SEMANTIC UNDERSPECIFICATION AND ANAPHORA*

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1. Introduction

Recent work in language processing (Christianson, Hollingworth & Ferreira, 2001; Sanford & Sturt, 2002; Swets, Desmet, Clifton & Ferreira, 2008) suggests that interpretive processes are often incomplete, such that comprehenders do not commit to a particular meaning during a parse. Such "underspecified" representations have implications for understanding ambiguity at the syntax-semantics interface, particularly for scope ambiguous sentences, such as (1a):

(1) a. Every kid climbed a tree.
    b. The trees were in the park.
    c. The tree was in the park.

Sentences such as (1a) are ambiguous, despite the fact that they lack any syntactic or lexical ambiguity. The different meanings are the result of different logical orders in which the quantifiers are interpreted. On one interpretation, it is the case that for *every* (∀) child, a (∃) tree was climbed, which results in an inference that several trees were climbed. This reading is called the 'surface scope' reading, since the order of interpretation of the quantifiers matches the surface linear order of the quantifiers in the sentence (see 2a). On another reading, called the inverse scope reading, the interpretation is that it is the case that there is a (∃) tree, such that every (∀) kid climbed it (see 2b). The inverse scope reading results in a meaning where just one tree was climbed. The logical formulae for these interpretations are given below:

(2) a. $(\forall x)$ (x is a kid) $\rightarrow$ $(\exists y)$ (y is a tree & x climbed y)
    [read as: "For every kid x, there is a tree y, such that x climbed y"]

    b. $(\exists y)$ (y is a tree) & $(\forall x)$ (x is a kid $\rightarrow$ x climbed y)
    [read as: "There is a tree y, such that for every kid, x, x climbed y"]

The present study seeks to address the following question: is the meaning of (1a) underspecified, or is a particular scope assignment preferred? Furthermore, how would the interpretation of (1a) impact anaphoric resolution downstream (as in 1b and 1c)? Previous behavioral studies are equivocal regarding the interpretation of (1a). In an end-of-sentence on-line grammatical acceptability task, Kurtzman & MacDonald (1993) (henceforth K&M; see also Anderson, 2004) showed that plural continuation sentences (1b), consistent with a surface scope interpretation of (1a), are preferred over singular continuations

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(1c), consistent with the inverse scope interpretation. However, recent behavioural findings indicate that these effects have not been fully replicated (see Tunstall, 1998; Filik, Paterson & Liversedge, 2004; Paterson, Filik & Liversedge, 2008, as well as Anderson, 2004). One potential reason why findings have been equivocal is that the above-mentioned studies examined several linguistic factors simultaneously—e.g., type of verb phrase, type of verb, type of quantifier, order of quantifiers. Moreover, Kemtes & Kemper (1999) showed that judgments for sentences like (1a) are modulated by age and working memory (WM) span. Perhaps the lack of replication could be explained by individual differences between participant groups across studies, where low span readers perform shallower processing, resulting in no scope preference.

Nevertheless, from a processing perspective, findings indicating a bias for the surface scope reading (2a) would be predicted. This is because the surface scope interpretaion of sentence (1a), would require the least amount of linguistic structure to represent at the level of Logical Form (May, 1985), since that representation is consistent with the linear order of the sentence. As such, K&M's finding is supported by the Minimal Structure Hypothesis of Dwivedi (1996) (see also Tunstall, 1998 and Anderson 2004):

(3) *Minimal Structure Hypothesis*
When constructing parse, postulate only as much structure as is required by the well-formedness rules of the grammar.

The present study follows up on a recent Event Related Potential (ERP) study conducted by Dwivedi, Phillips, Einagel, and Baum (2009) which also examined the interpretation of sentences such as (1a) by examining the interpretation at the continuation sentences (1b) and (1c).[1] In addition to these experimental conditions, crucial controls were added, where these conditions were modeled after those found in the original K&M study. The control context sentences were of the following form:

(4) a. Every kid climbed a different tree.
b. Every kid climbed the same tree.

In the sentences above, (4a) ensures that the plural continuation (1b) should follow unambiguously, whereas (4b) is control context for the singular continuation (1c). The conditions are summarized in Table 1 below:

[1] For methodological reasons, measurements in the previous ERP study were not taken at the Context sentence, (1a).

