9)a is a syntactic garden path and as such it requires extra syntactic processing. The local ambiguity between *toughest* as a modifying

adjective (the preferred interpretation) and *toughest* as a noun leads to parser down the garden path and (attempted) conscious reanalysis is required. (9) b, on the other hand, is completely unproblematic; coordination as such does not require extra syntactic processing. Furthermore, though the string *The toughest men* is potentially ambiguous, as it is in (9)a, the bias towards analyzing it as a DP, [$_{DP}$ *The* [$_{NP}$ [$_{AdjP}$ *toughest*] [$_{NP}$ *men*]]], results in the correct parse.

(9) a. The toughest men know use soap too.
(Compare: *The toughest people that men know use soap too*)
b. The toughest men know and use soap too.

(10) a. *More children have looked at animals than you have.
b. More children have looked at animals than at cars.

Garden paths, such as (9)a, were found to increase cortical activation compared to unambiguous control sentences, (9)b. A comparison of the two sentence types revealed significant differences in activation in a number of brain areas previously found to be activated by syntactic complexity (Christensen 2008; Christensen 2010; Christensen & Wallentin 2011), including Broca's area in the left hemisphere and parts of the so-called premotor cortex. This effect, where the level of cortical activation correlates with syntactic complexity, is predicted and relatively uncontroversial.

Analysis of the brain response to dead ends and corresponding controls revealed the opposite pattern. The same areas that showed increased activation when processing garden paths relative to controls, showed increased activation when participants processed normal elliptical sentences, such as (10)b. This effect fits nicely together with the analysis illustrated in (7) above; elliptical clausal comparative sentences, (10) b, trigger syntactic reconstruction, which requires additional syntactic processing (cf. the structure in Figure 1). Thus, reanalysis (in garden paths) and reconstruction (in normal ellipsis) showed more or less the same overall cortical effect. The most interesting result, however, was that dead ends, such as (10)a, triggered a relative decrease in activation – similar to the controls for garden paths, (9)b. In other words, the brain seems to process dead ends in the same way as normal, unproblematic sentences resulting in a relative decrease in cortical activation. This suggests that the participants did not discover that the dead ends were pseudo-elliptical and

treated them as normal non-elliptical sentences, not as semantic anomalies, such as (11)a, a typical selectional restriction violation, nor as semantico-syntactic subcategorization errors such as the illicit versions of the locative alternation in (12)d and (12)e (Arad 2006):

(11) a. #She drank a big glass of ice-cold, refreshingly smooth sand.
b. She drank a big glass of ice-cold, refreshingly smooth beer.

(12) a. They sprayed paint on the wall.
b. They sprayed the wall with paint.

c. They poured water into the bowl.
d. *They poured the bowl with water.

e. *They covered the blanket over the baby.
f. They covered the baby with the blanket.

If dead ends had been treated as semantic anomalies, the results should have shown increased activation in Broca's area (Christensen & Wallentin 2011; Hagoort, Hald & Bastiaansen 2004), the exact opposite of what the actual results showed. The absence of increased activation (relative to controls) suggests that there is no extra syntactic processing. That is, there is no reconstruction because there is no ellipsis (which would have elicited an anomaly response), and since there is no structural ambiguity to resolve, there is no syntactic reanalysis. Furthermore, there are no phrase structure violations, so there is nothing that prevents the parser form making a syntactic representation. There are also no semantic or pragmatic violations leading to an implausible or absurd interpretation. (Most people judge comparative illusions as being acceptable, not as ungrammatical or anomalous.) All this suggests that the sentence is assigned a syntactic structure – regardless of the absence of an actual full, congruent semantic interpretation. This, in turn, suggests that semantic processing can be 'shallow' (Ferreira & Patson 2007; Sanford & Graesser 2006; Sanford & Sturt 2002).

Reconstruction from ellipsis and right-dislocation is automatic, rapid and unconscious. In the comparative illusion, reconstruction is not triggered because there is no obvious candidate in the immediate context to be inserted at the potential ellipsis site. More importantly, the parser does not detect such an ellipsis site. In online parsing, most people are

systematically tricked by the grammatical illusion, and reconstruction or reanalysis is not applied. Instead, comparative illusions are misinterpreted (not reanalyzed or reconstructed) in a number of ways.

In an unpublished poster presentation, Wellwood et al. (2009) present the results from a study on comparative illusions (12 participants, acceptability judgment task on a 7-point scale; two experiments, 48 and 36 items + fillers). In a more recent study (Wellwood et al. 2011), they largely corroborate the findings from 2009, and so the discussion here refers almost exclusively to the 2009 study. Wellwood et al. (2009) argue that people misinterpret such sentences to involve event comparison, as illustrated in (13), and that there are two possible ways of reaching an event comparison interpretation, namely, either by syntactic reanalysis or by semantic coercion ('pragmatic reconstruction' or inference, or context-driven 'enriched interpretation').

(13) a. More people have been to Paris than I have.
→
b. People have been to Paris more (often) than I have.

To test the syntactic (reanalysis) vs. the semantic (coercion) hypotheses, Wellwood et al. included two different quantifiers, *more* and *fewer*, in one of their experiments. The quantifier *more* ('larger in number') is identical to the adverb *more* ('often'), whereas *fewer* is unambiguously a quantifier and, hence, cannot change syntactic category via syntactic reanalysis from D to Adv. A significant difference would support the syntactic account (only *more* is compatible with '…more than I have', cf. *'…fewer than I have'), whereas an absence of difference would support the semantic hypothesis. Indeed they found no significant difference between sentences with *more* and *fewer*. The ambiguous *more* did not elicit a different response from the unambiguous *fewer*, which presumably was reinterpreted as *less often*, as illustrated in (14), suggesting that syntactic reanalysis did not apply.

