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Patients with Broca's aphasia and Young Children can reconstruct elided VPs[1]

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1. The content of this chapter

This chapter is about Verb Phrase Ellipsis (VPE) in speakers whose language faculty is incomplete – patients with a language deficit who have lost part of their linguistic ability subsequent to (mostly focal) brain damage, and developing children who have not yet reached the steady state of adult language. We show that despite certain syntactic limitations, the ability of both patients with Broca's aphasia and children to reconstruct an elided VP is intact. While the present data set is of a relatively limited size, this result is nonetheless remarkable, we argue, and is important for our understanding of the nature of language loss subsequent to focal brain damage, as well as language acquisition.

We briefly review some properties of VPE, move on to their psycholinguistic relevance, and then describe 2 pilot experiments – in adult aphasic patients and in children – that tested the comprehension of VPE. We establish that VPE a. requires a comprehender to go beyond the information given on the surface; and b. requires complex syntactic and semantic analysis. As such, it provides an excellent testing ground for claims regarding language-incomplete individuals. With that in mind, we consider the comprehension of complex linguistic material in patients with aphasia, and in developing children. We report data that indicate that adult patients with Broca's aphasia and young children are quite capable with VPE, despite deficiencies elsewhere in syntax. We then consider these data in a broader context, and conclude by reflecting on the potential significance of the results of these experiments.

2. VPE

The context of the present volume permits us to be relatively brief in discussing structural issues regarding VPE, and we restrict ourselves to just those aspects of the construction

that are relevant to our endeavor. Our desire for brevity and focus leads us to be somewhat lenient in terms of precision and generality. The ingredients of the analysis of VPE are many, as are the associated questions and debates: what kind of operations are involved in the recovery of elided material? What is the type, size and constituency of the elided piece? And what constrains the relation between the ellipsis clause *E* and the overt antecedent clause *A*? We concentrate on the latter question, through an experimental exploration with language-impaired adults and developing children.

In our experimental investigation, we started off by studying relatively simple constructions, that is, coordinate VPE, in which the VP of the antecedent clause *A* must be interpreted in the ellipsis clause *E* (1a) (Fox 2000; Johnson 2001; Hardt 1993; Merchant 2001; Rooth 1992; Sag 1976; Williams 1977; see van Craenenbroeck in press, for a recent survey). Once the VP constituent in *A* (VP_A) cannot be identified as such in *E*, the sentence becomes unacceptable. The piece *sold a car* in (1b) and *told* in (1c) are not constituents, and the resulting sentence is marked:

(1) a. [$_A$ The detective *[$_{VP}$ found a child]*] and [$_E$ the cop did *[$_{VP}$ _]* too]

b. *[$_A$ The detective *[$_{VP}$ sold a car to Jim]*] and [$_E$ the cop did *[_]* to Mary too]

c. *[$_A$ The detective *[$_{VP}$ told Mary to leave]* and [$_E$ the cop did *[_]* to stay, too]

Most (though likely not all) of the properties associated with the constructions above carry over to VPE sentences with *so* and some version of auxiliary verb fronting:

(2) [$_A$ The detective *[$_{VP}$ found a child]*] and [$_E$ so did the cop *[$_{VP}$ _]*][2]

Ellipsis does not only have syntactic reflexes. Meaning is also at issue: the content of the elided VP_E must parallel that of VP_A. In (1a), VP_E is structurally identical to VP_A, and yet it is clear that (1a) cannot be interpreted as (3).

(3) [$_A$ The detective *[$_{VP}$ found a child]*] and [$_E$ the cop *[$_{VP}$ saw a bird]* too]

To account for these facts, assume that the form of the elided VP is governed by a constraint that requires parallelism between VP_A and VP_E (Fox 2000):

(4) Parallelism

VP-ellipsis is licensed only if at LF, the VP of the ellipsis clause *E* is identical to the VP of the antecedent clause *A*.

If "identical" means "containing the same syntactic constituents", then the acceptability of (1a), and the unacceptability of (1b-c) follows directly – VP_E must consist of the same syntactic pieces as VP_A. The unacceptability of (3) follows if Parallelism requires (roughly) *semantic* identity.

Next, consider inflectional features (tense, person, number). These seem to be exempt from the Parallelism requirement, as the ellipsis clause needn't parallel the antecedent clause. In (5), both tense and number are different in each of the coordinated clauses:

(5) [$_A$ The detective *[$_{VP}$ found a child]*] and [$_E$ the cops will *[$_{VP}$ _]* too]

Data like (5) suggest that the relevant features are left outside of the ellipsis, providing a first indication that the size of ellipsis may not amount to the complete size of VP_A (see van Craenenbroeck in press, for a recent review). Adjusting the size of ellipsis allows to maintain Parallelism in its strict form (4).

Still, a Parallelism constraint that forces content identity must allow for certain holes. That is, the VP_E sometimes allows an interpretation that is different from that of the VP_A. As is well known, anaphoric elements in object position of the antecedent clause bring about such situations (Bach & Partee 1980; Reinhart 1983; Williams 1977). Thus, the meaning of VP_E in (6) is ambiguous between (6a) and (6b):

(6) Jim walked his dog, and Bill did [VP_E] too.

a. ... Bill walked Jim's dog

b. ... Bill walked Bill's dog

Given the strict Parallelism in (4), how can the ambiguity in VP_E arise in the (apparent) absence of ambiguity in VP_A*?* Put differently, how can we reconcile between the need for a rigid Parallelism that would force the facts in (1-3), and the need for flexibility to account for (6)? One key idea (Grodzinsky & Reinhart 1993; Reinhart 1983) allows us to maintain rigid Parallelism by playing with the interpretation of the antecedent pronoun in VP_A. Assume that this pronoun is ambiguous: it may be assigned to *Jim,* but it may also be viewed as a variable, bound by a local antecedent t_1. In this clause, the two meanings happen to converge.

