What can sentence processing tell us about syntax

1. Introduction

Traditionally, linguists are relying on native speakers' "acceptability judgment" of sentences as the source of data. Recently, however, the importance of large-scale formal experiments has been emphasized (Phillips and Lasnik 2003, Phillips 2013, 2003, Sprouse 2008, 2011, Sprouse and Almeida 2012, Sprouse et al. 2012, Sprouse and Almeida 2013, Sprouse et al. 2013). The usefulness and the limits of certain experimental methodologies have been debated in the recent literature (Den Dikken et al. 2007, Fanselow 2007, Featherston 2007 among many others). The point of contention lies in the reliability of "acceptability judgment" methodologies. In addition to "acceptability judgment" methodologies, online sentence processing experiments have sometime been employed to answer questions in theoretical syntax and semantics (Bever and McElree 1988, Hackl et al. 2012, Huang et al. 2016, Koizumi and Tamaoka 2004, Kotek and Hackl 2013, McErlee and Bever 1989, Pickering and Barry 1991 among many others). In such studies, online measures (e.g., time spent for reading each word in a sentence (Reading Time or RT)), has been used to argue for or against syntactic analyses. Thus, it has been suggested that both offline methodologies (e.g., "acceptability judgment") and online methodologies (e.g., reading time experiments) can provide rich source of data and insights for formal syntactic theories.

In this light, I would like to think about what can online sentence processing studies tell us about syntax. In other words, I am interested in how online sentence processing experiments help us make progress in syntactic theories.

2. Sentence Processing

One of the central goals of the study of sentence processing is to describe the mechanism of online sentence comprehension (see Boland 2005, Crocker 1996, Pickering and Traxler 2000). As part of the mechanism of sentence comprehension, a theory of syntactic parsing can be developed, which specifies, for example, how the structure of sentences is build, what structure of sentence is built and what sort of linguistic and non-linguistic knowledge influences the structure building.[1] Thus typically, the study of sentence processing involves, a theory of structure building (or a structure building algorithm), a theory of representation (or a theory of syntax), and considerations of linguistic and extra-linguistic factors that affects the structure building (e.g., syntactic constraints, working memory consideration, frequency of lexical items in the corpus etc.).

In addition to these considerations, to experimentally investigate the mechanism of sentence processing, a linking hypothesis must be established. A linking hypothesis is a hypothesis that maps the measures (e.g., RT) observed through experiments and the behavior of the model of sentence processing mechanism. In other words, we need to establish the relationship between a model of sentence processing mechanism and experimentally obtained data.

Let us take an example of well-known garden path sentences, and explore these points

[1] What structure the parser builds depends on the theory of representation assumed in the theory of sentence processing mechanism. It is possible that the online sentence comprehension mechanism builds the structure that is different from what the grammar licenses. For example, it is possible that the online comprehension mechanism builds a rough and ready structure that is sufficient for obtaining the rough meaning of the sentence (e.g., thematic relations, grammatical functions etc.) (Ferreira et al. 2002, Ferreira and Patson 2007, Fodor et al. 1974). This is independently an interesting point, but I will not go into details about this and simply assumes that the structure that the parser builds is the same as what the grammar licenses.

further. An example like (1) cause the so-called garden path effect, i.e., it is difficult to comprehend a sentence like (1).

(1) The horse raced past the barn fell.
  a. $[_{CP}[_{TP}$ the horse $[_{VP}$ raced past the barn]]]
  b. $[_{CP}[_{TP}[_{DP}$ the horse $[_{CP}$ Op_1 $[_{TP}$ t_1 $[_{VP}$ raced past the barn]]]]]]$[_{T'}$ T $[_{VP}$ fell]]

In online reading experiments, the slower RT of the main verb *fell* compared to the appropriate baseline condition is typically observed, and it is normally understood that the RT slowdown is caused by the difficulty associated with an example like (1).