(14) a. Fewer people have been to Paris than I have.
→
b. People have been to Paris less (often) than I have.

In short, Wellwood et al. (2009) argue that listeners/readers assign an event comparison interpretation by semantic coercion, not syntactic reanalysis. Furthermore, they argue that the effect of the illusion depends on two

crucial factors, namely, repeatability of the event denoted by the VP and the grammatical number of the *than*-subject. When the VP describes a repeatable event (e.g., 'calling the family' and 'getting involved with team sports') people are tricked significantly more frequently by the dead ends than when the VP is non-repeatable (e.g. 'beginning law-school' and 'being laid off'). In addition, Wellwood et al. (2009) report an effect of the grammatical number of the *than*-phrase subject. When it is a bare plural (e.g. *workers* and *people*), people are tricked significantly more often than when it is singular, either a pronoun (e.g. *he*) or a definite full DP (e.g. *the boy*), both of which are dependent on context for reference and "may lower acceptability by drawing attention to themselves and to illicit individual comparison."

The aim of this paper is to explore the (mis)interpretation of the comparative illusion and some possible factors that influence the strength of the illusion. The experiment in the next section was explicitly designed to test the three factors from Wellwood et al. (2009): Do the grammatical number of the *than*-subject (singular vs. plural, [±Plur]), repeatability of the VP [±Rep], and the type of quantifier [Quant] (Danish *flere* 'more' vs. *færre* 'fewer') affect the acceptability of (and hence, the strength of) the comparative illusion.

In sections 4 and 5 it will be shown that people are systematically tricked by comparative illusions such as (6) above. Even when it is explicitly pointed out that such sentences may be meaningless, a significant proportion of people are still tricked. Furthermore, people consistently fail to agree on an single interpretation; instead, the interpretations are drawn from a small consistent set.

2. Repeatability, Plurality, and the choice of Quantifier

As described in the introduction above, Wellwood et al. (2009) argue that people misinterpret the comparative illusion to involve event comparison, see (13) above, either by syntactic reanalysis or by semantic coercion ('pragmatic reconstruction'). As their experiment showed no difference between sentences with *more* (ambiguous between the quantifier meaning 'larger in number' and the adverb meaning 'more often') and sentences with *fewer* (no effect of [Quant]), Wellwood et al. (2009) argue that interpretation did not involve syntactic reanalysis and hence, it must be semantic coercion. Furthermore, Wellwood et al. (2009) argue that the effect of the illusion depends on two crucial factors, namely, repeatability of the

event denoted by the VP and the grammatical number of the *than*-subject, such that [+Rep] and [+Plur] makes the illusion stronger. Consequently, the following three predictions were made for Danish:

Prediction 1: [+Rep] is more acceptable than [–Rep], i.e. participants make more errors when the VP is repeatable (e.g. 'make mistakes', 'visit the family', 'break the rules') than when the VP is not repeatable (e.g., 'finish the course', 'lose hearing', 'commit suicide').

Prediction 2: A [+Plural] subject in the (pseudo elliptical) *than*-phrase makes the sentence more acceptable compared to sentences with singular [–Plural] subjects.

Prediction 3: The choice of quantifier [Quant] is not significant. There is no difference between *flere* ('more') and *færre* ('fewer'), neither of which are ambiguous between a quantifier reading and an adverb reading (unlike English).

2.1 Methods and materials

This experiment involved 32 participants (14 male, 18 female; mean age 23.34 years, range 20-34 years).

The stimulus consisted of four target (task-related) conditions ([±Repeatable] VP and [±Plural] *than*-phrase subject) and three filler conditions, see Table 1.

Target sentences	**[±Rep]**	**[±Plur]**
Flere/færre mænd har spist kød end kvinder har ifølge rapporten. *More/fewer men have eaten meat than women have according to report-the* 'More/fewer men have eaten meat than women have according to the report.'	+	+
Flere/færre drenge har mistet hørelsen end piger har i Danmark. *More/fewer boys have lost hearing-the than girls has in Denmark* 'More/fewer boys have lost the sense of hearing than girls have in Denmark.'	–	+
Flere/færre pædagoger har taget medicin end læreren har i Sverige. *More/fewer nursery-teachers have taken medicine than teacher-the has in Sweden* 'More/fewer nursery teachers have taken medicine than the school teacher has in Sweden.'	+	–
Flere/færre bankfolk har begået selvmord end frisøren har i år. *More/fewer bankers have commited suicide than hairdresser-the in year* 'More/fewer bankers have commited suicide than the hairdresser has this year.'	–	–

(table continued on next page)

Fillers	**Type**
Flere/færre journalister har omtalt sagen end ignoreret den i medierne. *More/fewer reporters have discussed case-the than ignored it in media-the* 'More/fewer reporters have discussed the case than ignored it in the media.'	CP-comp
Flere/færre journalister end forskere har omtalt sagen i medierne. *More/fewer reporters than researchers have discussed the case in media-the* 'More/fewer reporters than researchers have discussed the case in the media.'	DP-comp
Flere/færre journalister end i medierne har forskere fået fyresedlen. *More/fewer reporters than in media-the have researchers gotten dismissal-notice-the* 'More/fewer reporters than in the media have researchers gotten the dismissal notice.'	*Ungram

Table 1: Representative examples of target sentences and fillers.

