



## Syntactic predictions and asyntactic comprehension in aphasia: Evidence from scope relations



Maria Varkanitsa<sup>a,\*,1</sup>, Dimitrios Kasselimis<sup>b,c</sup>, Andrew J.B. Fugard<sup>d</sup>,  
Ioannis Evdokimidis<sup>c</sup>, Judit Druks<sup>a</sup>, Constantin Potagas<sup>c</sup>, Hans Van de Koot<sup>a</sup>

<sup>a</sup> Department of Linguistics, University College London, UK

<sup>b</sup> Department of Psychology, University of Crete, Greece

<sup>c</sup> Department of Neurology, School of Medicine, National & Kapodistrian University of Athens, Greece

<sup>d</sup> Department of Clinical, Educational & Health Psychology, University College London, UK

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### ABSTRACT

People with aphasia (PWA) often fail to understand syntactically complex sentences. This phenomenon has been described as *asyntactic comprehension* and has been explored in various studies cross-linguistically in the past decades. However, until now there has been no consensus among researchers as to the nature of sentence comprehension failures in aphasia. *Impaired representations* accounts ascribe comprehension deficits to loss of syntactic knowledge, whereas *processing/resource reduction* accounts assume that PWA are unable to use syntactic knowledge in comprehension due to resource limitation resulting from the brain damage. The aim of this paper is to use independently motivated psycholinguistic models of sentence processing to test a variant of the *processing/resource reduction* accounts that we dub the Complexity Threshold Hypothesis. According to this hypothesis, PWA are capable of building well-formed syntactic representations, but, because their resources for language processing are limited, their syntactic parser fails when processing complexity exceeds a certain threshold. The source of complexity investigated in the experiments reported in this paper is syntactic prediction. We conducted two experiments involving comprehension of sentences with different types of syntactic dependencies, namely dependencies that do not require syntactic prediction (i.e. unpredictable dependencies in sentences that require Quantifier Raising) and dependencies whose resolution requires syntactic predictions at an early stage of processing based on syntactic cues (i.e. predictable dependencies in movement-derived sentences). In line with the predictions of the Complexity Threshold Hypothesis, the results show that the agrammatic patients that participated in this study had no difficulties comprehending sentences with the former type of dependencies, whereas their comprehension of sentences with the latter type of dependencies was impaired.

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\* Corresponding author. Room 102, Chandler House 2, Wakefield Street, London, WC1N 1PF, UK.

E-mail address: [maria.varkanitsa.09@ucl.ac.uk](mailto:maria.varkanitsa.09@ucl.ac.uk) (M. Varkanitsa).

<sup>1</sup> Present address: Neuropsychology Laboratory, Massachusetts General Hospital – Harvard Medical School, 100 Cambridge Street #2057, Boston, MA 02114, United States.

## 1. Introduction

Syntactic comprehension deficits in people with aphasia (PWA) and more specifically agrammatism have been the focus of language breakdown research cross-linguistically. Numerous studies have shown that PWA often experience difficulties in processing syntactically complex sentences. The main finding is that PWA are unable to construct a complete grammatical structure for an input sentence and identify the thematic role of the participants in the event described in the sentence. On the basis of this evidence, two types of accounts have been put forward to explain sentence comprehension deficits in aphasia, namely *impaired representations* accounts and *processing/resource reduction* accounts, which are briefly presented in the following paragraph.