Let us suppose that we indeed observed RT slowdown at the main verb position, i.e., when the main verb *fell* is read slower than the baseline condition in a reading time experiment, such as a word-by-word self-paced moving window experiment. What does this RT slowdown tell us? Normally, the RT slowdown in this case is interpreted as the cost (or difficulty) associated with the reanalysis process. When the main verb *fell* is encountered, the reader is forced to reanalyze the structure of the sentence from (1a) (the main clause analysis) to (1b) (the reduced relative clause analysis). When the string *the horse raced past the barn* is encountered, the parser built the main clause structure in (1a) probably because there is no element that suggests other analysis. When the parser recognized that the verb *fell*, the parser recognized that *fell* is not compatible with the structure in (1a) and is forced to reanalyze the structure. Thus, the RT slowdown is understood as caused by the parser's attempt of reanalysis.

This understanding of the RT slowdown in the processing of a typical garden path sentence like (1) requires certain assumptions about the "components" of a theory of sentence processing. First, it is assumed that a certain structure is built by the parser. In the case of (1), it is assumed that "the correct structure" of the sentence in (1) is something like (1b), where a reduced relative clause modifies the subject NP. Second, it is assumed that the parser temporarily builds "a wrong structure" such as (1a), where the string *raced past the barn* is analyzed as the VP of the main clause. Third, the main clause structure in (1b) is built by the parser because the parser does not find any evidence until the verb *fell* is encountered, that suggests that the string *raced past the barn* should be part of the relative clause attached to the subject DP. In other words, the parser builds the structure online based on the information available locally. Thus, in (1), the verb *raced* is ambiguous, but the parser prefers the main clause structure over the reduced relative structure. This means that there is a mechanism (and linguistic or extra-linguistic factors) that governs the preference for the main clause structure. Furthermore, the parser does not delay in building a structure of the sentence. If the parser does not build the structure before an element that comes at the later point of the sentence such as the verb *fell* in (1), the garden path effect is not expected as the parser can build the structure using the information from the verb *fell*, which suggests that *raced* cannot be the verb in the main clause. Finally, it is assumed that when the parser encounter the verb that suggests the structure built so far is "a wrong structure", the parser reanalyzes the structure and builds "the correct structure".

In this view, the linking hypothesis is concerned with the parser's structure building. That is, the slow RT of the word *fell* is linked to the parser's reanalysis process. It is important to note that the observation (i.e., the RT slowdown) is not linked directly to the syntactic structure itself. Rather, it is linked to the hypothesized behavior of the mechanism of sentence processing, namely the reanalysis process.

3. Linking Hypotheses

In the experimental psycholinguistics literature, various linking hypotheses have been assumed in the model of online sentence processing. Some of the linking hypotheses in the literature are summarized in (2) (the list is taken from Crocker 2005). Various models of sentence processing assume that RT slowdown or speedup is due to:

(2)
a. Structural complexity (Frazier 1985)
b. Backtracking (Abney 1989, Crocker 1996)
c. Non-monotonicity (Sturt and Crocker 1996)
d. Non-determinism (Marcus 1980),
e. Re-ranking of parallel alternatives (Jurafsky 1996,Crocker and Brants 2000),
f. Storage and integration cost (Gibson 1998)
g. The reduction of uncertainty (Hale 2003)
h. Competition (McRae et al. 1998

I do not go into details about each of the linking hypotheses listed in (2). However, it is important to note that each linking hypotheses in this list are concerned with what the parser does (e.g., reanalysis, or re-ranking of alternatives, storing elements in the memory) and the property of the structure that the parser builds (e.g., structural complexity). Linking hypotheses are not directly concerned with the syntactic structures. Given that most of the times, the theory of representation must be independently assumed and justified, the relation between the data from online experiments and the theory of representation must be indirect. In other words, given that the theory of representation must be independently assumed, it is difficult to test theories of representation directly, using the data from online sentence processing experimental.

4. Sentence Processing and Syntax

Given the view of the study of sentence processing outlined above, what can sentence processing tell us about formal syntax and formal linguistic theories? As noted above, formal linguistic theories or theories of syntactic representations alone do not provide prediction in terms of online sentence processing. To interpret the data from online experiments, a theory of structure building and a linking hypothesis must be supplied. In addition, syntactic theories are not theories of sentence comprehension or sentence production (Chomsky 1965). Thus, even if a theory of sentence processing that incorporates a specific theory syntax (or a theory of syntactic representation) failed to capture results of online sentence processing experiment, it does not immediately mean that a theory of syntax is falsified. It is always possible that the problem lies in the theory of structure building and/or the linking hypothesis. Results from online sentence processing do not bear directly on the theory of representation. Therefore, as Boland puts it, it is possible that "most psycholinguistic data is irrelevant to formal linguistic theory" (Boland 2005: 23). Still, I think (like Boland 2005), there are cases where sentence processing studies can tell us something about syntax formal linguistic theories. I would like to discuss some of such cases and think about the relation between online sentence processing studies and formal linguistic theories.