The three filler conditions were as follows: 'CP-comp' were well-formed clausal (event) comparisons. 'DP-comp' consisted of nominal (set) comparisons; and '*Ungram' consisted of ungrammatical sentences (word salad permutations of phrases from target conditions). The task-related stimuli (96 sentences in total) were divided into four lists to ensure that each participant only saw any of the sentences in one version (either with a plural or a singular subject in the than-phrase, and either with *flere* 'more' or *færre* 'fewer' as the quantifier). The set of fillers (72 in total) were divided into two lists, again making sure that each participant saw only one version of the same sentence (±Plur); each filler list was combined with two task-related lists. Each of the four lists thus consisted of 60 sentences in fully randomized order, and each list was shown to eight different participants. The stimulus was presented visually on a computer screen one sentence at a time on a PC running DMDX (Forster & Forster 2003). Prior to the actual session, a training session was run to familiarize participants with the task. The entire session lasted approximately 5 minutes.

Participants were asked to judge whether the sentences were 'good' (well-formed) or 'bad' (either ungrammatical or semantically unacceptable). They were instructed to respond as fast and as accurate as they could. RT and answer were recorded for each sentence.

2.2 Results

The data was analyzed with a generalized linear mixed-model using the software R (R Development Core Team 2009) and the packages lme4 (Bates, Maechler & Bolker 2012), languageR (Baayen 2011), and MASS (Venables & Ripley 2002). The analysis showed no significant effects

on response time (all p>.12). As for the error rates – the extent to which people found the grammatical illusions acceptable – only the [±Plur] factor has a significant effect (p<.001); all other contrasts and interactions are non-significant ([±Rep] p=.071, [Quant] p=.541; all interactions p>.16). As is visible in Figure 4, there is tendency for repeatable [+Rep] to be more acceptable than non-repeatable [–Rep], but this effect does not reach statistical significance (p=.071).

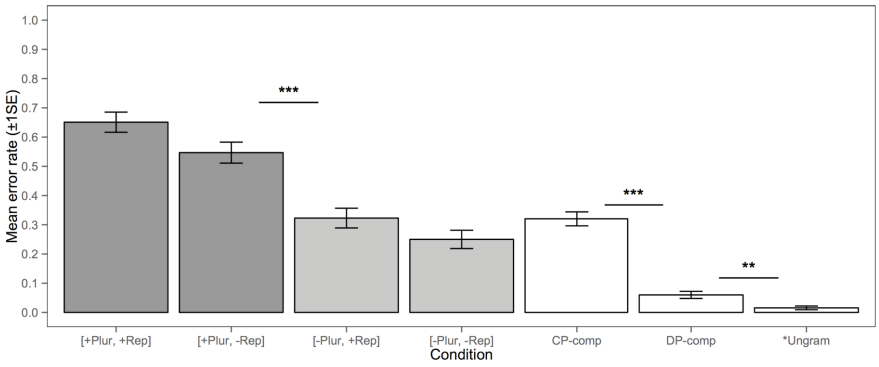

Figure 4: Mean error rates per condition ±1 standard error. (An error rate of 0 would mean that everyone found the example unacceptable, whereas an error rate of 1 would mean that they everyone found the example acceptable.) ***p<.001, **p<.01.

2.3 Discussion

Prediction 1 [±Rep] was not borne out. The participants did not make significantly more errors when the VP was repeatable [+Rep] compared to non-repeatable VPs [–Rep] (p=.071). In other words, VP denoting a repeatable event did not strengthen the illusion, contra Wellwood et al. (2009). Prediction 2 [±Plur], on the other hand, was indeed borne out. A [+Plur] subject in the (pseudo elliptical) *than*-phrase makes the sentence acceptable more often compared to sentences with singular [–Plur] subjects (p<.001). Following Wellwood et al. (2009), this could be taken to suggest that people use semantic coercion to induce an event comparison. As expected (prediction 3), the choice of quantifier [Quant], *flere* 'more' vs. *færre* 'fewer', has no significant effect (p=.541). This result corroborates Wellwood et al. (2009) who found no difference between *more* and *fewer* in English, suggesting that people did not apply syntactic reanalysis to change the quantifier into an adverb.

Wellwood et al. (2009) argue that because "susceptibility to the illusion is modulated by semantic properties", a semantic coercion account is more feasible than a syntactic reanalysis account. Furthermore, they argue, comparative illusions do not reflect broad superficial heuristics. This seems to suggest that people consistently interpret sentences such as (6) above (as well as those in Table 1) as instances of event comparison. However, the present study shows that the semantic property of event repeatability [±Rep] has no significant effect, whereas the [+Plur] property does. People did equally well on controls and [–Plur] illusions; in other words, people were not fooled by [–Plur] illusions. This is not because such sentences are well-formed, but because the stimulus was designed such that an inclusive interpretation was ruled out; e.g. 'more men … than the woman' does not allow an inclusive interpretation where 'the woman' is a subset of 'the men', whereas 'more people … than the woman' does. Furthermore, as I will show in section 4 below, people disagree on what the actual interpretation is, and this interpretation is not always a comparison of number of events. I shall also argue that all these (mis)interpretations are structurally more complex than the actual but ungrammatical one in (2) above. First, I present data showing that the parsing of comparative illusions is relatively fast and, interestingly, fastest when people are tricked by the illusion.

3. People are fast at getting it wrong

This experiment tests whether people are faster or slower at responding whether illusions are meaningful or not compared to controls (though the experiment in section 2 did not show any such effect), and whether there is a relationship between error rate and sentence type.

