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Linguistics and Linking Problems

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1. Linking Genes, Brains, and Behavior

I am not an expert on language disorders. As a relative outsider at the meeting that this volume is based upon, I was impressed by two general conclusions. First, I was impressed by the extreme specificity that is now possible in the descriptions of both genotypes and phenotypes for a number of different developmental disorders that affect language. Second, I was impressed by the gulf that lies at present between our understanding of the genetic causes and the behavioral outcomes of developmental disorders. Although we know a great deal in some instances about which genes are associated with which specific disorders, we have little idea about why those genes have the specific consequences that they have for language. The goal of this paper is to outline two ways in which linguistics can be put to good use in helping to narrow this gap, particularly in relation to the search for brain-level models of language. In other words, my concern here is with the role of linguistics in the search for 'linking hypotheses', for normal and disordered language alike.

I should make it clear at the outset that I do not mean to claim that linguistics has all of the answers. One of the main goals of the paper is to argue that some basic changes are needed in fundamental assumptions about how linguistic knowledge is encoded, in order to make linking hypotheses more tractable.

There are many good reasons to want to answer the question of how the human brain makes natural language possible. (This is the question of how specific patterns of activity in specific cells or cell assemblies give rise to language, not the question of which brain regions are associated with which general functions, which I take to be just a first step towards addressing more interesting questions.) The search for an answer to this question should be interesting for purely scientific reasons.

If it were the case that individual genes control individual behavioral 'traits', then it might be satisfying to know which genetic disruptions lead to disruptions in which behavioral traits, while having little understanding of exactly how the genes give rise to specific traits, in terms of protein synthesis, brain development, or whatever else might be involved. Correlations between genes and behavioral outcomes could reasonably be viewed as partial linking hypotheses, and it wouldn't much matter whether we understood in detail how specific neuronal structures support language.

As we know, however, there is little plausibility to the notion that individual genes control individual behavioral traits. Genes play a far more complex role in regulating the synthesis of proteins, which, among many other things, give rise to specific events in neuronal growth, which in turn somehow gives rise to a human brain, which is somehow equipped to learn and use human language. Besides, there are simply not enough genes available for each gene to control an individual trait.

Therefore, the observation that specific genetic disruptions lead to specific cognitive and linguistic disorders becomes all the more puzzling. For example, if it is true that there are genetic disruptions that cause children to have special difficulty in the marking of tense morphology in their speech, and if we can be fairly confident that there is no gene that codes for tense morphology, then it is all the more puzzling that specific areas of language turn out to be more vulnerable than others. In fact, the puzzle is made even more interesting by the fact that *different* genetic disruptions appear to lead to often similar areas of vulnerability in language (e.g., inflectional morphology, non-word repetition, non-canonical word order in syntax), as appears to be the case. If we are to understand these connections between genes and behavior, we have no choice but to understand the complex sequence of causes and effects that link genes with brain development, and that link brain circuitry with language abilities. In other words, the search for linking hypotheses for language takes on far more than mere academic interest.

On the question of how to link genes and brain development, I must defer to the expertise of others. On the other hand, the question of how to link up our understanding of language with what we know about brain circuitry is one that has occupied me a great deal, and one that is also relevant to the question of how we can gain a deeper understanding of language disorders. In this paper, I discuss two ways in which linguistic research can make valuable contributions to our understanding of the causes of developmental language disorders.

In the first section of the paper, I present a number of examples that show that systematic patterns of errors in the course of normal language development can be better understood in light of a detailed understanding of cross-linguistic variation in adult languages. These findings fit with the common suggestion that constraints on language development reflect constraints on the range of possible adult languages. If the systematicity of errors in normal language development often reflects constraints on cross-language variation, and if it is true that many features of developmental language disorders parallel difficulties observed in normal development, then it is reasonable to expect a connection between the systematic nature of breakdown in language disorders and the scope of cross-language variation. In other words, this section shows how the tools of linguistic analysis can already be brought to bear on the problem of understanding language disorders.

In the second section of the paper, I argue that the results of linguistic analysis can more usefully be brought to bear on linking hypotheses about brain and behavior if grammatical knowledge is viewed as a real-time system for constructing sentences. This contrasts with the standard view in linguistics and psycholinguistics, according to which knowledge of language is fractionated into separate time-independent and time-dependent systems (sometimes known as 'competence systems' and 'performance systems'). Therefore an important part of my argument involves a critical review of arguments in favor of the standard view. I argue that the 'grammar', the 'parser', and the 'producer' nowadays appear much more similar than they once did, and that their unification can provide an important step towards developing linking hypotheses for normal and disordered language. If, on the other hand, we are forced to maintain the standard view that grammatical knowledge involves mental computations that are too elusive to be pinpointed in time, then I believe that we have little hope of developing and testing viable linking hypotheses for linguistic knowledge.