*Impaired representations* accounts ascribe the deficit to loss of syntactic knowledge; they assume that patients suffer from a breakdown in their knowledge of grammar and therefore universal failure to apply specific operations (e.g. Trace Deletion Hypothesis; Grodzinsky, 1995). As a result, PWA's sentence comprehension relies on extralinguistic heuristic strategies. Therefore, under these accounts there are qualitative differences in processing routines between PWA and unimpaired adults due to loss of syntactic knowledge. *Processing/resource reduction* accounts, on the other hand, assume that the underlying grammatical knowledge is preserved, but PWA often fail to use it due to the brain damage that has limited the resources available for language processing. In the literature, there are several formulations of processing accounts. For instance, it has been suggested that, due to the resource reduction, PWA cannot carry out syntactic computations at the normal rate (slowed processing accounts; Friederici & Kilborn, 1989; Kolk, 1995; Piñango, 2002). A number of suggestions have been made regarding the disturbances in cognitive processes that could underlie this slowdown, including slow activation or too-fast decay of structural information (Haarmann & Kolk, 1991), slower automatic lexical (re)activation (Ferrill, Love, Walenski, & Shapiro, 2012; Love, Swinney, & Zurif, 2001), slowed online assembly of phrase structure (Burkhardt, Piñango, & Wong, 2003), or delayed formation of the syntactic representation (Piñango, 2002). Nevertheless, researchers agree that this slowdown allows non-syntactic mechanisms, otherwise suppressed in normal processing, to emerge, creating competition between the two possible sources of interpretation: the regular but slowed down syntactic mechanism and one that bypasses syntax altogether. Other researchers have suggested that resource reduction results in weakened (not slow down) syntactic computations (weakened syntax; Avrutin, 2006; Dickey, Choy, & Thompson, 2007; Dickey & Thompson, 2009; Meyer, Mack, & Thompson, 2012; Thompson & Choy, 2009). Under this view, the outcome of syntactic computations is weakened and therefore vulnerable to influence from non-syntactic means for encoding information.

Of particular interest for the hypothesis presented in this paper are *intermittent deficiency* accounts. Similar to other processing accounts, *intermittent deficiency* accounts suggest that PWA suffer from resource limitations that result in parsing failures. However, they further suggest that those parsing failures are not constant. Rather, according to these accounts, resource limitations cause intermittent parsing failures. In those cases, PWA rely on non-syntactic alternative sources to assign an interpretation to the input sentence. *Intermittent deficiency* accounts have been supported by recent online studies which show that PWA sometimes manage to compute structures and meaning and that, when they do so, their processing routines resemble those of unimpaired speakers. Sometimes, however, their syntactic parser fails, with more frequent failures occurring when processing load is high or, in other words, complexity exceeds a certain threshold (Caplan, Waters, DeDe, Michaud, & Reddy, 2007; Hanne, Sekerina, Vasishth, Burchert, & De Bleser, 2011).

But, when is processing load considered too high for PWA? Although processing of syntactically complex sentences has been extensively investigated in the aphasia literature, the factors that contribute to complexity have rarely been discussed. Caplan et al. (2007) briefly discussed relativization and passivization as processes that increase complexity. Specifically, both online and end-of-sentence data from the self-paced listening task they administered showed that object relativization was associated with increased processing load (as reflected in lower accuracy and slower listening times) compared to subject relativization. Increased load was also found to be associated with passive compared to active sentences, as measured with listening times at the verb position. The authors concluded that different sentence types are not equally difficult to process but, rather, structural parameters in fact may affect performance. In their experimental manipulations, Hanne et al. (2011) associated high complexity with the canonicity of word order; their main finding was that comprehension of non-canonical sentences was severely impaired.

The aim of this paper is to combine aphasia-specific accounts with independently motivated computational models of sentence processing to allow the investigation of more fine-grained hypotheses regarding comprehension failures in PWA. Like many previous researchers we assume that PWA are capable of normal sentence processing but have resource limitations that cause their syntactic parser to suffer occasional intermittent failures in environments that push syntactic complexity above a certain threshold. For the purposes of the present study, we dub this hypothesis the Complexity Threshold Hypothesis. This view of comprehension failure in aphasia can be refined by combining it with what is known about processing complexity in the unimpaired population. Detailed psycholinguistic work has identified several factors that determine complexity in sentence processing and prominent among these are the intertwined effects of syntactic prediction and locality (see Dependency Locality Theory: Gibson, 1998, 2000; Grodner & Gibson, 2005), similarity-based interference (see Cue-Based Retrieval Theory: Lewis & Vasishth, 2005) and frequency (see Surprisal Theory: Levy, 2008). The present study makes use of these psycholinguistic results and focuses on the effects of syntactic prediction in sentence processing in PWA.

Syntactic predictions have played a major role in the study of sentence comprehension in the field of psycholinguistics. Of particular interest, here, are those psycholinguistic theories that have related syntactic predictions to syntactic complexity (see Levy, Fedorenko, & Gibson, 2013 for a similar summary). These theories are known as memory-based theories and their

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