(7) a. [$_A$ Jim [$_{VP}$ walked his$_{\rightarrow Jim}$ dog]

b. [$_A$ Jim [$_1$ t_1 [$_{VP}$ walked his$_1$ dog]]]

Now, consider the ellipsis clause. For each meaning, Parallelism guarantees an identity relation between VP_A and VP_E, and the ambiguity of the former (7) leads to these LFs of the latter:

(8) a. [$_E$ Bill [$_{VP}$ walked his$_{\rightarrow Jim}$ dog]

b. [$_E$ Bill [$_1$ t_1 [VP walked his$_1$ dog]]]

The difference in reading comes from the fact that while the pronoun in (8a) is assigned to *Jim* as before, in (8b) it is locally bound. The ambiguity follows, as the resulting LFs of the ellipsis sentence are roughly those in (9):

(9) a. [$_A$ Jim $_1$ t_1 [VP walked his$_{\rightarrow John}$ dog]]] and [$_E$ Bill [$_{VP}$ walked his$_{\rightarrow John}$ dog]]]

b. [$_A$ Jim $_1$ t_1 [VP walked his$_1$ dog]]] and [$_E$ Bill$_1$ [t_1 [$_{VP}$ walked his$_1$ dog]]]

The meaning in (9a), known as *strict identity*, allows only for 1 dog to have been walked–Jim's; whereas the meaning of (9b), known as *sloppy identity*, allows two. The ambiguity is thereby obtained, and Parallelism is nonetheless observed. While this analysis is not problem-free (cf. Fox 2000; Heim 1998, 2007 among many others), it illustrates how Parallelism interacts with other assumptions to account for a range of VPE phenomena[3].

Lastly, there is the critical issue of recoverability of the elided part of VPE. Even on its broadest formulation, Parallelism only constrains the form and content of ellipsis; it says nothing about the elision itself. But why and how can phonologically overt material be missing? Is the ellipsis site itself an empty category of some sort (Lobeck 1995; and especially van Craenenbroeck in press, who propose that the conditions that license it are akin to those that license *pro*)? Do the conditions that allow for elision need to be specifically formulated for VPE, or are they, rather, general to all ellipses (cf. van Craenenbroeck & Merchant 2012)? Moreover, is VPE a result of PF deletion, or rather, of copying at an abstract syntactic or semantic level?

At present, we remain agnostic on these issues, as the goals of this chapter are modest. Our experimental evidence from developing children and brain-damaged aphasic

patients will mostly bear on developmental and neuropsychological issues. Still, we will argue that the aphasic deficit may shed some light on the nature of ellipsis licensing.

3. The Psycholinguistic Relevance of VPE: Broca's aphasia

Next, we turned to test the comprehension of patients with Broca's aphasia (Walenski et al. 2012). Why can VPE be informative in this context? We can see 2 reasons: first, results from a comprehension experiment on VPE may bear on our view of the comprehension deficit in this syndrome, and as a consequence, on our understanding of the role of Broca's region in language processing. Second, the pattern of impairment and sparing that would emerge might point to a neurological natural class that would bear on the theory of VPE.

3.1. Broca's aphasia as a clinical entity

Using patients with Broca's aphasia requires some discussion regarding the status of this clinical entity. Some have questioned the validity of Broca's aphasia as a stable and identifiable syndrome complex, presenting a pattern that is replicable across patients. The main argument behind the challenge of this 150-year-old syndrome has been that the observed inter-patient variability is too large for this collection of phenomena to count as unitary (Caramazza 1984, *passim*).

Caramazza's paper paved the way not only for an intense, protracted conceptual debate, but also for several quantitative analyses in which the inter-patient variability, mostly in the receptive domain, was measured. The result that seems to have settled this round of debate was based on a series of retrospective studies on a large data set (n=69, Drai & Grodzinsky 2006a,b): while there is considerable variation between patients who have been assigned this diagnosis, certain performance contrasts in the receptive domain remain very stable. The grouping of these patients, then, seems justified.

3.2. The Comprehension Deficit in Broca's aphasia – TDH vs. WM/Generic Complexity

Broca's aphasia was traditionally thought of as a deficit in production (cf. Goodglass & Kaplan 1972 for the most frequently used diagnostic test). Later, this deficit was shown to extend to comprehension (Caramazza & Zurif 1976). Since then, its precise nature – and the subsequent role of Broca's region in language processing – has been hotly debated.

At present, there seem to be 2 dominant views of the comprehension deficit, and the role of Broca's region: the movement view, embodied in the Trace-Deletion Hypothesis (TDH) and its processing ramifications (e.g., Grodzinsky 1984, 1986, 2000; Grodzinsky & Santi 2008; Shapiro et al. 1993; Shapiro, Swinney & Borsky 1998; Zurif et al., 1993) and the syntactic complexity view, that relates to Working Memory (WM, e.g., Caplan & Waters 1999; Friederici 2002; Stromswold et al. 1996). A brief description of the positions is followed by a discussion of the relevance of a test of VPE comprehension in aphasia.

In brief, the movement account is based on the observation that the core comprehension deficit is restricted to structures that involve the displacement of a phrasal constituent. Patients are presented with binary-choice interpretive tasks (essentially ϑ-role assignment, evinced through the choice of the correct ϑ-order in a setup with 2 scenarios, one of which makes the sentence true, and the other, false via ϑ-reversal). Patients with Broca's aphasia are typically at chance on object-gap relative clauses (whether these are on the subject to form a center-embedded sentence, or on the object, thereby right-branching); their performance, however, is *above* chance when the gap in the relative clause is in subject position (see Drai & Grodzinsky 2006a, for a review). The idea behind

the TDH is to set up the representational conditions that would *derive* this performance pattern – chance in displacement and above-chance otherwise. As the typical task involves proper ϑ-assignment, chance performance must stem from ϑ-confusion. This is obtained by the following:

(10) a. Trace-Deletion Hypothesis (TDH)

Delete all traces from agrammatic representations

b. Direct ϑ-Link strategy:

Assign a default ϑ-role to a ϑ-less NP (subsequent to trace deletion):

Given a grid $<\vartheta_1, \vartheta_2 \ldots \vartheta_n>$, and a linearized surface order

$NP_1>>NP_2>>\ldots>>NP_n$, if NP_i is ϑ-less, link it to ϑ_i.