Throughout the paper, I focus mainly on issues involving syntax, the study of sentence structure. This should not be taken to imply that syntax is more important or more central than other areas of language. It merely reflects the fact that this is one area of language where enough of the pieces are in place to allow us to seriously consider how to address the linking problem.[1]

Language Development and Cross-Language Variation

The finding in research on developmental disorders that specific areas of language are more vulnerable than others is familiar from the literature on normal language development. Our understanding of the constraints on normal language development has been strongly informed by theoretical and descriptive linguistic research on cross-language diversity. In this section, I review a number of examples from our own work where the study of cross-language variation has provided new insight into the question of why children make certain kinds of errors and do not make certain other kinds of errors. This typological approach leads to evidence of both language internal and cross-linguistic constraints on development. I should point out that the studies described here were not conceived with the programmatic goal of showing that children's errors reflect constraints on possible adult languages. In some instances, we were pursuing an entirely different hypothesis. However, we were repeatedly led back to the same conclusion by our findings.

#1: Root Infinitives

Normally developing two- to three-year olds show patterns of morphosyntactic errors in their spontaneous speech that are very similar to errors that have been widely observed in developmental language disorders. Over the past 15 years, this has been one of the most fruitful domains of research in normal language development, due in large part to the fact that it has become possible to compare findings from a wide variety of languages. The point of this section is to outline some systematic differences in the distribution of these errors across languages, which may provide clues to the source of the errors.

Some of the studies of different languages have revealed striking cross-language similarities. For example, the reason why inflection omissions in English-speaking children are nowadays described as 'root infinitives' is because the counterparts of these errors in many other languages appear as verb forms that are clearly marked as infinitives (1-3) (Wexler, 1994). Even in languages where the relevant form is not an infinitive *per se*, such as Greek (Stephany, 1997; Varlokosta, Vainikka, & Rohrbacher, 1998), it is still the case that young children frequently replace correctly inflected forms with a morphologically unmarked 'default' form (4).

(1) Eve sit floor. [Eve, 1;7] English

[1] For discussion of some specific linking proposals in the area of phonetic and phonological categories, see Phillips (2001).

(2)	Maman manger mom eat.inf	[Daniel, 1;8]	French
(3)	Ty mame pomogat'. you.nom mommy.dat help.inf 'You to help mommy'	[Varvara, 2;0]	Russian
(4)	Ego katiti I sit.3per.perf.	[Janna, 1;11]	Greek

Another consistent result of these studies is that children's infinitive forms are not randomly distributed across the different syntactic constructions that they use. Whereas some constructions, including run-of-the-mill declarative sentences, show large numbers of infinitive errors, other constructions show a striking absence of infinitive errors. For example, it is not uncommon for a two-year old child learning German, Dutch or Swedish to produce infinitive verb forms in 20-30% of his declarative utterances, but this percentage drops to 0-2% when we look only at his questions (Clahsen, Kursawe, & Penke, 1996; Haegeman, 1995; Santelmann, 1994) or sentences in which a non-subject is topicalized (Poeppel & Wexler, 1993).

(5) Dutch: Finiteness in declaratives and questions (Haegeman, 1995)

Hein 2;4–3;1	+*finite*	-*finite*
All clauses	3768 (84%)	721 (16%)
wh-questions	88 (98%)	2 (2%)

Total = 4579, $\chi^2 = 12.71$, $p < 0.001$

(6) German: Finiteness in declaratives and questions (Clahsen, Kursawe, & Penke, 1996)[2]

4 children, 1;10-3;8	+*finite*	-*finite*
wh-questions	306 (99.7%)	1 (0.3%)

Similarly, root infinitives are very frequent in the speech of Dutch two-year olds, particularly in sentences where the child omits the subject of the sentence, but they are exceedingly rare in sentences in which the sentence begins with an overt subject NP (Krämer, 1993; Haegeman, 1995). A similar pattern is found among children learning Russian (Bar-Shalom, Snyder, & Boro, 1996) or German (Behrens, 1993).

[2] Although this study does not provide baseline rates of correct inflection from declarative clauses, root infinitives are a robust phenomenon in child German, typically occurring in 10%-30% of declarative clauses in the speech of children at that stage.

