



ELSEVIER

Contents lists available at ScienceDirect

Journal of Memory and Language

journal homepage: www.elsevier.com/locate/jmlThe syntactic complexity of Russian relative clauses [☆]Roger Levy ^{a,*}, Evelina Fedorenko ^b, Edward Gibson ^b^a Department of Linguistics, UC San Diego, 9500 Gilman Drive #0108, La Jolla, CA 92093-0108, USA^b Department of Brain & Cognitive Sciences, Massachusetts Institute of Technology, 77 Massachusetts Ave., Cambridge, MA 02139, USA

ARTICLE INFO

Article history:

Received 30 June 2011

Received in revised form 26 October 2012

Available online 17 June 2013

Keywords:

Sentence comprehension

Parsing

Syntax

Memory limitations in language processing

Expectation-based processing

Russian

ABSTRACT

Although syntactic complexity has been investigated across dozens of studies, the available data still greatly underdetermine relevant theories of processing difficulty. Memory-based and expectation-based theories make opposite predictions regarding fine-grained time course of processing difficulty in syntactically constrained contexts, and each class of theory receives support from results on some constructions in some languages. Here we report four self-paced reading experiments on the online comprehension of Russian relative clauses together with related corpus studies, taking advantage of Russian's flexible word order to disentangle predictions of competing theories. We find support for key predictions of memory-based theories in reading times at RC verbs, and for key predictions of expectation-based theories in processing difficulty at RC-initial accusative noun phrase (NP) objects, which corpus data suggest should be highly unexpected. These results suggest that a complete theory of syntactic complexity must integrate insights from both expectation-based and memory-based theories.

© 2013 The Authors. Published by Elsevier Inc. All rights reserved.

Introduction

Human language is distinctive among the communicative systems found in nature in its infinite expressivity. To a first approximation, every utterance that a comprehender hears is one that they have never heard before. The comprehender must thus deploy finitely-represented knowledge of language in real time to analyze the utterance. A crucial aspect of this knowledge is that of syntax, which allows a comprehender to recover the meaningful relationships between words arranged in sequences that may never have previously been encountered. The cognitive effort required for the deployment of syntactic knowledge is, however, highly variable across sentences and across words within a given sentence. In many cases the difficulty of a given

sentence is attributable to its specific syntactic properties. One key part of the central problem of sentence comprehension can thus be stated as follows: what major cognitive constraints govern the deployment of syntactic knowledge to achieve understanding in real time?

It has long been known that one major cognitive constraint in the deployment of syntactic knowledge is that humans cannot simultaneously pursue all possible analyses of an input string (partial or complete) in a cost-free way. Hence extensive work has been done on the problem of SYNTACTIC AMBIGUITY RESOLUTION, where a local ambiguity of syntactic interpretation is subsequently resolved through the influence of one or more information sources (Bever, 1970; Ferreira & Clifton, 1986; Frazier & Fodor, 1978; MacDonald, Pearlmutter, & Seidenberg, 1994; Mitchell, 1994; Tanenhaus, Spivey-Knowlton, Eberhard, & Sedivy, 1995; Tanenhaus & Trueswell, 1995; Trueswell, Tanenhaus, & Garnsey, 1994; among many others). For example, the first three words of sentence (1) are ambiguous between readings in which the defendant is the agent or the patient of the verb “examined”:

- (1) The defendant examined by the lawyer turned out to be guilty.

[☆] This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

* Corresponding author.

E-mail addresses: rlevy@ucsd.edu (R. Levy), evelina9@mit.edu (E. Fedorenko), egibson@mit.edu (E. Gibson).

For native English speakers there is measurable processing difficulty during comprehension of the rest of the sentence, which rules out the agentive reading. Though there remains disagreement regarding precise empirical details in syntactic ambiguity resolution, most notably how quickly non-syntactic information sources can be utilized, whether more than one analysis can ever be simultaneously entertained (e.g., Clifton et al., 2003), and the extent to which globally incoherent analyses are considered (Tabor, Galantucci, & Richardson, 2004), considerable evidence has also accumulated demonstrating humans' abilities in this area, and probability theory has emerged as a powerful formal framework for describing the cognitive constraints relevant in ambiguity resolution (Jurafsky, 1996).