The participants were instructed to evaluate whether or not the sentences (presented in randomized order) made sense or not by pressing one of two keys on a keyboard, and to respond as fast and as confidently as possible. A total of 60 people (17 male, mean age 23.18 years, range 18-44) participated in the experiment. The stimulus was presented visually on a computer screen one sentence at a time on a PC running DMDX (Forster & Forster 2003).

The stimulus consisted of four types of sentences, 40 sentences in total (all repeatable events):

(15) a. *Flere folk end i London har været i Paris. (nonsense)
More people than in London have been in Paris
"More people than in London have been to Paris.

b. *Flere folk har været i Paris end jeg har. (illusion)
More people have been in Paris than I have
"More people have been to Paris than I have."

c. Flere folk har været i Paris end i London. (com-CP)
More people have been in Paris than in London
"More people have been to Paris than to London."

d. Flere folk end mig har været i Paris. (com-DP)
More people than me have been in Paris.
"More people than me have been to Paris."

The results were subjected to a generalized linear mixed-effects analysis using R (R Development Core Team 2009) and the lme4 package for R (Bates, Maechler & Bolker 2012), using answer and RT (log-transformed to approximate the normal distribution) as dependent variables (fixed effects: type and order; random effects: participant and item; random intercepts).

As expected, the analysis of the answers (0 = 'no, does not make sense'; 1 = 'yes, it makes sense') showed that comparative illusions scored significantly higher (were judged as meaningful more often) than nonsense and significantly lower than the Com-CP and Com-DP control sentences, which did not differ significantly from each other ($p<.001$; mean answers: Nonsense .04, illusions .56, com-CP .86, com-DP .82). Likewise, people responded faster to nonsense than to comparative illusions ($p=.019$), which in turn was significantly faster than controls ($p<.001$) (mean RT in milliseconds: nonsense 3066, illusions 4255, com-CP 4325, com-DP 3591). (This experiment was not designed to test for plurality, but post hoc tests revealed no significant difference in RT or error rate between [+Plur] and [–Plur], $p>.24$.)

The analysis of the RT also showed significant differences between 'no' and 'yes' responses. While it took longer to say 'yes' to nonsense ($p<.001$), it took longer to say 'no' to the other three types ($p<.05$). In other words, providing the right answer, 'no' to nonsense and 'yes' to Com-

CP/DP, was faster than answering incorrectly. However, the comparative illusions patterned with the meaningful controls ('no' slower than 'yes'); in other words, participants were faster at giving the incorrect answer, the opposite pattern of the one observed for the other three types.

In summary, the pseudo-elliptical comparative illusions are faster to process than truly elliptical clausal comparatives. (They are slower than the comparative DP construction, which are comparison of sets of individuals, and this could be explained by the fact that the com-DPs are shorter and that the than-phrase is adjacent to the more-phrase.) Furthermore, people are as fast at answering incorrectly that the illusions are meaningful as they are at correctly answering that clausal comparatives are meaningful. This supports the hypothesis that comparative illusions are (superficially) easy to parse and (mis)interpreted directly, not by via ellipsis resolution and syntactic reanalysis.

In the next section, I present evidence that the (mis)interpretations of comparative illusions indeed do not rely on broad superficial heuristics, but fall into a small set of possibilities.

4. A set of interpretations

As part of the introduction to classes and lectures on language and the brain in 2009-2011 at Aarhus University, Denmark, and Uppsala University, Sweden, students were asked to write on a piece of paper in their own words what they thought the sentence in (16) meant, and hand it in anonymously.

(16) Flere folk har været i Paris end jeg har.
More people have been in Paris than I have
'More people have been to Paris than I have.'

The results are summarized in Table 2 (data from Christensen (2011). The Swedish data (25 speakers) is included here to show that the overall pattern is not restricted to Danish, but the discussion below will focus on the Danish data only.

Paraphrase	Danish		Swedish		Total	
	n	**%**	n	%	n	%
(a) Some people have been to Paris [**except me**]	**11**	**28.9**	3	12.0	14	22.2
(b) More people have been to Paris [**than (just) me**]	**8**	**21.1**	7	28.0	15	23.8
(c) Some people have been to Paris [**more (often)** than I have]	**6**	**15.8**	1	4.0	7	11.1
(d) It doesn't make sense	**3**	**7.9**	7	28.0	10	15.9
(e) More people have been to Paris [than I own]	**5**	**13.2**	4	16.0	9	14.3
(f) Other	**5**	**13.2**	3	12.0	8	12.7
Total	**38**	**100.0**	25	100.0	63	100.0

Table 2: Percentages of paraphrases provided to the sentence in (16). The 'other' answers (f) include verbatim repetition of the target sentence itself.

Only 7.9% responded that the sentence was meaningless. As 13.2% of the participants noted, the target sentence can be paraphrased as *More people than I own have been to Paris*, paraphrase (e) in Table 2. Despite this being an absurd reading, it is in fact the only possible full interpretation. The reason is that the verb *have* is ambiguous; it can be either an auxiliary verb (marking perfect aspect) or a main verb meaning 'to own'. Both the *than I own* (main verb *have*) and 'it doesn't make sense' (auxiliary *have*) are in fact correct responses. Together these responses make up 21.1%. The discussion here, however, focuses on the auxiliary verb interpretation of *have*.