The consequence of the TDH is a limited role to Broca's region in syntax – it only involves displacement[4]. It has further been argued that the actual role of this region is the on-line linking of non-adjacent positions (Shapiro et al. 1998), most notably, relating displaced constituents to extraction sites. The evidence comes from deficiencies in real-time tasks that critically rely on the linking of traces to their antecedent. Such deficiencies are observed for patients with Broca's aphasia through a host of reaction time studies that so indicate. As we shall soon see, this type of task has also been used in testing VPE in aphasia (Poirier et al. 2009). Regarding comprehension performance on VPE structures, it is clear that a limited deficit is predicted, observed only when comprehension depends on the analysis of trace-antecedent relation in a manner that is not properly compensated for by the Direct ϑ-Link strategy.

On the other side of the debate, it has been argued (e.g., Caplan and Waters 1999, and much subsequent literature) that Broca's aphasia is a Working Memory (WM) failure.

As WM for "language" is said to reside in Broca's region (cf. Smith & Jonides 1999), its demise leads to problems with "syntactically complex" structures (the precise nature of complexity is rarely made explicit). The idea is that syntactically complex material taxes WM in an incremental manner, and hence its failure results in an impairment in speakers' ability to process "complex sentences". The absence of a formal complexity metric is justified empirically: based on reaction time data, certain constructions are deemed more complex than others. E.g., object-gap relative clauses take longer to process than their subject-gap analogues, and are hence viewed as more complex and more taxing on WM (and to increased activity in Broca's region in neurologically unimpaired participants, see Makuuchi et al. 2013 for recent discussion).

A relatively widespread comprehension failure subsequent to damage to Broca's region follows. That is, any construction that is deemed as "syntactically complex" is likely to cause comprehension problems to patients that suffer from this brain disease. In particular, that VPE is a complex construction appears uncontroversial: any reasonable construal of the notion of syntactic complexity must include VPE, as this construction, at a minimum, is bi-clausal, involves copying/deletion of large chunks, and potentially LF movement. WM must be taxed: for Parallelism to be implemented, a comparison of the VP in *A* to the one in *E* is mandatory. At present, little evidence is available that pertains to this debate.[5]

Hence, *a WM* failure due to damage to Broca's region should lead to serious comprehension problems (whose precise nature depends on the complexity metric that is assumed).

We can see that the two accounts contrast in prediction regarding VPE: the predicted TDH-based deficit is structured and restricted, whereas the predicted WM-based deficit is rather widespread.

3.3. Testing VPE with patients suffering from Broca's aphasia

We based ourselves on methodology developed in Grodzinsky (2005), and used a verification task with VPE sentences with diagnosed Broca's aphasic patients. Focusing on Parallelism, we presented VPE structures along with situations whose interpretation forces the material in *A* to have its parallel in *E*. That is, we presented <ellipsis sentences, situation> pairs to patients, where the denotation of the elided part sometimes matches the situation, and sometimes it does not. The patient's task would be to assign a truth-value to the sentence. We now elaborate on this task.

Verification is an experimental paradigm that aims to test the patient's ability to fill in content from *A* into *E*, all scenarios make *A* true, and the only potential sentence/picture mismatch pertains to *E*, the ellipsis part. This setup forces the patient to consult Parallelism in order to assign an interpretation to the sentence and determine its truth-value. If sentences that accompany situations requiring improper reconstruction are deemed true, we can infer that Parallelism does not exist in the patient's grammar (or at least cannot be put to use at the right time); otherwise, we can conclude that she possesses the relevant knowledge and can put it to use.

To illustrate, consider the sentence in (11), and the accompanying scenarios (11a-d) in Table 19.1. If constraints on ellipsis are not known, or unavailable for use, then any interpretation of *E* that is consistent with an *E* whose elided part contains *a man* as either subject or object may be legitimate. This can be put to the test, in which the evaluation of

VP_E would provide the critical clue to the patient's knowledge of Parallelism. If Parallelism is not known, and is hence violable, then the range of possible interpretations of VP_E is extended.

This is what was put to the test here. In (11), we present a sentence, and 4 accompanying scenarios (11a-d). Each scenario consists of 2 event, one that always makes *A* true, and a second one, that makes *E* true (11a) and false (11b-d) in 3 different ways. A patient lacking Parallelism should accept all scenarios (11a-d) as true, because they all feature *a man* – the only constraining factor for VP_E interpretation under this assumption. Conversely, a patient that masters Parallelism should only deem true (11a). The difference between knowledge of Parallelism and lack thereof is testable, and presented in Table 19.1, which marks the possible responses of a patient with and without Parallelism:

Table 19.1 Test conditions: VPE sentence + images

		Parallelism available?	
(11)	[$_A$ The woman kicked a tiger] and [$_E$ the man did [$_{VP}$__] too]	*Yes*	*No*
Match	a. "*A woman kicking a tiger, and a man kicking a tiger"*	**T**	**T**
MisMatch 1	b. "*A woman kicking a tiger, and a tiger kicking a woman*"	**F**	**T**
MisMatch 2	c. "*A woman kicking a tiger, and a woman kicking a man"*	**F**	**T**
MisMatch 3	d. "*A woman kicking a tiger, and a tiger kicking a man*"	**F**	**T**

This part of our test consisted of Match cases (11a), as well as MM1 (11b), depicting role-reversal in *E*, the ellipsis clause; MM2 (11c), corresponding to an incorrect object in *E*, and MM3 (11d), corresponding to incorrect subject and object in *E*. Given the world created in the images, both Yes and no responses are plausible. As controls, we used non-elided coordinate structures, whose primary meaning was identical to the elided ones. In

the absence of ellipsis, the invocation of Parallelism is not necessary for interpretation, no error is attributable to a Parallelism failure, and therefore, all the relevant populations are expected to perform at ceiling (see Table 19.2).