4.1. Argument/Adjunct Distinction (Boland 2005)

It is sometimes difficult to distinguish arguments from adjuncts (Boland 2005, Larson 1988, Schütze and Gibson 1999 among many others). For example, an instrumental PPs *with a monkey*

wrench in (3) shows properties of both arguments and adjuncts.[2] For example, like arguments, instrumental PPs cannot be iterated as in (3a) and they can be extracted easily from a weak island as in (3b). However, like adjunct, they can co-occur with VP pro-form, *do so*.

(3) Kim changed the tire with a monkey wrench.
  a. *John cut the meat [PP with a knife] [PP with sharp end].
  b. [PP With which key] do you deny that the butler could have opened the door?
  c. John will eat the cake with a fork and Mary will do so [PP with a spoon].

Thus, based on standard syntactic tests, it is not easy to tell whether the instrument PP is an argument or an adjunct. Boland (2005) argues that online sentence processing studies can provide a clue to distinguish arguments from adjuncts. It has been known that the processing of PPs (integrating the newly encountered PPs into the existing structure during online sentence processing), is influenced strongly by the "lexical frequency": When a lexical item can be in multiple syntactic structure (e.g., a word like *duck* can be used as a verb or a noun, or some verbs can have single object or multiple objects), the more frequent syntactic structure that the lexical item specifies, is easier to process and thus faster to process (results in a shorter RT) than less frequent ones. For example, both the verb *suggest* and *delegate* can take an NP object, but they can also take prepositional PP object, as illustrated in (4).

(4) a. The parents suggested the chore (to their kids).
  b. The parents delegated the chore (to their kids).

Boland shows that the dative PP occurs more frequently with *delegate* than with *suggest*. Assuming the linking hypothesis above, then, it is expected that the processing of the dative PP following *delegate* is easier and faster than the one following *suggest*. On the other hand, Boland argues that unlike arguments, adjuncts are not specified in verb's lexical information (i.e., adjuncts are not selected by the verb). Thus, the processing of adjuncts is not influenced by the choice of the verb. Boland et al. (2004) tested the following paradigm.[3] The PP in (5a) is read faster than (5b) in phrase-by-phrase self-paced reading experiment, that is in the case of dative PP, the lexical frequency effects were observed. On the other hand, the processing of PPs in (5b) and (5c) were not different: The lexical frequency effects are not observed for the processing of these PPs.

(5) a. The chores that the parents delegated [PP to their kids] ...
  b. The chores that the parents suggested [PP to their kids] ...
  c. The tire that the mechanic changed [PP with a monkey wrench] ...
  d. The customer that the salesman noticed [PP with a quick glance] ...

The absence of the lexical frequency effects in the processing of PPs in (5c) and (5d), following

[2] These examples and judgments are taken from Boland (2005).
[3] The experiment and the explanation are simplified. For details see Boland (2005) and Boland et al., (2004).

the linking hypothesis above, suggests that these PPs are not selected by the verb, and thus they are not arguments.

In summary, Boland suggests that argument and adjuncts can be distinguished in terms of whether a PP shows lexical frequency effects, which can be measured as RT slowdown. In Boland study, the crucial part is the linking hypothesis. She recognizes that RT is affected by lexical frequency and verb's lexical information (whether a verb selects certain PPs or not) influence the lexical frequency effects.

4.2. Backward Binding and Islands (Yoshida, Kazanina, Pablos & Sturt 2014)

I would like to discuss another online sentence processing study that can potentially tell us something about formal syntax theories, which is concerned with the processing of pronoun-antecedent cataphoric dependencies and island constraints.