Yet there are also well-documented processing difficulty effects which do *not* seem to arise from ambiguity in the analysis of a partial input string; we will use the term *SYNTACTIC COMPLEXITY* to describe such cases (Gibson, 1998, 2000; Lewis, 1996; Miller & Chomsky, 1963; Yngve, 1960, *inter alia*). The present paper reports experiments designed to shed further light on the nature of the cognitive constraints underlying syntactic complexity, about which there is less agreement in the field. One hope is that theories of syntactic complexity in locally unambiguous contexts may be able to subsume theories of ambiguity resolution and thus lead to a more parsimonious and satisfactory theory overall (Clifton & Frazier, 1989; Gibson, 1991, 1998; Grodner, Gibson, & Tunstall, 2002; Hale, 2001, 2003, 2006; Levy, 2008). In the study of syntactic complexity, *RELATIVE CLAUSES* (RCs) have played a particularly prominent role, partly because they exemplify one of the formally most complex corners of natural language syntax and play a key role in how language achieves its full richness of expressive capacity, and partly because they have been a rich source of empirical syntactic-complexity results. One of the most-studied cases is the asymmetry in processing difficulty between English *SUBJECT-EXTRACTED* and *OBJECT-EXTRACTED* transitive RCs as in (2) below, in which both the head noun phrase (NP; *the reporter* in (2)) and the RC-internal NP (the subject in an object-extracted RC, or the object in a subject-extracted RC; *the senator* in (2)) are animate, definite, and full.

- (2) a. The reporter who attacked the senator hoped for a story. (Subject-extracted RC)
 b. The reporter who the senator attacked hoped for a story. (Object-extracted RC).

A wide range of experimental studies (Ford, 1983; Grodner & Gibson, 2005; Gordon, Hendrick, & Johnson, 2001; King & Just, 1991; Traxler, Morris, & Seely, 2002; Wanner & Maratsos, 1978, *inter alia*) have demonstrated that comprehension difficulty is differential for these cases: the object-extracted RC (ORC; (2b)) is more difficult than the subject-extracted RC (SRC; (2a)). These studies have also demonstrated that processing difficulty is localized: the locus of greatest processing difficulty is at the ORC verb (Grodner & Gibson, 2005). More recently, the results of Staub (2010) suggest that the onset of the subject NP in ORCs—the word *the* in (2b)—may also be a locus of some processing difficulty (a point we will return to in the general discussion of Experiment 2). Hence ORCs of the type

seen in (2b) are more complex than the SRCs of the type seen in (2a), and the measurable processing difficulty associated with that complexity is localizable to two different regions within the RC. The English SRC/ORC processing asymmetry of (2) serves as an effective touchstone for describing the wide variety of theories of syntactic complexity prominent in the literature today and upon which the new research reported in this paper, on the syntactic complexity of Russian relative clauses, will bear. The remainder of this introduction provides an overview of both general and RC-specific theories of syntactic complexity. Experiment 1 and Experiment 2 each report two studies on Russian RC comprehension designed to discriminate and test the predictions of a wide range of these theories. We conclude with a general discussion of these results and their theoretical implications.

Memory versus expectations as foundations of syntactic complexity

In broad strokes, two prominent classes of theory regarding the key cognitive constraint determining syntactic complexity can be identified: theories based on *MEMORY LIMITATIONS* and theories based on *EXPECTATIONS* (see Gibson & Wu (2013) for a similar summary). One such theory based on memory limitations is the *DEPENDENCY LOCALITY THEORY* (DLT, closely related to its predecessor, the *SYNTACTIC PREDICTION LOCALITY THEORY*: Gibson, 1998, 2000), according to which the key operations in syntactic comprehension are *STORAGE* and *RETRIEVAL* of potential elements in structural dependency relationships within a sentence, and *INTEGRATION* of a retrieved preceding element into a structural dependency relation with the current input. On this theory, the resources involved in retrieval, integration, and maintenance of stored-element representations are limited. Thus dependency integrations are more difficult when more elements need to be integrated simultaneously, and when the retrieved elements have greater linear distance from the integration site. The DLT successfully predicts the English SRC/ORC processing difficulty asymmetry: the most integration-intensive word in either RC of (2) is the ORC verb *attacked*, with which both the preceding subject and object NPs must simultaneously be integrated; no other word in (2a) or (2b) involves more than one simultaneous integration (see Gibson, 1998, 2000 for further details).

A closely related theory is the *ACTIVATION AND CUE-BASED RETRIEVAL* theory of Lewis and Vasishth (2005; see also Lewis, Vasishth, & Van Dyke, 2006; Vasishth & Lewis, 2006). In this theory, the representation of a sentence in real-time comprehension is an incrementally extended syntactic structure; similar to DLT, the theory's processing bottleneck is retrieval of a preceding syntactic element or elements from this structure, with which the current input word must be integrated. Once an element is stored in memory, its activation level begins to decay, so that greater linear distance between a dependent and its governor generally increases the difficulty of the dependency integration, as in DLT. A distinguishing feature of the activation and cue-based retrieval theory, however, is that when elements of the incremental structure are accessed intermediately, they are reactivated, counteracting decay. This reactivation means that

Download English Version:

<https://daneshyari.com/en/article/10459732>

Download Persian Version:

<https://daneshyari.com/article/10459732>

[Daneshyari.com](https://daneshyari.com)