Table 1: Stimuli from Dwivedi et al. (2009)

Number	Context: Ambiguous	Context: Control
Plural continuation	Every kid climbed a tree. The trees were in the park.	Every kid climbed a different tree. The trees were in the park.
Singular continuation	Every kid climbed a tree. The tree was in the park.	Every kid climbed the same tree. The tree was in the park.

Thus, the within-subjects study was defined by two independent variables: type of Context (Ambiguous (A) or Control (C)) and type of Continuation sentence (Plural (P) or Singular (S)). ERPs were recorded at the Noun, Verb and Verb+1 position in Continuation sentences. Results were not consistent with those found by K&M; there was no neurophysiological evidence for a preference for the plural continuation. Instead, both Ambiguous Plural (AP) and Ambiguous Singular (AS) continuation sentences patterned together, exhibiting a late sustained negative shift 900 ms after the presentation of the Noun “tree(s)” and lasting throughout the presentation of the auxiliary Verb “was/were” (for details of analysis and discussion, please see Dwivedi et al., 2009). This finding was interpreted as evidence that in very early stages of linguistic analysis, the parser/brain leaves scope ambiguous sentences as “underspecified”, to be resolved later. Interestingly, the Control Singular condition also patterned with Ambiguous Plural and Ambiguous Singular conditions. We explained that finding by pointing out that the comparative adjectives “same” and “different” both have deictic as well as sentence internal interpretations (Carlson, 1987). Since there is no previous context, both “same” and “different” are interpreted on their sentence-internal interpretation (ie., “Every kid climbed the same tree *as compared to each other”*; “Every kid climbed a different tree *as compared to each other”*). However, the presence of the definite determiner in “**the** same” condition vs. “**a** different” allowed the processor to still entertain a deictic reading, effectively allowing for scope ambiguity in Control Singular conditions (see Barker, 2007).

The question therefore remains: given processing principles such as the *Minimal Structure Hypothesis*, as well as previous empirical findings, why was no preference found? The present work sought to answer this question. One possibility could be that ERP measures occur very early in the time course of linguistic analysis. The preferences that K&M reported were measured at the end of sentences, arguably quite late in terms of language processing. It is unclear what might occur using another on-line technique, which measures slightly later on than the ERP technique. While scope ambiguous sentences could be left underspecified very early on, perhaps slightly later on, these are assigned a preferred analysis. In the present work, self-paced reading methodology is used, which is an on-line technique, arguably without the exquisite time resolution of ERPs. In order to try and replicate the finding that surface scope is the preferred interpretation of sentences such as (1a), we also limited our stimuli selection (to be described below) and used better controls (as described below).

Given these design changes, we predicted that Ambiguous context sentences would be interpreted on their surface scope reading. As such, the empirical effect of this interpretation would be that the AP continuation would be preferred as compared to AS. Thus, reading times for AP sentences should not differ from their control, CP, whereas the Ambiguous Singular condition, the non-preferred condition, should take significantly longer to read as compared to its control, CS. Given our previous findings that indicated a late effect regarding this disambiguation, we predicted that effects would occur after the Verb in the Continuation sentences. On the other hand, it could be the case that even at the stage of processing as measured by reading times, scope ambiguous constructions are still left underspecified. If that is the case, then the prediction would be that Ambiguous contexts would be read faster than their Controls, since the former would be processed in a shallow manner. Predictions regarding continuation sentences are unclear; this RT advantage could carry over, or not. In addition, if no preference for an interpretation is made at the Context sentence, then both plural and singular continuations would likely be processed similarly, resulting in no difference for these sentences. Furthermore, if shallow processing is the result of a lack of cognitive resources, then it could be the case that readers with Low working memory spans show Ambiguous context differences more strongly than those with High working memory.

2. Methods

2.1 Participants

80 right-handed native speakers of English (59 female, mean age 22 years, range 18 to 34 years) were recruited at Brock University and were either paid $10 each to participate in the experiment or were given partial course credit (if applicable).