Kazanina et al. (2007) showed that when the parser encounters a pronoun, the parser launches an active antecedent search. Here active antecedent search means that the parser tries to identify the antecedent and link the pronoun to the antecedent as soon as possible. Furthermore, the parser locates the antecedent only in grammatically sanctioned positions. Kazanina et al., argue that the same mechanism is working behind online cataphoric dependency formation and wh-gap dependency formation. It has been long known that the parser launches the active search for the gap upon encountering the wh-phrase (Frazier and Flores d'Arcais 1989, Phillips 2006, Stowe 1986 among others).

In the previous literature, it has been noted that when the parser attempts to link a pronoun or a reflexive to its antecedent, and if the gender information of the pronoun and the potential antecedent are not congruent (e.g., *John$_1$ hates herself$_1$*), the word that signals the gender mismatch is read slower (Sturt 2003, van Gompel and Liversedge 2003). This effect is called the Gender Mismatch Effect (GMME). The RT slowdown is thus caused by the parser's attempt to link the pronoun to the potential antecedent, and the failure of the attempt due to the mismatched gender specification of the antecedent and the pronoun/reflexive. In other words, the linking hypothesis is that RT slowdown associated with the gender mismatch is linked to parser's attempt to link the pronoun/reflexive to its antecedent (the dependency formation). Thus, if the parser does not attempt to link the pronoun/reflexive to the potential antecedent, the RT slowdown associated with the GMME is not expected. Assuming this linking hypothesis, Kazanina et al., tested the following paradigm in (6). All the examples in (6) involves the cataphoric pronoun, i.e., a pronoun that precedes the antecedent. In (6a) and (6b), the pronoun c-commands the potential antecedent *young quarterback*, which is stereotypically construed as male. On the other hand in (6c) and (6d), the pronoun is embedded within a larger NP and thus does not c-command the potential antecedent.

(6) a. He chatted amiably with some fans while the talented, young quarterback signed autographs for the kids ...

b. She chatted amiably with some fans while the talented, young quarterback signed autographs for the kids ...

c. His managers chatted amiably with some fans while the talented, young quarterback signed autographs for the kids ...

d. Her managers chatted amiably with some fans while the talented, young quarterback signed autographs for the kids ...
(Kazanina et al. 2007's experiment 3)

Kazanina et al., contend that if the parser's antecedent search and dependency formation process is constrained by grammatical constraint, such as Binding Condition C (BCC), then we do not expect to observe the RT slowdown associated with GMME in the comparison between (6a) and (6b) but we expect the GMME in the comparison between (6c) and (6d). This is so because, in (6a) and (6b), the pronoun c-commands the NP *young quarterback* and thus, linking the pronoun to the *young quarterback* results in the BCC violation. On the other hand, in (6c) and (6d), the pronoun does not c-command *young quarterback*, thus linking the pronoun to young quarterback does not result in the BCC violation. Put differently, if the parser does not build ungrammatical structure, the parser does not try to locate the antecedent for the pronoun in the position which is c-commanded by the pronoun. On the other hand, if the parser's search for the antecedent does not respect grammatical structure, then the parser could link the pronoun to the NP that is linearly the closest to the pronoun. In a word-by-word self-paced reading experiment, Kazanina et al indeed found such reading time contrast between (6a) vs. (6b) on the one hand and (6c) vs. (6d) on the other, i.e., the GMME was absent in (6a) vs. (6b) comparison but GMME was observed in (6c) vs. (6d) comparison. This result, suggests that the online structure building respects grammatical constraints such BCC, and the parser builds hierarchical structure that encodes configurational relation such as c-command.

Taking advantages of Kazanina et al's finding, Yoshida et al., (2014) investigated the online cataphoric dependency formation in the context of islands (Chomsky 1977, Ross 1967). Recently, some studies argue that island effect should be understood as a processing phenomenon not a grammatical phenomenon. In other words, these studies argue that the wh-gap dependency that spans across island boundaries is grammatical. The unacceptability that is caused by island-crossing wh-gap dependencies are due to general cognitive considerations such as processing costs and the processing overload (Hawkins 1999, Hofmeister and Sag 2010, Kluender and Kutas 1993). Furthermore, it has been known that the parser does not attempt to locate a gap within an island domain, and this is because such a dependency formation incurs too much burden to the verbal working memory. The processing of wh-filler-gap dependency involves certain component processes. The wh-phrase must be linked to a verb or a preposition so that it can be properly interpreted. Thus during the online processing of wh-constructions, the wh-phrase must be held in the working memory until the parser finds a verb or a preposition to which the parser can link the wh-phrase. Holding the wh-phrase in the memory incurs processing costs. When the wh-gap dependency spans a long distance, the parser needs to process the elements that intervenes between the wh-phrase and the gap while holding the wh-phrase in the memory. It has been known that each lexical item has different contribution to the working memory cost depending on whether the element requires discourse reference. NPs or any elements that requires discourse reference incur processing cost. For example, definite NPs are more costly than indefinite NPs. Under this view,