Table 19.2 Control condition: Coordination + images

(12)	12. [$_{IP1}$ The tiger kicked a tiger] and [$_{IP2}$ the man kicked a tiger] *Expected response*	
Match	a. "*A woman kicking a tiger, and a man kicking a tiger"*	**T**
MisMatch 1	b. "*A woman kicking a tiger, and a tiger kicking a woman*"	**F**
MisMatch 2	c. "*A woman kicking a tiger, and a woman kicking a man"*	**F**
MisMatch 3	d. "*A woman kicking a tiger, and a tiger kicking a man*"	**F**

3.4. Experiment

As we discussed, our test required subjects to verify sentences against depicted visual scenarios – participants responded "yes"/"no" to <sentence, scenario> pairs.

In trying to adhere to *principles of good design*, we took extra measures to ensure that Parallelism must indeed be consulted, and that no tricks or heuristics would help the aphasic patient get around it.

First, the design of scenarios was crucial: four scenarios were coupled with each experimental sentence – one scenario made the sentence true (the Match M) whereas the remaining three scenarios (MisMatches 1-3)represented three different ways of making the sentence false. Each scenario was shown separately, and thus every sentence was presented 4 times – once for each scenario.

Second, as all our stimuli contained two conjoined clauses, they required 2 situations per scenario – one for each of the clauses *A* and *E* (11), or IP_1 and IP_2 in the

control condition (12); the scene for *A* always made it true, as the mismatches were made false only by the scene that related to *E*.

Third, we tried to ensure that there is congruence between NPs in the sentences and the characters in images – every character in the pictures is mentioned, and every NP is depicted. This way, the presence or absence of mentioned referents cannot be used as a heuristic.

Fourth, to avoid a violation the uniqueness requirement imposed by definites, the object of the antecedent clause *A* was headed by an indefinite.

Fifth, every character appeared in pictures as either actor or recipient of action.

Sixth, animacy and plausibility were perfectly balanced (rotated across positions in the sentence).

Seventh, we had one M and three MM conditions, which could lead to a "yes"/"no" imbalance. We therefore maintained a 2:3 ratio between tokens that required a correct "yes" (M) vs. those requiring a "no" (MM) response, thereby preventing strategic responding. We had 18 Match and 27 (9*3) Mismatch tokens (=45 items per condition), for a total of 45*3=135 trials, as in Table 19.3, and the accompanying images in Fig. 19.1.

Table 19.3 Experimental conditions

	Match	*MisMatch 1*	*MisMatch 2*	*MisMatch 3*
a. COORDINATION:	***18***	***9***	***9***	***9***
The girl kicked a tiger and the boy kicked a tiger				
b. VPE_{TOO}:	***18***	***9***	***9***	***9***
The girl kicked a tiger and the boy did too				
c. VPE_{SO}:	***18***	***9***	***9***	***9***
The girl kicked a tiger and so did the boy				

INSERT FIGURE 19.1 ABOUT HERE

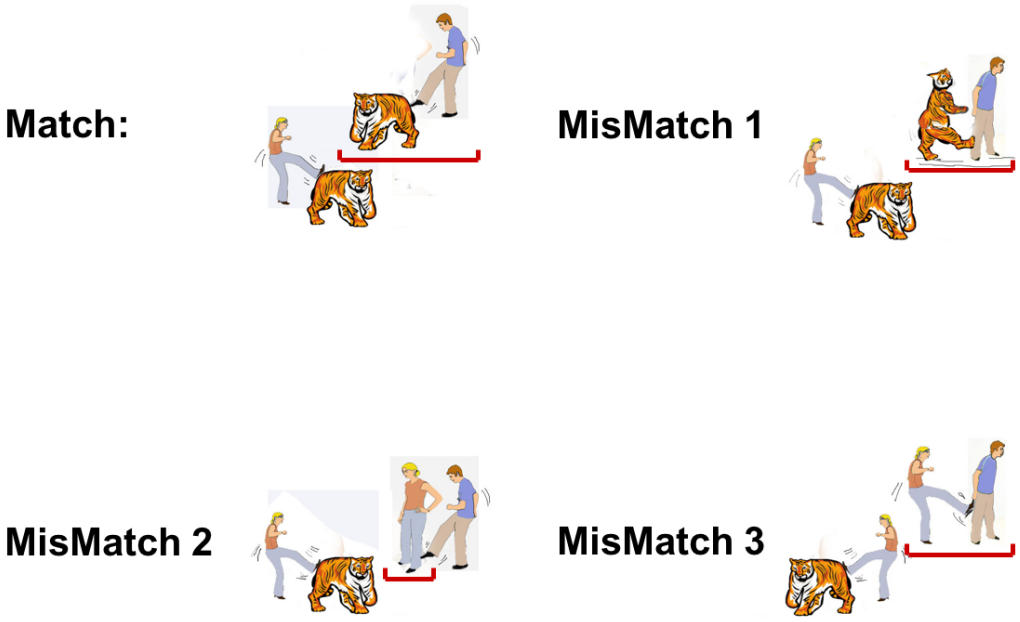

Figure 19.1 Experimental stimuli

As control populations, we tested healthy and right-hemisphere damaged patients, who were at- or near-ceiling in all conditions. Next, we started testing patients with a clinical diagnosis of Broca's aphasia. At present, we have results for 3 patients, as finding candidates for testing is exceedingly difficult (Walenski et al. 2012). These patients' clinical profiles can be found in Table 19.4.

Table 19.4. Patients' demographic and clinical profiles

Subject	Gender	BDAE[a] severity level (1=severe, 5=mild)	Years post stroke	Age at test (years)	Educational level
009	M	2	5	45	College + l
019	F	2	14	59	High School
101	M	2	2	60	Ph.D.

a. Boston diagnostic aphasia examination

All 3 subjects exhibited the familiar, TDH-based, comprehension pattern: in a sentence-to-picture matching task with "reversible" sentences, they performed better on actives than on passives, and better on subject- than on object-relative clauses. Once clinical and TDH-based diagnoses were established, we proceeded to the VPE test.

Subjects were tested in several sessions, with a short training session, and many breaks during testing. The experiment was conducted with an ethics approval and informed consent in keeping with the ethical principles of testing applying at McGill University, as well as San Diego State University, where the subjects were tested.