2.2 Materials

24 experimental stimuli were prepared such that each consisted of 2 sentences: a Context sentence and a Continuation sentence. The Context sentence always began with “Every NP” as a subject, and the direct object was either an NP preceded by an existential quantifier (“a”) for Ambiguous contexts, or a demonstrative determiner (“that/those”) for Control contexts. The use of these referential determiners would ensure that no scope ambiguity could occur with these conditions. The continuation sentences began with a singular or plural subject noun phrase and auxiliary verb (“The tree(s) was/were”; “The melon(s)

was/were”), followed by either a prepositional phrase (“in the park”) or conjoined adjectives (“soft and juicy”). Please see Table 2 below.

The 24 items were combined with 64 stimuli from an unrelated experiment, and 64 fillers, for a total of 152 items. Four lists were created in order to ensure that the conditions were counterbalanced in Latin square format. In order to ensure that participants were paying attention to the experiment, the 64 filler items were followed by simple questions pertaining to their superficial content. The questions were forced choice, with two buttons (labeled as “1” and “2”) designated for answer selection. An example stimulus/question pair is shown in (5) below:

(5) Because of the thunderstorm, Lara had trouble sleeping.
She felt terrible the next day.

Did Lara sleep well?
1) Yes 2) No

Participants pressed the button that corresponded to the answer on the screen. Answers were counterbalanced such that an equal number of correct answers were displayed on the right and left side of the screen.

Table 2: Critical Stimuli (example).

Number		Context: Ambiguous	Context: Control
	Plural continuation	Every kid climbed a tree. The trees were in the park.	Every kid climbed those trees. The trees were in the park.
	Singular continuation	Every kid climbed a tree. The tree was in the park.	Every kid climbed that tree. The tree was in the park.

2.2.1 Stimuli

The 24 ambiguous context sentences were selected from a previous off-line study conducted reported in Dwivedi, Phillips, Einagel and Baum (2009). Two semi-randomized lists were created and 32 subjects (none of whom participated in the present experiment) read ambiguous context sentences as above, and were asked to circle their preference (see Figure 1). In this off-line task, discourses were presented in a booklet in a pseudo-random order, with the constraint that no more than two of the same type of trial succeeded one another. In each list, 80 ambiguous context sentences were presented, as well as 80 unambiguous ones (40 Control Singular and 40 Control Plural, as in Table 1 above). Note that plural and singular continuation choices were counterbalanced to appear either on the top or bottom position. In addition, 80 fillers were used from an unrelated experiment. Results were consistent with those of Kurtzman and MacDonald (1993), such that the plural interpretations were preferred for Ambiguous contexts such as *Every kid climbed a tree* 73% of the time. For the present study, an items analysis was conducted. Results indicated that not all items were biased in the same way, such that plural judgments ranged from 20-

100%. The 24 items used in the present study were 93-100% plurally biased, i.e., heavily biased for surface scope interpretation (11 items judged as plural at 100%, 9 at 94%, and 4 at 93%).

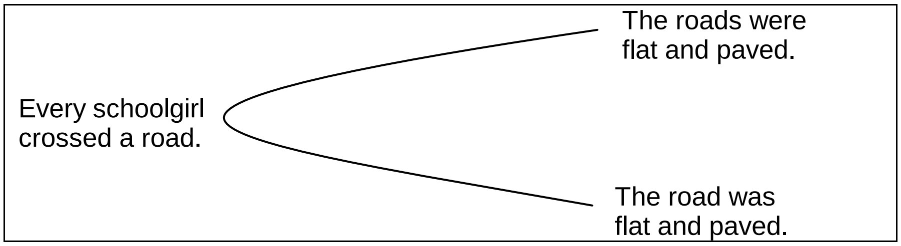

Figure 1: An example of an ambiguous pretest item.

2.3 Procedure

2.3.1 Working Memory Task

A Working Memory task derived from Daneman & Carpenter (1980) was administered to participants prior to the computer-based task (Siegel & Ryan, 1989). In the task, sentences were read aloud to participants such that the final word in each sentence was left blank. Participants were instructed to produce the most appropriate concluding word. Subsequent sentences were administered immediately following the participant's response. After presentation of sentence(s), participants were instructed to recall the concluding words they had named, in the order presented.

Each span level contained 3 sets; a set consisted of one "round" of sentence completions, followed by word recalls. If the participant achieved a perfect score on at least one set of a given span level (for having the correct words in the order presented), they qualified to advance to the next span level. If a participant failed to achieve a perfect score on any of the sets within a level, the task was concluded and the computer-based task was then administered. Working memory span was defined as the total number of final words out of 18 that were recalled (i.e., 6 levels @ 3 sets/level yields a maximum score of 18). The mean span was 7.73 (*SD = 2.24*; range = 3 to 15). Participants scoring higher than the mean (8 or higher) were categorized as "High WM", while participants scoring 7 or lower were placed in the "Low WM" category.