island effects are understood as the processing difficulty resulted from the combination of the processing cost associated with holding of the wh-phrase in the memory and the processing cost associated with the intervening elements. Elements that constitute the island boundary are typically the elements that incur heavy processing cost.

Yoshida et al argue that if the island effect is understood as the processing difficulty caused by the processing cost of the element held in the memory and the intervening elements, any online dependency formation that spans across the island boundary should show the effect similar to island effects. Thus, for example, cataphoric dependency formation, in which the pronoun must be held in working memory until it is linked to its antecedent (this is why the active antecedent search is launched), could be blocked by island boundary because holding the pronoun in the memory and processing the costly elements at the island boundary at the same time could be too costly, exactly like in the processing of wh-filler-gap dependency formation. On the other hand, if the islands are understood as grammatical constraints that are sensitive to grammatical differences between filler-gap dependency and cataphoric dependency, then, island-like effects are not expected in the online cataphoric dependency formation. Yoshida et al., tested the following paradigm in a word-by-word self-paced moving window paradigm.

(7) a./b His/Her managers revealed that [$_{NP}$ the studio [$_{CP}$ that notified Jeffrey about the new film]] selected a novel for the script ...

b./c. He/She revealed that [$_{NP}$ the studio [$_{CP}$ that notified Jeffrey about the new film]] selected a novel for the script ...

In (7a) and (7b), the pronoun does not c-command the potential antecedent *Jeffrey*. On the other hand in (7c) and (7d), the pronoun c-commands the potential antecedent. Furthermore, the potential antecedent *Jeffrey* is embedded within a complex NP island with definite NP as the head of the relative clause, which is a costly element. Because the pronoun does not c-command *Jeffrey* in (7a) and (7b), linking the pronoun to *Jeffrey* does not violate BCC, contrary to (7c) and (7d). If the cataphoric dependency can be formed in (7a) and (7b), then we expect the slower RT at *Jeffrey* region in gender mismatching (7b) than gender matching (7a). In (7c) and (7d), due to the BCC violation configuration, the parser should not attempt the dependency formation, and thus not GMME is expected. On the other hand, if the cataphoric dependency formation is blocked by island, the GMME in (7a) and (7b) is not expected. Yoshida et al, observed the GMME in (7a) and (7b) but not in (7c) and (7d), suggesting that the parser attempted the cataphoric dependency formation across an island boundary. Yoshida et al., contend that this effect is not expected straightforwardly from processing complexity accounts. But this result readily follow from the grammatical analysis of islands where two dependency types are grammatically distinguished, and islands are constraints on movement dependencies.

5. Summary

By reviewing some other related studies, I would like to discuss what a fruitful relation between online sentence processing studies and formal syntax and formal linguistic studies. What can online sentence processing tell us about syntax, and what the benefit and limitation of the online processing studies in terms of the syntax studies?

Abney, Steven. 1989. A Computational Model of Human Parsing. *Journal of Psycholinguistic Research* 18:129-144.

Bever, Thomas G., and Brain McElree. 1988. Empty Categories Access Their Antecedents During Comprehension. *Linguistic Analysis* 9:35-43.

Boland, Julie, E. 2005. Cognitive Mechansms and Syntactic Theory. In *Twenty-First Century Psycholinguistics: Four Cornerstones*, ed. Anne Cutler, 23-42. London: Lawrenec Erlbaum Associates, Publishers.

Chomsky, Noam. 1965. *Aspects of the Theory of Syntax*. Cambridge, Massachusetts: MIT Press.