Healthy, education- and age-matched control participants performed near or at-ceiling on all conditions. Table 19.5 details how our patients performed on the VPE test.

Table 19.5 Number of accurate response per condition for each patient on the VPE test

	Control condition (number correct)				*VPE (number correct)*				
Subject	M (*/18*)	MM1 (*/9*)	MM2 (*/9*)	MM3 (*/9*)		M (*/18*)	MM1 (*/9*)	MM2 (*/9*)	MM3 (*/9*)
009	***18***	***8***	***0***	***9***	***TOO***	***18***	***9***	***0***	***8***
					SO	***17***	***9***	***0***	***9***
019	***12***	***8***	***5***	*7*	***TOO***	***16***	***6***	***4***	*7*
					SO	***16***	***3***	***2***	*7*
101	*17*	*7*	***8***	***8***	***TOO***	***18***	***8***	***8***	*7*
					SO	***17***	***8***	***6***	***6***

Overall, Patient ***009*** performed well (a total of 105/135 [78%] correct); Patient ***019*** performed slightly worse (a total of 93/135 [69%] correct); and Patient ***101*** performed best (a total of 118/135 [87%] correct). Patient ***101*** leaves little room for discussion, being near- or at-ceiling on all conditions. There can be little doubt that he knows and respects Parallelism. The other patients require a more detailed examination to reveal the source of their errors.

Patient ***009*** was near- or at-ceiling on M, MM1, and MM3 across all 3 conditions, and erred systematically on MM2 across the board – he was at 0 correct on both ellipsis and overt coordination. That is, he accepted as true every MM2 trial, which is judged False by healthy speakers, because it features a recipient of action that does not correspond to the object of VP_A (hence the covert object of VP_E did not refer to it). What is crucial in this case is the fact that he judged this sentence-image pairs as True, *in both control and 2 test conditions*. This highly systematic error, whose source is unknown, generalizes over both VPE and coordination, hence seems unrelated to VPE. Viewed against his

performance on the control, then, we can safely assert that ***009*** demonstrated knowledge of Parallelism, and an additional, yet unrelated, deficit.

Patient ***019*** presents a more complex picture: On the Match trials, she was not as apt as the previous patients, but nevertheless performed above chance. This relatively weak performance (across both VPE and COORD conditions) provides the backdrop against which her performance on the MisMatch trials must be evaluated. She was at chance on MM1 and MM2, and above chance on MM3. These results are not easy to analyze quantitatively or interpret, and will be left in their raw form. Performance on the COORD condition (expected to serve as a baseline) is rather low; performance level on the test conditions must be evaluated accordingly. Two aspects of the result provide hints regarding the preservation of Parallelism: first, on the Match trials of both +VPE conditions, the patient scores are well above chance; second, performance levels are almost identical for both +VPE conditions.

Thus, from a perspective that focuses on Parallelism, the performance of this small group of patients provides no evidence for failure in both knowledge and execution. Moreover, the virtually identical performance scores of all 3 patients across the two VPE types (*…did too*, *…so did*) strongly suggests that the problem does not arise from a lexical deficit (e.g., misunderstanding of the word *too*). Together with the fact that the main sources of error were independent of VPE (as they occurred as frequently in the control condition), this cross-condition identity also lends credibility to our interpretation, according to which a Parallelism failure is not part of the deficit in Broca's aphasia.

3.5. Patients' Relative Success in Analyzing VPE and the Complexity/WM view

We conducted this experimental study with the hope of shedding new light on the comprehension deficit in Broca's aphasia, and of gleaning new neurological insights regarding the theory of VPE. We can now clearly assert that the patients were able to use Parallelism for the comprehension of VPE. This assertion helps to rule out the (rather vague) view that Broca's aphasic patients fail to comprehend complex sentences – VPE can hardly be viewed as a simple construction. Regarding a WM deficit: an overt VP in clause *A* and its elided copy in clause *E* are large non-adjacent chunks; VP_A cannot be reconstructed on-line in VP_E with WM.

Our results thus exclude an account of Broca's aphasia as a generic deficit in analyzing syntactically complex stimuli, or as a plain WM impairment.[6]

3.6. Patients' Relative Success in Analyzing VPE and the Movement (TDH) view

What about a movement, TDH-based, account? VPE contains a relation between the antecedent VP and the ellipsis site (VP_A and VP_E); we might therefore wonder whether this dependency relation is affected by the deficit in Broca's aphasia. Standard approaches to VPE view the relation between overt and elided material as being akin to pronominal binding, albeit a silent one. Elbourne (2008) and Schwarz (2000) argue against a movement analysis on the basis of highly complex data.[7] If the deficit in Broca's aphasia is restricted to traces, this approach predicts that patients' comprehension ability of VPE as tested here is preserved. Prima facie, then, VPE stays outside the scope of the TDH, hence its representation is expected to be intact in Broca's aphasia, as our experiment indeed found.[8]

3.7. VPE in Reaction Time experiments

So far, we looked at experiments in which comprehension error rates are the dependent measure. We now turn to the time domain. Here, we find two reaction time studies on VPE with Broca's aphasic patients (Poirier et al. 2009; Walenski et al. 2012). These present an interesting new puzzle. Consider first some results about priming-at-a-distance – a paradigm in which participants are tested in a priming paradigm, however the target is not adjacent to the prime, but rather, appears further downstream. Neurologically intact populations do show remarkable priming-at-a-distance that is based on trace-antecedent relations. A displaced antecedent can prime not only adjacently, but also, at the position of their trace:

(13) The policeman saw [**the boy**] [who [the crowd at the party [1] *accused* [2] of the crime.

Nicol & Swinney (1989), and many other authors since, have used the Cross-Modal-Lexical-Priming technique to determine whether listeners fill gaps online. They presented subjects with spoken sentences such as (13). At the positions marked by [1] and [2], visual probes that were semantically related to the correct antecedent (*boy*), as well as unrelated control probes, were presented. As always with this task, subjects were required to make lexical decisions to the visual probes. It was discovered that there was significant priming for probes related to the correct antecedent at the gap ([2]), but not at the pre-gap ([1]) probe site. The same group later tested patients with Broca's aphasia, who failed to prime in this way (e.g., Zurif et al., (1993), in keeping with the predictions of the TDH.