2.3.2 Self-Paced Reading Task

Following the WM task, participants were administered a computer-based non-cumulative self-paced reading task. Both sentences were presented at once, and were masked by dash symbols (-) before reading commenced, such that each letter/punctuation mark within a word was allotted one dash, while spaces were left blank. When the participant pressed the ‘advance’ button on the button box, the first word was displayed, while the rest of the words remained masked. The second word was revealed upon a second button press, while again the rest of the words remained masked; furthermore, the first word was “re-masked” with dashes. Reading time was recorded as the time between button presses. This presentation pattern continued as such through to end of the continuation sentence. Note that the continuation sentence always began on a new line, on the left margin adhered to by the context sentence (the same applied for lengthy sentences which occupied more than one line). Before starting the experiment, participants practiced on a short list of items in order to familiarize themselves with the task.

E-Prime software was used to present the self-paced reading task. A 19" widescreen Dell LCD monitor was approximately 18-24 inches from the participant, level with the participant's point of view. The order of sentence presentation was randomized per participants by E-Prime software. Participant responses were recorded via a PSTnet button box.

3. Results

The individual participant results obtained for accuracy on the comprehension questions were averaged, with an overall average of 95.94% accuracy obtained, indicating that participants were indeed paying attention.

Reading times: Outlier data were filtered by establishing upper and lower ceiling values, such that any data point (within subject, condition, and word position) exceeding 2 standard deviations in either direction was attenuated to the nearest ceiling value. This affected less than 1% of the data. Tables 3 and 4 report the average raw reading time for Context sentences at the post-verbal region (for ambiguous contexts "a tree"; for control contexts: "that/those tree(s); as such this is called the Art-DO region for Article Direct Object) and final word position (the Direct Object only, "tree(s)), respectively, and Table 7 reports the average raw RTs for Continuation sentences (S2) at the subject-Verb ("tree(s) was/were") region. Finally, Table 9 reports RTs for the post-disambiguation region (V1V2V3 "in the park") for Continuation sentences. From these tables and Fig. 2, it is apparent that significant differences in RTs are only apparent at S1, the Context sentence, to be discussed in detail below.

Separate 2 (Working Memory) x 2 (Context) x 2 (Number) ANOVAs, using Residual Reading Times (RRT; see Trueswell & Tanenhaus, 1994; Ferreira & Clifton, 1986) were conducted for the Context sentence (S1) and Continuation sentence (S2).

Table 3: Context sentence Mean Raw Reading Times and Standard Deviations at the post-verbal region (Art-DO).

Condition	*Mean Time (ms) / S. D.*
Ambiguous	427 / 123
Control	460 / 145

Table 4: Context sentence Mean Raw Reading Times and Standard Deviations at the final word position (Direct Object).

Condition	*Mean Time (ms) / S.D.*
Ambiguous	484 / 169
Control	536 / 211

Table 5: Context sentence ANOVA at the post-verbal ROI (Art-DO) based upon RRT data.

Effect (df)	F_1 *Value*	*p Value*	*Mean Square Error*
C (1, 78)	4.8	0.03	6111
N (1, 78)	1.0	0.32	7672
C * N ((1, 78)	1.1	0.31	4922
C * WM (1, 78)	3.4	0.06	6111

C= Context; N = Number; WM = Working Memory.

Table 6: Context sentence ANOVA at the final word position (Direct Object) based upon RRT data.

Effect (df)	F_1 *Value*	*p Value*	*Mean Square Error*
C (1, 78)	16.7	0.00	15365
N (1, 78)	0.1	0.77	22504
C * N ((1, 78)	1.4	0.24	12569
C * WM (1, 78)	2.6	0.11	15365

C= Context; N = Number; WM = Working Memory.