Chomsky, Noam. 1977. On Wh-Movement. In *Formal Syntax*, ed. Peter Culicover, Thomas Wasow and Adrian Akmajian, 71-132. New York: Academic Press.

Crocker, Matthew, and Thorsten Brants. 2000. Wide-Coverage Probabilistic Sentence Processing. *Journal of Psycholinguistic Research* 29:647-669.

Crocker, Matthew. 2005. Rational Models of Comprehension: Addressing the Performance Paradox. In *Twenty-First Century Psycholinguistics: Four Cornerstones*, ed. Anne Cutler, 363-380. Hillsdale, NJ: Lawrence Erlbaum Associates.

Crocker, Matthew W. 1996. *Computational Psycholinguistics : An Interdisciplinary Approach to the Study of Language*: Studies in Theoretical Psycholinguistics ; V. 20. Dordrecht ; Boston: Kluwer Academic Publishers.

Den Dikken, Marcel, Judy B. Bernstein, Christina Tortora, and Raffaella Zanuttini. 2007. Data and Grammar: Means and Individuals. *Theoretical Lignuistics* 33:335-352.

Fanselow, Gisbert. 2007. Carrots - Perfect as Vegetables, but Not as a Main Dish. *Theoretical Lignuistics* 33:353-367.

Featherston, Sam. 2007. Data in Generative Grammar: The Stick and the Carrot. *Theoretical Linguistics* 33:269–318.

Ferreira, F., K. G. D. Bailey, and V. Ferraro. 2002. Good-Enough Representations in Language Comprehension [FEB]. *Current Directions in Psychological Science* 11:11-15.

Ferreira, Fernanda, and Nikole D. Patson. 2007. The 'Good Enough' Approach to Language Comprehension. *Language and Linguistics Compass* 1/1:71-83.

Fodor, Jerry A., Thomas Gordon Bever, and Merrill F. Garrett. 1974. *The Psychology of Language: An Introduction to Psycholinguistics and Generative Grammar*: Mcgraw-Hill Series in Psychology. New York,: McGraw-Hill.

Frazier, Lyn. 1985. Syntactic Complexity. In *Natural Language Parsing*, ed. David Dowty, Lauri Kartunnen and Arnold Zwicky. Cambridge, UK: Cambridge University Press.

Frazier, Lyn, and Giovanni B. Flores d'Arcais. 1989. *Filler Driven Parsing: A Study of Gap Filling in Dutch*.

Gibson, Edward. 1998. Linguistic Complexity: Locality of Syntactic Dependencies. *Cognition* 68:1-76.

Hackl, Martin, Jorie Koster-Hale, and Jason Varvoutis. 2012. Quantification and Acd: Evidence from Real Time Sentence Processing. *Journal of Semantics* 29:145-206.

Hale, John. 2003. The Information Conveyed by Words in Sentences. *Journal of Psycholinguistic Research* 32:101-124.

Hawkins, John A. 1999. Processing Complexity and Filler-Gap Dependencies across Grammars. *Language* 75:244-285.

Hofmeister, Philip, and Ivan A. Sag. 2010. Cognitive Constraints and Island Effects. *Language* 86:366-415.

Huang, Yujing, Laine Stranahan, and Jesse Snedeker. 2016. The Unaccusative Hypothesis

Revisited. In *Paper Presented at the 22nd Architectures and Mechanisms for Language Processing*

Jurafsky, Daniel. 1996. A Probabilistic Model of Lexical and Syntactic Access and Disambiguation. *Congitive Science* 20:137-194.

Kazanina, Nina, Ellen Lau, Moti Lieberman, Masaya Yoshida, and Colin Phillips. 2007. The Effect of Syntactic Constraints on the Processing of Backwards Anaphora *Journal of Memory and Language* 56:384-409.

Kluender, Robert, and Marta Kutas. 1993. Subjacency as a Processing Phenomenon. *Language and Cognitive Processes* 8:573-633.

Koizumi, Masatoshi, and Katsuo Tamaoka. 2004. Cognitive Processing of Japanese Sentences with Ditransitive Verbs. *Gengo Kenkyu*:173-190.