There were three other, more interesting paraphrases, namely (a), (b), and (c) in Table 2, which are all incompatible with the actual syntax and lexical material of the target sentence, (16), see the structure in (2) above. Paraphrase (a) is interesting for two reasons: One, the interpretation is simply not licensed by the lexical material, and two, it contains negation, either in the form of the negative operator *not* (Danish *ikke*), '…but not me', or as part of the preposition *except* (Danish *undtagen*), '…except me'. The right-dislocated *than I have* in the target sentence does not contain negation. To get interpretation (a), *more…than* has to be interpreted as

some…except, where the quantifier *more* is replaced by *some*, and the preposition *than* + clausal complement is replaced by *except* (or by *but not*) + DP complement , see Figure 5. Interestingly, this 'except me' interpretation does not figure in Wellwood et al. (2009).

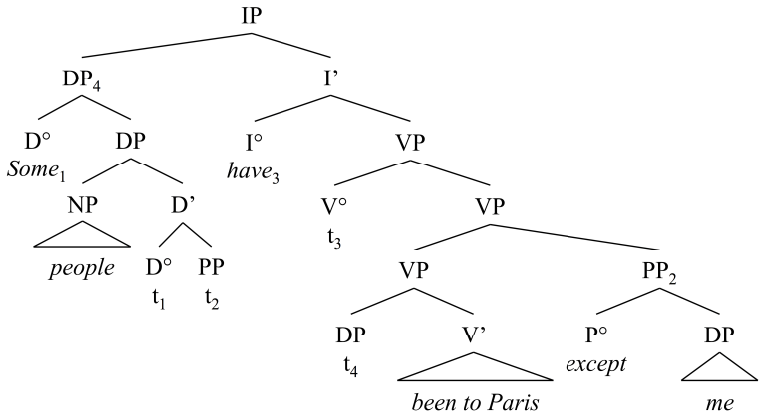

Figure 5: The structure of the exclusive reading of of (6)/(16).

Paraphrase (b) is only possible if the verb *have* in the *than*-clause is deleted (or ignored), and the nominative *I* is replaced by the accusative *me*, see Figure 6. Wellwood et al. (2009) found no support for a 'than (just) me' reading, i.e. a comparison of number of individuals (which they assumed would otherwise have supported syntactic reanalysis); they found no difference between sentences that support a 'more x than just me' reading (e.g., *More girls drive to school than she does*, cf. *More girls than just her*) and those that do not (*More girls drive to school than he does*, cf. **More girls than just him*). However, in the present study, this interpretation was in fact provided by a full 21.1% of the participants.

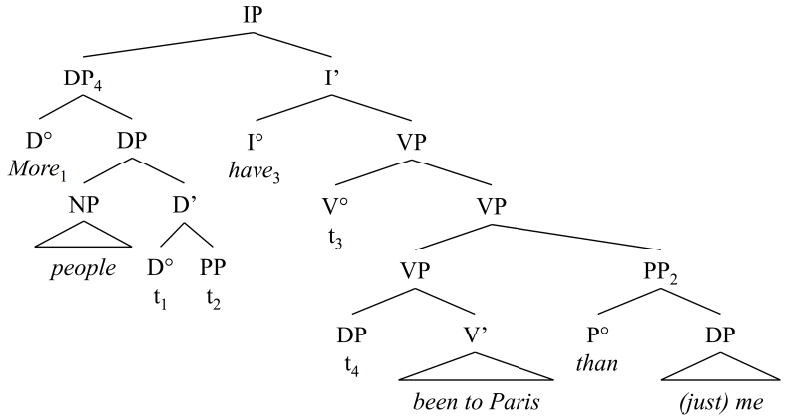

Figure 6: The structure of the comparison-of-sets-of-individuals reading of (6)/(16).

According to Wellwood et al. (2009), paraphrase (c), *(Some) people have been to Paris more (often) than I have*, is derivable either by syntactic reanalysis (moving *more* into the embedded clause) or by semantic coercion (pragmatic 'reconstruction' or inference, or context-driven 'enriched' interpretation). This is possible because the English *more* is ambiguous between being a quantifier (comparative of *many*) and an adverb (comparative of *much*). However, the corresponding Danish expression, *flere* ('more'), is unambiguous. It can only be a quantifier (comparative of *mange* 'many'); the adverbial version is *mere* (the comparative form of *meget* 'much').

The 'more/less often' interpretation is equivalent to a 'more/fewer times' reading. If indeed both *more* and *fewer* (Danish *flere* and *færre*) are interpreted as being inserted as quantifiers in the embedded clause as illustrated in Figure 7, that would account for the absence of a [Quant] effect in Wellwood et al. (2009) as well as in the experiment presented in section 2 above.

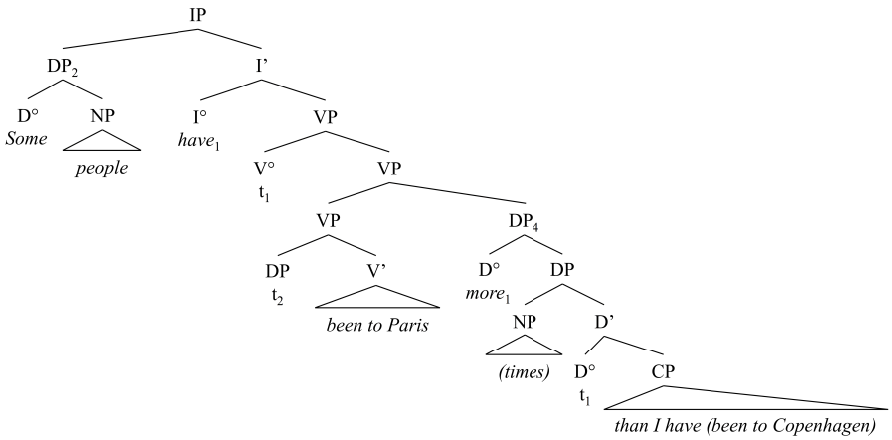

Figure 7: The structure of the comparing-number-of-events reading of (6)/(16).