The results of a 2x 2 x 2 mixed ANOVA involving Working memory (High vs. Low), Context (Ambiguous vs. Control) and Number (Plural vs. Singular) based on RRT data show that a main effect of Context was found at the post-verbal region (Art-DO) (F_1 (1, 78) = 4.8, *MSE* = 6111; *p* = 0.03; F_2 (1, 46) = 2.033, *MSE* = 10937, *p* = 0.16). Additionally, the same ANOVA was run (F_1 (1, 78) = 16.7, *MSE* = 15365; *p* = 0.00; F_2 (1, 46) = 5.9, *MSE* = 16084, *p* = 0.02) at the Direct Object (final word position) within the Context sentence. (i.e., "Every kid climbed a/that/those **tree(s)**"). Although the RRT analysis corrects for length differences, the significance at the DO region confirms that the effects present at the Art-DO region are not due to simple length differences between Ambiguous and Control context sentences. A trend involving the Context x Working Memory interaction (F_1 (1, 78) = 2.6, *MSE* = 15365, *p* = 0.11;) was revealed, indicating that a major contributor to this difference could be the High Working memory group. Simple pair-wise comparisons revealed that within the High WM group, there was a 56 ms RT difference between contexts (Ambiguous = 416 ms; Control = 472 ms).

Table 7: Continuation Sentence Mean Raw Reading Times and Standard Deviations at the Subj-V ROI.

Condition	*Mean Time (ms) / S. D.*
Ambiguous	353 / 90
Control	356 / 93

For Continuation sentences, no main effects or interactions were found at the subject-Verb region (based on RRT data; see Table 8). Averaged raw reading times (Table 7) show only a 3 ms difference between contexts.

Table 8: Continuation sentence ANOVA at the Subj-V ROI based upon RRT data.

Effect (df)	*F_1 Value*	*p Value*	*Mean Square Error*
C (1, 78)	1.3	0.27	1766
N (1, 78)	0.6	0.45	1890
C * N ((1, 78)	0.2	0.69	1198
C * WM (1, 78)	0.2	0.66	1766

C= Context; N = Number; WM = Working Memory.

Table 9: Continuation sentence Mean Raw Reading Times and Standard Deviations at the post-verbal ROI (V1-V2-V3).

Condition	*Mean Time (ms) / S. D.*
Ambiguous	413 / 124
Control	408 / 117

Raw reading times at the post-disambiguation region (see Table 9), defined as V1-V2-V3 (“in-the-park”) in Continuation sentences, revealed a small 5ms RT advantage for Ambiguous vs. Control conditions. As Table 10 shows, this did not result in a significant Context effect; no other significant main effects or interactions were found for this region.

Table 10: Continuation sentence ANOVA at the post-verbal ROI (V1-V2-V3) based upon RRT data.

Effect (df)	*F_1 Value*	*p Value*	*Mean Square Error*
C (1, 78)	0.853	0.36	4581
N (1, 78)	1.542	0.22	3741
C * N ((1, 78)	1.847	0.18	3053
C * WM (1, 78)	1.395	0.24	4581

C= Context; N = Number; WM = Working Memory.

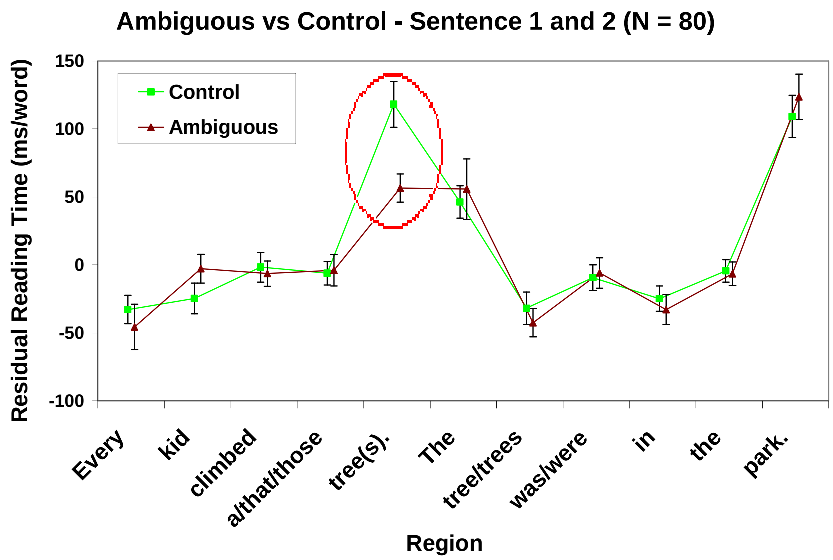

Figure 2: Average residual reading times at each word position for Ambiguous vs. Control conditions.