Kotek, Hadas, and Martin Hackl. 2013. An Experimental Investigation of Interrogative Syntax/Semantics. In *Proceedings of the 2013 Amsterdam Colloquium*, ed. Maria Aloni, Michael Franke and Floris Roelofsen, http://events.illc.uva.nl/AC/AC2013/uploaded_files/inlineitem/2019_Kotek_Hackl.pdf.

Larson, Richard K. 1988. On the Double Object Construction. *Linguistic Inquiry* 19:335-391.

Marcus, Mitchell P. 1980. *A Theory of Syntactic Recognition for Natural Language*: Mit Press Series in Artificial Intelligence. Cambridge, Mass.: MIT Press.

McErlee, Brian, and Thomas G. Bever. 1989. The Psychological Reality of Linguistically Defined Gaps. *Journal of Psycholinguistic Research* 18:21-35.

McRae, Ken, Michael J. Spivey-Knowlton, and Michael K. Tanenhaus. 1998. Modeling the Influence of Thematic Fit)and Other Constraints) in on-Line Sentence Pcmprehension. *Journal of Memory and Language 38*.

Phillips, Colin, and Howard Lasnik. 2003. Linguistics and Empirical Evidence. *Trends in Cognitive Sciences* 7:61-62.

Phillips, Colin. 2006. The Real-Time Status of Island Phenomena. *Language* 82:795-823.

Phillips, Colin. 2013. Some Arguments and Nonarguments for Reductionist Accounts of Syntactic Phenomena. *Language and Cognitive Process* 28:156-187.

Phillips, Colin, & Howard Lasnik. 2003. Linguistics and Empirical Evidence. *Trends in Cognitive Sciences* 7:61-62.

Pickering, Martin J. , and Matthew J. Traxler. 2000. Parsing and Incremental Understanding During Reading. In *Architectures and Mechanisms for Language Processing*, ed. Matthew W. Crocker, Martin Pickering and Jr. Charles Clifton, 238-258: Cambridge University Press.

Pickering, Martin. J., and Guy. D. Barry. 1991. Sentence Processing without Empty Categories. *Language and Cognitive Processes* 8:229-259.

Ross, John R. 1967. Constraints on Variables in Syntax, MIT: Ph.D.

Schütze, Carson T., and Edward Gibson. 1999. Argumenthood and English Prepositional Phrase Attachment*1, *2, *3. *Journal of Memory and Language* 40:409.

Sprouse, Jon. 2008. The Differential Sensitivity of Acceptability to Processing Effects. *Linguistic Inquiry* 39:686-694.

Sprouse, Jon. 2011. A Test of the Cognitive Assumptions of Magnitude Estimation: Commutativity Does Not Hold for Acceptability Judgments. *Language* 87:274-288.

Sprouse, Jon, and Diogo Almeida. 2012. Assessing the Reliability of Textbook Data in Syntax: Adger's Core Syntax. *Journal of Linguistics* 48:609-652.

Sprouse, Jon, Matthew Wagers, and Colin Phillips. 2012. Working-Memory Capacity and Island

Effects: A Reminder of the Issues and the Facts. *Language* 88:401-407.
Sprouse, Jon, and Diogo Almeida. 2013. The Empirical Status of Data in Syntax: A Reply to Gibson and Fedorenko. *Language and Cognitive Processes* 28:222-228.
Sprouse, Jon, Carson Schütze, and Diogo Almeida. 2013. A Comparison of Informal and Formal Acceptability Judgments Using a Random Sample from Linguistic Inquiry 2001-2010. *Lingua* 134:219-248.
Stowe, Laurie A. 1986. Parsing Wh-Constructions: Evidence for on-Line Gap Location. *Lanugage and Cognitive Processes* 3:227-245.
Sturt, Patrick, and Matthew W. Crocker. 1996. Monotonic Syntactic Processing: A Cross-Linguistic Study of Attachment and Reanalysis. *Language and cognitive processes* 11:449-494.
Sturt, Patrick. 2003. The Time-Course of the Application of Binding Constraints in Reference Resolution. *Journal of Memory and Language*.
van Gompel, Roger P. G., and Simon P. Liversedge. 2003. The Influence of Morphological Information on Cataphoric Pronoun Assignment. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 29:128-139.