As argued in section 1, the neuroimaging data suggest that the illusion does not trigger extra syntactic processing in the form of reanalysis or reconstruction (Christensen 2010). In addition, the results for the experiment in section 3 showed the comparative illusions induced faster RT than elliptical controls, and even faster at getting the interpretation wrong (not spotting the illusion), which also suggest that reanalysis is not applied. The three (mis)interpretations (Figure 5 – Figure 7) are therefore the results of direct syntactic misanalysis. People do not arrive at the ill-formed parse (the target sentence in Figure 2) and reanalyze it to get to one of the three reported interpretations. It is interesting to note two important things: One, the set of interpretations is constrained, and two, all three (mis)interpretations are structurally much more complex than the actual but ungrammatical parse of the comparative illusion in Figure 2 – not 'shallow' or partial 'good enough' representations. I agree with Wellwood et al. (2009) that a semantic coercion account is more feasible than a syntactic reanalysis account and that comparative illusions do not reflect broad superficial heuristics. The data presented here support this idea. However, the data also show that people do not always arrive at event-comparison interpretations, but also sets-of-individuals and exclusive interpretations – all of which have complex syntactic representations.

Unlike garden paths, comparative illusions are not taken to be ungrammatical; instead they go unnoticed until people are asked to explain what it means. In this respect a comparative illusion is similar to the so-

called depth charge sentence in (17) which people consistently misinterpret to mean exactly the opposite of what it actually means (Kizach, Christensen & Weed 2015; Natsopoulos 1985; Wason & Reich 1979); compare (17) and (18), which by most speakers are give the same interpretation:

(17) No head injury is too trivial to be ignored.

(18) No head injury is too trivial to be treated.

The problem with (17) is that it is overly complex; for one thing, it involves no less than three types of negation, in addition to a semantic anomaly and a pragmatic violation; for details and a recent 'deconstruction' of the depth charge construction, see Kizach, Christensen & Weed (2015). Though the comparative illusion is crucially different, both comparative illusions and depth charges yield consistent but wrong interpretations, depth charges only one, comparative illusions (at least) three (plus the fact that comparative illusions are meaningless or absurd).

The fact that the (mis)interpretations of the comparative illusion can (more or less) be divided into the categories in Table 2 also shows that it is far from being a normal sentence. People even disagree as to whether part of the meaning of (16) is 'I have been to Paris' or whether it is 'I have not been to Paris', a rather important difference. On the other hand, the results also show that this type of grammatical illusion is different from an ordinary semantic anomaly, such as a selectional restriction violation, as in (11)a and (12)d and e, which most people easily detect and agree about. Though I have argued that the semantic interpretation drawn from comparative illusions reflect a 'shallow' interpretation (as an in-depth interpretation would have revealed that something is not normal), it should be emphasized that these interpretations do not reflect arbitrary guesswork or broad superficial heuristics. Note the parallel between the structure of the DP in the 'normal' clausal comparative construction, Figure 1, and the exclusive 'except X' reading in Figure 5, the comparing-sets-of-individuals reading, 'more than (just) me' interpretation in Figure 6, and the event comparison reading, 'more (times)' in Figure 7.

In the experiment presented in section 2 above, A [+Plur] *than*-clause subject facilitates acceptability and makes people more susceptible to the comparative illusion. A [+Plur] subject is compatible with comparing sets

of individuals (Figure 7, e.g. 'more reporters than researchers'), comparing number of events ('more often/times', Figure 6), but not necessarily with the exclusive 'except, reading (Figure 5, e.g. '*some reporters except researchers', but 'some researchers except linguists'). A [–Plur] subject is also compatible with event comparison ('more times/often), but not with comparison of sets of individuals ('*more reporters than the researcher') and not necessarily with the exclusive reading (*'some reporters except the researcher' but 'some researchers except the linguist). The exclusive 'except' reading is most compatible with pronominal subjects or proper nouns ('linguists except her/Johanna'). In other words, there are more potential ways that a comparative illusion with a [+Plur] subject could be construed / interpreted to be grammatical compared to when the subject is [–Plur]. The effect of repeatability of the event described by the VP is not significant here; people apparently find 'eating meat more times than X' and 'losing the sense of hearing more often than X' equally acceptable – or rather they fail to notice the difference. This is compatible with the fact that in online parsing, the parser readily accepts anomalous intermediate representations (e.g. 'to decide a tree'), which however has a negative effect on overall acceptability, but not ungrammatical, i.e. syntactically ill-formed intermediate representations. In other words, we accept the implausible, but not the impossible (Kizach, Nyvad & Christensen 2013).

One might speculate that the reason why 79% of the participants (i.e. those who provided paraphrases (a)-(c) and (f) in Table 2) did not see that the comparative illusion is in fact ill-formed (globally incoherent) could (at least partially) be attributable to the nature of the task; perhaps people felt obliged to come up with an interpretation that makes sense, just as people usually understand what other people say even when they make various errors. People might have assumed that the teacher (me) observed the cooperative principle (Grice 1975) while flouting the maxim of manner by not being clear, unambiguous, brief and orderly. The following internet-survey investigates whether it makes a significant difference to explicitly point out that such sentences might be meaningless. The illusion, however, turns to be very robust indeed.