4. Discussion

The purpose of the present study was to examine whether scope ambiguous sentences such as *Every kid climbed a tree* exhibited a bias for surface scope interpretations as measured by self-paced reading times. Such a bias would be expected on both theoretical (see Dwivedi, 1996) and empirical (K&M; Anderson, 2004) grounds. However, an earlier ERP study that we conducted (Dwivedi et al., 2009) did not show such a preference. Results for the present study indicate that despite the fact that heavily biased items were used (where these biases were measured in an off-line judgment task), in addition to better Control conditions, no differences were found between Ambiguous Plural and Ambiguous Singular continuation sentences. Instead, Ambiguous context sentences patterned together as compared to the Control contexts. That is, Ambiguous context sentences were read more quickly at post-verbal regions than Controls. Furthermore, no significant main effects or interactions were observed in Continuation sentences. Although a trend for an interaction between Context x Working memory was observed, no significant effects involving working memory were found. We interpret these findings in terms of an account that posits that scope ambiguous sentences are left underspecified, and as a result are only processed using "good enough" strategies. This leads to faster RTs for these constructions vs. unambiguous control contexts, which are processed more deeply. We discuss the significance of these findings below.

The first point to note is that despite the fact that stimuli were heavily biased for a particular interpretation, (93-100% bias for surface scope interpretation found off-line) no on-line evidence of this was observed. This point underscores the importance of the use of converging methodologies in investigations of language processing. In off-line judgment tasks, readers are presented with sentences all at once; furthermore, they have time to consider pragmatic implications of scenarios as posited by certain lexical items. Furthermore, while K&M's study was computer-controlled, there too, judgments were measured at the end of sentences which were presented all at once. In other words, the preferences previously observed were due to very late linguistic processes. Self-paced reading methodology, on the other hand, presents words one-at-a-time. This more on-line technique measures earlier stages of language processing, where syntactic and semantic computations occur, and as such sheds light on an earlier time course of language processing. Thus, both self-paced reading as well as ERP measures indicate that scope ambiguous sentences are interpreted as underspecified constructions. In a future experiment, we will test whether the effect remains if participants are explicitly asked about scope interpretation during on-line reading. That is, it could be the case that readers do not resolve scope ambiguous sentences simply as a way of saving time during reading. Perhaps if readers were asked on different trials about scope interpretation (see Swets et al., 2008) the difference between Ambiguous and Control conditions would be attenuated. Furthermore, an explicit scope bias might also then be found. This remains open for future investigation.

From a theoretical perspective, according to Sanford & Sturt (2002) and Swets et al., (2008), faster reading times for Ambiguous contexts are expected, since these are read with less commitment, or in a shallower manner, than are unambiguous Controls. Swets et al. (2008), replicating findings by Traxler et al. (1998), showed that sentences with temporary ambiguities as in (6a) were read more quickly than those that were disambiguated, as in (6b) and (6c):

(6) a. The maid of the princess who scratched herself in public was terribly humiliated.
b. The son of the princess who scratched himself in public was terribly humiliated.
c. The son of the princess who scratched herself in public was terribly humiliated.

Swets et al. (2008) showed that under superficial task demands (that is, when participants knew that they would not have to prove whether they knew whether it was the maid or the princess who scratched herself in public), participants showed an ambiguity advantage in RTs for (6a) vs. (6b) and (6c), exactly analogous to the findings at hand. The idea is that the parser leaves the attachment of the Relative Clause in (6a) as underspecified; consistent with the principle of "revision as last resort", where the parser does not want to revise structure it has already built (see Sturt, Pickering, Scheepers & Crocker, 2001). If we extend that explanation to the present findings, then the parser does not commit to a particular scope assignment; instead it simply leaves scope ambiguous sentences as underspecified. Under this explanation, the fact that at Continuation sentences, no main effects or interactions were found has two possible explanations. Either it is the case that given that there is no preference for a particular scope assignment in Ambiguous contexts, both continuations are equally plausible (and hence there is no difference between these and Control continuation sentences) or it is the case that once readers adopt a shallow processing strategy in the first sentence, they simply assume coherence with the second sentence (note that RTs for Ambiguous post-disambiguation regions were slightly faster, though not significantly so, than Controls; see Barton & Sanford, 1993). Hannon & Daneman (2001) indicate that once shallow processing is adopted "the comprehension system may assume coherence as a default, as long as there is sufficient global coherence," (Ibid., p. 459).