With this picture in mind, Shapiro et al. (2003) turned to VPE. They found that in neurologically intact populations, the copy at the ellipsis site induces priming to a noun

related to the elided object. Participants are given a Cross- Modal Priming task with sentences as in (14):

(14) The locksmith photographed the babysitter and the friendly [1] neighbor did [2] too, according to [3] the clumsy plumber

Healthy adults reacted faster to a related word when it is presented at point [2], but not when presented at points [1] or [3]. This pattern seems to be due to the fact that this word was primed by the copy of the elided object, as priming was observed only at the ellipsis site (point [2]).

Against this background, Poirier et al. (2009) tested patients with Broca's aphasia on a similar task: Broca's patients evinced no priming of the object from the antecedent VP at the elided position in the ellipsis clause, though in a similar study (Walenski et al. 2012), Broca's patients evinced delayed priming (that is, priming at a probe position downstream from the elided position).

The conflict between these results and ours is puzzling: previously, data from Cross-Modal Priming aligned with comprehension data. That is, patients failed to prime exactly in constructions where their comprehension was impaired. In VPE, we find evidence for the intactness of Parallelism in comprehension in the face of priming deficiencies. At present, we have no account of this performance split, but we note that the patients with Broca's aphasia *do* prime for the elided material, though it is later in the time course of the sentence relative to unimpaired participants.

Thus, while the results we obtained are highly structured, and help exclude certain accounts, a full explanation of the experimental findings is not yet available.

Experimentation with ellipsis that would go beyond VPE – Gapping, Sluicing, N'-ellipsis – would hopefully help to shed light on the nature of the deficit in Broca's aphasia.

4. The psycholinguistic relevance of VPE: Acquisition

We now move to discuss another population with incomplete linguistic abilities – developing children, whose abilities in VPE bear on yet another central issue – the "innateness debate". If children only imitate input, as many have argued (cf. Gennari & MacDonald 2006 for a recent statement), and if "input" only means overt phonological strings, then there is little room for ellipsis in children's language, for it requires the reconstruction of missing material in the ellipsis clause (*E*) from the antecedent clause (*A*) – an operation for which no source of evidence is available on this approach. To produce and properly analyze VPE, children must go "beyond the information given", especially given the paucity of ellipsis constructions in the input.

To see how directly children's abilities on ellipsis, and on VPE in particular, bear on this issue, consider first a recent exchange on "innateness" in the context of children's comprehension of relative scope of logical operators, and specifically on whether they are able to represent "inverse scope" of quantifiers. At issue are scopally ambiguous sentences – ones that contain more than one Scope Bearing Element as in (15). Representations of different orderings of the bolded words **not** and **some** produce distinct meanings – (16a) entails that no child was found by the detective, whereas (16b) does not:

(15) The detective did **not** find **some** children

(16) a. It is **not** the case that the detective found **some** children

¬[∃x[child (x) & [detective find (x)]]]

b. There are **some** children such that the detective did **not** find them

$\exists x[\text{child}(x) \& \neg[\text{detective find}(x)]]$

At issue is whether children who are confronted with (15) are able to represent not only surface scope representations (16a), but also inverse scope relations (16b). Going "beyond the information given" (Bruner 1957) amounts to analyzing (15) as (16b). Phonological material is identical in both cases, but (16b) requires an abstract (LF) reordering operation. Details aside, Musolino and Lidz (2004), as well as Conroy, Lidz & Musolino (2009) have claimed that children (up to 5:9 years of age) are only able to represent surface scope (16a).[9]

Gennari and MacDonald (2006) argue that this result provides empirical support for the claim that language development is entirely dependent on input, rather than determined by innate knowledge. Specifically, they claim that distributional patterns observed in adult speech production influence both adult and child comprehension. Given that inverse scope is rarely produced by adults, children cannot be expected to possess it early on.

Children's performance on VPE may shed new light on whether syntax and semantics acquisition is a purely input-driven process, or is, rather, privy to prior, innate, linguistic knowledge. While relatively infrequent, VPE comprehenders must invariably go beyond the information provided by surface form – they must complete material missing in *E*, and guarantee that it parallels *A*. No surface-based strategy, allegedly used by children in the "inverse scope" case discussed above, can rescue the child. She must reconstruct elided material in a highly constrained fashion. Parallelism, a crucially necessary principle, cannot be attested in the input, and the computation moreover is not

easy to perform if one's parsing system is still budding. Moreover, if abilities depend on exposure as Gennari & McDonald (2006) would have it, then VPE should be very difficult to master, as it is rather infrequent in use.

Gennari and MacDonald, then, would expect constraints on ellipsis to be absent from the child's syntactic arsenal.[10] A radical innatist, by contrast, would expect ellipsis to be known at an early age. At hand is, therefore, a prediction that distinguishes the two approaches.

And yet, the few studies of VPE in children (most notably, Thornton and Wexler 1999, cf. also Goksun et al. 2011, for some experimental work, and Santos 2006, for work on Portuguese) have not directly tested their ability to invoke Parallelism. These studies have by and large focused on the interpretation of pronouns in VPE (in the context of the so-called "condition B debate" of the 1990s, Chien & Wexler 1990; Grodzinsky & Reinhart 1993). Little experimental work has been done on other aspects of VPE (with the exception of Santos 2009, see below).

We therefore set ourselves to provide experimental evidence from VPE that would bear on the debate.

4.1. Spontaneous Production of VPE – Parallelism is used in early childhood

We first turned to investigate young children's abilities to check that $VP_A =^{P} VP_E$ (see Grodzinsky 2005). To forecast, we found that their comprehension performance – for reconstruction under Parallelism had to be recruited – was near-perfect at a surprisingly early age. A preamble to this conclusion was a remarkable finding from production: a search in the CHILDES database indicated that children use VP-ellipsis in free speech very early on, even before they turn 3. There were not many such uses (20 instances out of

3199 utterances for the 3-year-olds, and 11/1254 for the 4-year-olds), but VPE was nonetheless attested in the spontaneous speech of several children (see Table 19.6 for examples).