5. Are people just being cooperative?

A total of 545 people (169 male, age 17-77, mean 33 years) from all parts of Denmark completed the survey described below, which was constructed

using LimeSurvey (http://www.limesurvey.org/) running on the Aarhus University internet server.[3]

The stimuli consisted of eight Danish comparative illusions and eight normal and meaningful control sentences, parallel to (10)a and (10) b, respectively (plus 24 unrelated fillers not discussed here). The sentences were presented one a time in random order together with a list of five possible paraphrases (also in random order), as illustrated in (19) below, based on the results from the study in section 4 above. One of the possible paraphrases was always 'It doesn't make sense'; another option was always to answer 'Other', if one thought that none of the listed paraphrases was appropriate.[4] People had unlimited time to respond.

(19) *More people have been to Paris than I have. [–Sing]
a. 'I haven't been to Paris, but many others have.'
b. 'More people than me have been to Paris.'
c. 'Many people have been to Paris more often than I have.'
d. It doesn't make sense.
e. Other

Seven of the eight comparative illusions had a singular subject in the *than*-phrase, as in (19) (see Danish version in (16) above), while the eighth sentence had a plural subject, (20):

(20) *Flere kvinder har været på ferie end mænd har i år. [+Plur]
More women have been on holiday than men have in year
'More women have been on holiday than men have this year.'

Admittedly, this was not intentional. However, as predicted from the discussion above, the effect of [±Plur] was significant. A full 87% of participants found this sentence meaningful (only 13% said 'It doesn't make sense'):

[3] Results from incomplete forms were excluded from the analysis and so was one participant who wrote in the comments that he just made random responses because he felt that the survey was too long.

[4] The original survey also included 'Many people have been to Paris' in the list of paraphrases. Here, those responses are categorized as 'Other'.

Paraphrase	[+Plur] (1 item)	%	Mean [-Plur] (7 items)	SE	%
(a) …[but not X]	2	0.37	53.57	1.13	9.83
(b) …[than (just) X]	246	45.14	23.43	0.71	4.30
(c) …[more (often)...]	188	34.50	72.71	0.99	13.34
(d) Nonsense	71	13.03	383.14	1.41	70.30
(e) Other	38	6.97	12.14	0.12	2.23
	545	100.00	545.00		100.00

Table 3: Paraphrases provided for the sentence in (20), (see also Table 2 above). SE = standard error of the mean.

From the results in Table 3, two major conclusion can be drawn. Firstly, although there is a significant effect of the option of answering 'It doesn't make sense', the illusion is still rather robust. Compared to the 7.9% in the experiment in section 2 of Table 2, a total of 70.3% responded that the comparative illusions were meaningless (I return to the 13% in the [+Plur] sentence shortly). In other words, pointing out that the stimulus sentences could be meaningless did indeed have a significant effect. Nonetheless, a large proportion of the participants, namely no less than 29.7%, provided meaningful, and therefore incorrect, paraphrases in spite of the explicit possibility that the target sentences could be meaningless. In comparison, 87.6% (SE=.79) responded correctly to the control sentences.[5] (Note also the small variation in the response pattern to the [–Plur] sentences reflected in the very small values for the standard error, SE, in Table 3.)

The second conclusion that can be drawn from Table 3 is that plurality matters, as was also shown in section 2 above, see Figure 4; see also parallel examples with [+Plur] subjects in Table 1. The sentence with a [+Plur] subject in the *than*-phrase, i.e. (20), elicited a response pattern very different from the responses to sentences with a [–Plur] subject. That it is in fact not a well-formed sentence becomes clear when attempting to resolve the pseudo-ellipsis and reconstruct the right-dislocation, as illustrated in (21) below:

[5] One might also speculate that the temporal adjunct in (21)a ('this year') somehow masks the pseudo-ellipsis; it could be that it strengthens the illusion and makes the sentence more acceptable. However, the experiment in section 3 also tested for the presence versus absence of such an adjunct. The results showed no difference in acceptability (generalized linear mixed-effects analysis, p=.925).

(21) a. *More women have been on holiday than men have this year.
(comparative illusion: pseudo-ellipsis)
b. *More women have been on holiday than men have ~~been on holiday~~ this year.
(pseudo-ellipsis 'undone')
c. *More women [than men have ~~been on holiday~~] have been on holiday […] this year.
(reconstruction: right-dislocation 'undone')

Interestingly, the type of sentence (20)/(21) is considered "non-illusory" and "meaningful, not just acceptable" and are used as controls in Wellwood et al. (2011), as well as in Wellwood et al. (2009). However, as is evident from the data from 545 speakers in Table 3, the sentence is far from normal. 246 people (45.14%) responded that it means 'more women than men have been on holiday this year' (comparison of individuals), whereas 188 (34.50%) responded that it means 'women have been on holiday more often than men have this year' (event comparison), and 71 people (13.03%) said that it is meaningless. This is very unlike normal sentences and even structurally ambiguous ones, as in (2) above. If someone were to maintain that it is a perfectly fine structure with a single interpretation, say, 'more women than men', and hence not a grammatical illusion, then they would clearly be ignoring the judgments of the remaining 299 speakers who disagree in this survey. In my opinion, this only underlines the strength of the illusion and again point to the similar robustness of effect of the depth charge construction in (17) (Kizach, Christensen & Weed 2015).