An alternative explanation could be that the difference found between Ambiguous vs. Control context sentences has less to do with sensitivity to ambiguity (leading to shallow processing) and instead has to do with pragmatic anomaly. In other words, it could be the presence of the demonstrative determiners "that" and "those" in the referential Control contexts, which cause the difference in RTs between Ambiguous vs. Control conditions (recall that the residual reading time data argue against a simple length difference). That is, since Control context sentences were not preceded by sentences that posited the existence of the direct objects (e.g., "that/those tree(s)"), perhaps the slowed RTs here are due to presuppositional failure. A further experiment is planned to test this hypothesis. One preliminary argument that would support the present claim, however, would be that if this were a pragmatic anomaly effect, we might expect to see spill-over effects at the Continuation sentence, specifically at the subject-Verb region, where reference to the direct object is made again. However, no main effects or interactions were found in that region. Second, if the empirical effect were captured via pragmatic anomaly (instead of underspecification due to ambiguity), then it is hard to explain why Continuation sentences did not show differential effects. In any case, only future research can adjudicate between the explanations above.

As a final note, it is interesting that behavioural responses at the Continuation sentences showed no significant effects or interactions as a result of underspecification in the Ambiguous context sentence. That is, not only was it the case that no differences were found between AP and AS continuation sentences, no differences were found for Ambiguous vs Control continuations, either. The lack of a contrast for the latter conditions differs from that found in our previous ERP experiment (Dwivedi et al., 2009). For that experiment, continuation sentences following scope ambiguous context sentences exhibited a Late Slow Negative Wave, which is understood as a waveform that is elicited when complex computational tasks are required. In other words, it seems that the brain was doing the work of integrating the continuation sentence into the underspecified context. In the present study, this effect was not observed behaviourally (that is, where Ambiguous continuation sentences would take longer to process than Control sentences). One reason for the difference could be that the rate of presentation of the stimuli in the ERP experiment was relatively slow (one word per 600 ms, compared to a normal reading rate of about 5 words per second) and not under the control of the reader. As such, in the ERP Continuation sentence, readers have the time to integrate the sentence into the previous context sentence, which is left as underspecified, and as a result of this, exhibits a cost in neurophysiological processing. In contrast, for the self-paced reading study, once readers decide to be quick and shallow, they may continue on with that strategy, which is compatible with what was observed (cf. Barton & Sanford, 1993; Hannon & Daneman, 2001). A future ERP study is planned where readers will control the rate of presentation of the sentences. In addition, we note that behavioural and EEG data do not always match for particular phenomena, as these techniques measure different time courses of language and perceptual processing (see work in the Attentional Blink paradigm, eg. Luck, Vogel & Shapiro, 1996; Vogel, Luck, & Shapiro, 1998)

In sum, the present study confirms previous findings regarding scope ambiguous sentences—these are left as underspecified constructions. That is, despite the fact that we used previously normed stimuli that were heavily biased for plural interpretations (surface scope), no (on-line) preference was found for AP or AS continuation sentences as compared to their controls. Instead, there was an advantage for Ambiguous context sentences—these were read more quickly than their control counterparts. Thus, commitment has a cost. Furthermore, the behavioural measure replicated patterns found with EEG, where no difference between AP and AS was found. In addition, underspecification is indeed a strategic use of resources: no difference was found between High vs Low span readers. Clearly this preliminary work asks more questions than it answers. In future research, steps will be taken in order to modulate depth of processing. For example, a previous context sentence will be added for two reasons: this will give an appropriate context set for quantifiers to range over. Perhaps if the grammatical requirements of the quantifier are not met, the parser does not do the work of interpreting the quantifier which could lead to the additional consequence of no scope assignment. In addition, an additional context sentence would serve to better integrate the Control contexts, which both use demonstrative determiners “that” and “those”. Second, in another experiment, every trial will be followed by questions that specifically ask about the scope assignment; as a result, readers might pay more attention to the goal of assigning scope.

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