Table 19.6 Examples of spontaneous production of VPE by children

Name of child	**CHILDES file name**	**Example**
Abe	Kuczaj_Abe102	*CHI: I don't know. *FAT: you didn't do anything? *CHI: we did **too**. *FAT: tell me. *CHI: we did a lot of stuff.
Ben and Deb	Garvey_Bendeb	*DEB: I will be the policemen okay? *BEN: no I wanta [:want to] I wanta [:want to]. *DEB: I will **too** okay? *DEB: okay? *DEB: okay.
Nina	Suppes_Nina46	*CHI: what kind of bus does he have? *MOT: he has a Volkswagen bus. *CHI: Dennis does **too**. *MOT: that's right Gary and Dennis have the same car. *CHI: uhhuh [=yes]

It is difficult to see how any of these utterances can be analyzed as anything other than VPE. Their meaning, moreover, cannot be reconstructed in the absence of

Parallelism: Abe responds to a full negative question by eliding the VP and excluding its negation. To be sure, he then elaborates on the father's request, and reiterates the VPE as a full sentence. Deb asks for consent to her being the police(wo)man, and Nina uses VPE by way of confirming that Dennis has a VW bus. And these, recall, are 3-year-olds, said to be unable to carry out operations that involve unattested stimuli, and use inverse scope because it is too taxing on their parser! These data add to evidence by Santos (2009), in which examples of child productions in Portuguese are given, that are claimed to be unambiguous instances of ellipsis.

4.2. Children Comprehend VPE Very Early on: experimental evidence

Our success in finding evidence that children are capable of constructing VPE in production led us to a comprehension study, in the hope that it would bear directly on the "innateness/input dependence" debate. As 3-year-old children have difficulties in sitting still and concentrating, we turned to 4-year-olds.

Focusing on Parallelism, and basing ourselves on methodology developed in Grodzinsky (2005), we planned to give children a verification task with VPE sentences, presented along with situations whose interpretation forces the material in *A* to have its parallel in *E*. That is, to present <ellipsis sentences, situation> pairs to children, where the denotation of the elided part sometimes matches the situation, and sometimes does not. The child's task would be to assign a truth-value to the sentence. We now elaborate on this task, which has also been used by Santos (2009), who found that by and large, children interpret ellipsis in an adult-like fashion.

As this experimental paradigm aims to test the child's ability to fill in content from *A* into *E*, all scenarios make *A* true, and the only potential sentence/picture mismatch

pertains to E, the ellipsis part. This setup forces the child to consult Parallelism in order to assign an interpretation to the sentence and determine its truth-value. If sentences that accompany situations requiring improper reconstruction are deemed true, we can infer that Parallelism does not exist in the child's grammar (or at least cannot be put to use at the right time); otherwise, we can conclude that she possesses the relevant knowledge and can put it to use.

As an example, consider the sentence in (17), and the accompanying scenarios (17a-d) in Table 19.7. If constraints on ellipsis are not known, or unavailable for use, then *any* VP may be a legitimate completion for *E*. If so, then she should accept all the situations (17a-d) as true (this deficit would become apparent when their errors on VPE are compared to the control coordination condition); conversely, if the child knows and uses constraints on ellipsis, she should only deem (17a) as true. The difference between these situations is depicted in Table 19.7, which marks the possible responses of the child with and without Parallelism.

Table 19.7 Test Condition: VPE + images

		Parallelism available?	
17 [$_A$ The detective found a child] and [$_E$ the policeman did [$_{VP}$__] too]		*Yes*	*NO*
a.	"*A detective finding a child, and a policeman finding a child*"	**T**	**T**
b.	"*A detective finding a child, and a policeman finding a detective*"	**F**	**T**
c.	"*A detective finding a child, and a detective finding a policeman*"	**F**	**T**
d.	"*A detective finding a child, and a child finding a policeman*"	**F**	**T**

Note that all the situations above are plausible, and the child's task is to check the sentence against them, with constraints on ellipsis being the sole factor determining truth

conditions. To make sure that sentence length, or number of clauses, are not an intervening factor that increases difficulty, we used non-elided coordinate structures with the same meaning as controls as detailed in Table 19.8.

Table 19.8 Control condition: Coordination + images

18. [$_1$ The detective found a child] and [$_2$ the policeman found a child]	
a. "*A detective finding a child, and a policeman finding a child*"	**T**
b. "*A detective finding a child, and a policeman finding a detective*"	**F**
c. "*A detective finding a child, and a detective finding a policeman*"	**F**
d. "*A detective finding a child, and a child finding a policeman*"	**F**

Our test, then, required subjects to verify sentences against depicted visual scenarios – participants responded "yes"/"no" to <sentence, scenario> pairs.
In trying to adhere to *principles of good design*, we took extra measures to ensure that Parallelism must indeed be consulted, and that no tricks or heuristics would help the child get around it.

We ran this experiment at the Centre de La Petite Enfance de McGill (with an ethics approval and informed parental consent in accordance the McGill Research Ethics Board). All participants were right-handed with normal hearing. They range in age from 4:6 to 5:6 (5 boys, mean= 59 months).

Our participants were 7 children. They were tested by one of us (I.D.) one child at the time, in a secluded area within their classroom. Sentences were read aloud, and the pictures shown concomitantly. The children responded to each pair <auditory sentence, scenario> verbally, and their responses were recorded immediately.

The relatively large number of test items (n=45), and the young age of the children, forced 4-5 testing sessions per child. Prior to each testing session, the instructions and four training sentences were presented to each child. Each session lasted no more than 30 minutes. Results (number of correct responses) are presented in Table 19.9.