In summary, the illusory well-formedness of comparative illusions is very robust. Though people are less apt to be tricked when it is made explicitly clear that such sentences might be meaningless, almost 30% still provided meaningful paraphrases; with a plural subject in the *than*-phrase, it was a full 87%. The conditions in the informal study (section 2) are closer to 'normal' language use, suggesting that the interpretations provided are actual interpretations, not merely an artifact of being cooperative and pleasing to the experimenter.

6. Discussion and conclusion

This paper has explored the pseudo-elliptical, seemingly grammatical, but ill-formed sentence type called the 'comparative illusion' or 'dead end'. In doing so, I have drawn on a number of experiments. The brain imaging

study discussed in section 1 shows that comparative illusions do increase activation in Broca's area of the brain, which suggests that such sentences do not trigger additional syntactic processing (unlike garden path sentences and truly elliptical sentences). People (mis)interpret them directly, not via ellipsis resolution or syntactic reanalysis of some intermediate representation. This is also supported by the evidence presented in section 3 which showed that the illusion is fast and (superficially) easy to parse; people are even faster at stating that the illusion makes sense than in stating the opposite.

The experiment in section 2 investigated the effect of three factors on the acceptability of the comparative illusion. The results show that whether the event described by the sentence is repeatable or not [±Rep] does not affect acceptability. There is also no difference in acceptability between *more* and *fewer* [Comp]. The third factor, plurality of the *than*-phrase subject [±Plur], however, does have a significant effect. When the subject is plural, people are tricked significantly more often, finding it more acceptable. The [Plur] effect corroborates Wellwood et al.'s (2009) findings, but the non-significance of repeatability [±Rep] runs counter to their results and their main argument, namely, that comparative illusions are consistently assigned an event comparison interpretation.

The data in section 4 show that comparative illusions are not associated with a single representation agreed upon across people. In contrast, the (mis)interpretations are consistently drawn from a small, stable set of possibilities. This, together with the fact that all these interpretations are syntactically more complex than the actual structure of the illusion, show that interpretation does not rely on random guess work. Wellwood et al. (2009) argue that "comparative illusions do not reflect broad superficial heuristics" and I agree. The structure of the DP in the 'normal' clausal comparative construction, Figure 1, the exclusive reading, Figure 5, comparison of individuals, Figure 6, and event comparison, Figure 7, are remarkably similar. However, the data presented here also shows that the comparative illusion is not always assigned an event comparison interpretation by semantic coercion, contra Wellwood et al. (2009).

Finally, the survey in section 5 shows that people are not just being cooperative when asked to explain what comparative illusions, such as (6), mean. Even when people are told that such examples may actually not make sense, they are still tricked, showing that the effect is very robust. Since people have great difficulty accepting that such sentences are in fact meaningless (globally incoherent), even when this is explicitly pointed out

to them, it might be tempting to argue that they are indeed as meaningful as people claim. The problem is, however, that people do not agree on the interpretation. This disagreement is very different from what is the case with syntactic global, (2), as well as local (garden path) ambiguities, (3). Global syntactic ambiguities have two possible interpretations, and the choice between them is dependent on context, though one is preferred over the other. The set of possible interpretations of *More people have been to Paris than I have* given in Table 2 cannot be explained as different but mutually compatible presuppositions, implicatures or subjective connotations. For example, in Table 2, (b) is incompatible with (c) and (d) (which are mutually compatible), and all three are incompatible with (e).

Phillips et al. (2011) argue that the parser is prone to illicit dependency formation (resulting in binding or agreement errors) when non-structural information (e.g. pragmatics and frequency) is available simultaneously with structural information relevant to dependency formation. In a comparative illusion, such as (6), the clause-initial quantifier, *more/fewer*, signals a comparative construction involving *than* (i.e. it is early structural information); on the other hand, due to the diversity of this type of construction (i.e. non-structural information), the parser cannot form a definite prediction about the right edge of the sentence. For example, *More people have been to Paris* can be followed by a number of different *than*-phrases:

(22) More people have been to Paris…
  a. …than (just) me.
  b. …than elephants.
  c. …than I can possibly count.
  d. …than to Copenhagen.

This accounts for why the syntactic information alone may be insufficient for a full in-depth structural parse. However, as also noted by Phillips et al. (2011:21), it does not account for why people usually fail to see that comparative illusions are anomalous.

What triggers the illusion is a conspiracy of factors. First of all, the syntactic parser automatically constructs a syntactic representation, unless it is hindered by e.g. massive center-embedding (nesting), tricky local ambiguities (garden path effects) or downright syntactic errors. Second, there is a collocation between *more* and *than*, a piece of non-structural information, which however, is not strong enough to predict the structural

contents of the *than*-phrase. Third, the grammatical number of the *than*-subject; plural *than*-subjects induce stronger effects than singular ones, possibly because it is potentially compatible with more (mis)interpretations than singular subjects. Fourth, quantifiers and degree expressions are complex in terms of syntax, semantics, as well as pragmatics. Finally, in the absence of obvious evidence to the contrary, we expect language to make sense, as it usually does. However, that does not normally seem to stop people from detecting other types of complexities, anomalies, or ungrammaticalities.

While garden paths are grammatical but unacceptable, comparative illusions are ungrammatical but acceptable; together these structures highlight not only the difference between competence and performance but also a contrast between the way syntax and semantics are processed. We easily detect when the syntactic parser is lead astray by ambiguities and garden path sentences, or completely derailed by errors; it is less easy to detect when semantic decoding yields incongruous or implausible interpretations, or when it leads to syntactically guided misinterpretations – that is, when interpretation runs into a dead end.

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