Table 19.9: Experimental results

	Control condition				*VPE*				
Child	M (/6)	MM1 (/3)	MM2 (/3)	MM3 (/3)		M (/6)	MM1 (/3)	MM2 (/3)	MM3 (/3)
1	***6***	***3***	***3***	***3***	***TOO***	***6***	***3***	***3***	***3***
					SO	***6***	***3***	***3***	***3***
2	***6***	***3***	***3***	***3***	***TOO***	***6***	***3***	***2***	***3***
					SO	***6***	***3***	***3***	***3***
3	***6***	***3***	***3***	***3***	***TOO***	***6***	***3***	***3***	***2***
					SO	***6***	***3***	***3***	***2***
4	***6***	***3***	***3***	***3***	***TOO***	***6***	***3***	***3***	***1***
					SO	***6***	***3***	***3***	***2***
5	***6***	***3***	***3***	***3***	***TOO***	***6***	***3***	***3***	***3***
					SO	***5***	***3***	***3***	***3***
6	***6***	***3***	***3***	***2***	***TOO***	***6***	***3***	***3***	***2***
					SO	***6***	***3***	***3***	***3***
7	***6***	***3***	***3***	***3***	***TOO***	***5***	***3***	***3***	***2***
					SO	***5***	***3***	***3***	***2***

As can be easily seen, there were hardly any errors on any of the conditions. In both control and test conditions, children correctly verified the Match pictures, and rejected the MisMatches. We can safely conclude, it seems, that in every instance that the analysis of conjoined clauses was not an obstacle, Parallelism was used for ellipsis reconstruction.

In conclusion, then, children invoke Parallelism in VPE in both production and comprehension. VPE is an infrequently used sentence type, and the task we used forced children to use a linguistic constraint to which they have no direct evidence in the input.

Our results seem to provide clear evidence for the use of a highly abstract, unobserved, linguistic principle – Parallelism – in the processing of VPE. The significance of this result is further underscored by the relative rarity of VPE in the child's ambient language. Early mastery of VPE speaks clearly against Genarri & MacDonald's position, and weakens the force of the "isomorphism" claim, that can no longer cover VPE, even though VPE would be a natural candidate for such a requirement.

5. Where are we? What to do next?

We have seen relatively good comprehension performance in our pilot study of Broca's aphasia. We have also seen that very young children use and analyze VPE properly, despite the fact that such use requires highly abstract principles that are never attested in the data. Theoretically, the evidence from aphasia speaks against a generic "complexity" deficit in these patients, and suggests that VPE can be used as a research tool with patients, which would hopefully explore more refined structural issues, aimed at providing evidence that is relevant to theory construction. With children, we have provided yet another demonstration that highly complex knowledge is attained in the absence of evidence. Experimentally, it is clear that our perspective must first be broadened to other types of ellipsis – gapping, sluicing, N'-ellipsis. In children, we must look at how abstract principles like Parallelism interact with children's presumed deficiencies with inverse scope. In aphasia, we must gain deeper understanding of the discrepancy between on- and

off-line performances. In the meantime, the preliminary hints at hand suggest that ellipsis and its kin are likely to provide important clues on language development and breakdown.

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[2] Inverted constructions like (2) are distributionally more restrictive than (1a), e.g., they disallow negation:

(1) a. The detective found a child, and the cop didn't

b. *The detective found a child and so did**n't** the cop

c. *The detective found a child and **n**either did the cop

A multitude of reasons – syntactic and semantic (perhaps even phonological) – may conspire to lead to this restrictiveness. Yet these issues are obviously beyond the scope of the present study.

[3] Among the drawbacks of this analysis is that it has the consequence that a possessive pronoun in object position is always ambiguous (between the bound variable and referential readings), or else the copying of 2 different LF representations into *E* would not be possible (cf. Fox 2000; Heim 2007 for discussion).

[4] No empirical test has been conducted, to examine whether deletion extends to other empty categories and elements that are represented on the surface (Grodzinsky, 2011).

[5] We are aware of one attempt to study VPE in aphasia: Vasic, Ruigendijk and Avrutin (2006) used what they claimed are Dutch VPE constructions (although see van Craenenbroeck in press:20-22 for recent discussion of whether or not Dutch has VPE). Vasic et al. tested patients with Broca's aphasia in a picture selection task. They were interested in the interpretation of pronouns, hence all their sentences contained anaphora, with distractors as described in (1). The relevant foil is the "related distracter" (1-c), which forces the possessive pronoun in the antecedent clause to have a local antecedent, but the possessive pronoun in the ellipsis clause to have a deictic antecedent. For this meaning to match the sentence, Parallelism must be violated.

(1) a. Here are *L, M, N*. *L* photographed her horse and *M* did, too

b. Correct: *LL*'s horse & *M L/M*'s horse (strict and sloppy readings)

c. Foil: *LL*'s horse *M N*'s horse (deictic reading)

These scenarios may have led to infelicity: a silent pronoun (the copy in the elided VP) refers deictically, even though emphatic stress (cum pointing) is necessary for deixis to work in such contexts. (NB: controls' error rates were ~10%, a non-negligible level). This work, at any rate, did not test Parallelism.

[6] Other pieces of empirical evidence point to a similar conclusion regarding a WM deficit (cf. Grodzinsky & Santi 2008).

[7] Grodzinsky (2005) argues, based on preliminary data from an experiment with patients, that VP-fronting at LF is mandatory in VPE, as VPE is impaired in Broca's aphasia. He argued that if the TDH is the right deficit analysis, then mandatory VP-fronting in VPE would predict the pattern he observed.

However, the data presented above, which come from a study with much improved design, seem to point to the intactness of VPE in Broca's aphasia, and hence no conclusions regarding VP-fronting follow. More refined experiments are needed to bear on this issue.

[8] Tanja Temmerman suggests that if we add a trace to a VP-ellipsis construction, the deficit would manifest. She proposes to test cases of remnant movement:

(i) I don't remember what Ryan made for our Valentine's Tea, but I know what Alice did

(ii) I know how fast Adam could run, but I don't remember how fast Hilary could

[9] Gualmini and colleagues (2004) argue against this position, on empirical grounds.

[10] Gennari & MacDonald's position would thus be unable to explain how Parallelism (or any other unattested constraint) is ever attained by humans.