(7) Dutch: Finiteness and null subjects (Krämer, 1993)

Thomas 2;3–2;8	+*finite*	-*finite*
overt subject	431 (95.4%)	21 (4.6%)
null subject	165 (40.1%)	246 (59.9%)

Total = 863, χ^2 = 307.07, $p < 0.0001$

(8) Russian: Finiteness and null subjects (Bar-Shalom, Snyder & Boro, 1996)

Varvara 1;6–2;4	+*finite*	-*finite*
overt subject	545 (99.1%)	5 (0.9%)
null subject	451 (81.9%)	100 (18.1%)

Total = 1101, $\chi^2 > 50$, $p < 0.0001$

(9) German: Finiteness and null subjects (Behrens, 1993)

Simone 1;8–4;1	+*finite*	-*finite*
overt subject	2918 (91.3%)	278 (8.7%)
null subject	781 (26.2%)	2199 (73.8%)

Total = 6176, χ^2 = 102.15, $p < 0.0001$

Both of these patterns are striking, because they reveal better morphosyntactic performance in more complex sentences, and worse performance in less complex sentences. Furthermore, it can be shown clearly that these results are not just artifacts of sampling from speech transcripts that cover a broad developmental time window. Patterns such as those shown in (5-9) provide a straightforward challenge to any attempt to explain the root infinitive phenomenon as a simple production overload effect, since such an account would surely predict greater difficulty in more complex sentences.

However, a review of the cross-language literature reveals further selectivity in the distribution of root infinitives across languages. The two effects shown in (5-9) appear in some languages, but not in others. The selective appearance of these effects can shed light on the nature of root infinitives in individual languages.

As we have seen in (7-9), children in a number of languages produce very few root infinitives in sentences with overt subjects, in contrast with their frequent use in sentences with null subjects. However, there are other languages where root infinitives remain frequent in sentences with overt subjects. Such languages include Danish, Icelandic, Faroese, and English (10-13).[3] This cross-language contrast can be explained once we consider the range of possible infinitival clauses in the corresponding adult languages. In the adult languages, of course, the infinitival clauses occur overwhelmingly as embedded clauses. English and the Scandinavian languages all allow embedded infinitival clauses with overt subjects, as shown in (14-15). These constructions are known in the linguistics literature as 'exceptional case marking' (ECM) constructions, due to the fact that the subject of the embedded clause appears with accusative case, as if

[3] In the Scandinavian languages it is still generally the case that rates of infinitive production are lower in sentences with overt subjects than in sentences with null subjects. This is probably also true in English, although there have been conflicting reports (cf. Phillips, 1995b; Schütze, 1997; Schütze & Wexler, 2000). However, it is probably a mistake to conflate a *reduction* in rates of root infinitive production with the *extreme rarity* of root infinitives following overt subjects in languages like Dutch and Russian.

it were the direct object of the main clause verb. German, Dutch, and Russian, in contrast, lack ECM constructions (16), although they do allow infinitival complement clauses with null subjects (17).[4]

(10) English: Finiteness and null subjects (Phillips, 1995b)

Adam 2;3–3;0	+*finite*	-*finite*
overt subject	79 (28.8%)	195 (71.2%)
null subject	34 (42%)	47 (58%)

Total = 355, $\chi^2 = 4.98$, $p = 0.026$

(11) Faroese: Finiteness and null subjects (Jonas, 1995)

Osvalt 1;10	+*finite*	-*finite*
overt subject	44 (31.9%)	94 (68.1%)
null subject	8 (10.7%)	67 (89.3%)

Total = 213, $\chi^2 = 11.86$, $p < 0.001$

(12) Icelandic: Finiteness and null subjects (Sigurjónsdóttir, 1999)

Birna 2;0-2;6	+*finite*	-*finite*
overt subject	689 (70.2%)	293 (29.8%)
null subject	111 (34.2%)	214 (65.8%)

Total = 1307, $\chi^2 > 50$, $p < 0.0001$

(13) Danish: Finiteness and null subjects (Hamann & Plunkett, 1998)[5]

Anne & Jens 2;0-2;10	+*finite*	-*finite*
overt subject	75%	40%
null subject	25%	60%

(14) a. They consider [him to be a genius] English
b. They want [him to leave]

(15) a. Eg tel hana hafa borðað epli. Icelandic (Vikner 1995: 213)
I believe her to.have eaten apple

[4] Although Dutch and German do not allow most of the types of ECM constructions available in English, they do allow ECM in the complements of perception verbs, such as *see*. This may be related to the fact that in such contexts the embedded verb ('dance' in (i)) is raised from the embedded clause to form a complex predicate with the main verb. This has led some linguists to conclude that the apparent accusative-marked 'subject' of the embedded clause is really a semantic argument of the main clause perception verb (e.g., Steinbach, 2002).

(i) dat Jan [haar.acc de tango] ziet dansen [Dutch]
that John her the tango sees dance

[5] These percentages are estimates, based upon the graphs in Hamann & Plunkett (1998). Note that the percentages shown apply to the columns of the table, in contrast to the other tables in this section.

b. Jag anser Peter att vara dum. Swedish (Holmberg, 1986)
I consider Peter to be stupid

c. Vi anser honom (ha) kommit för sent. Norwegian (Julien, 2001)
we consider him have come too late

(16) a. * Sie erwarten [ihn anzukommen] German
They expect him to.leave

b. * Ja ozhidaju [jego prijehat' zavtra] Russian
I expect him arrive tomorrow

(17) a. Maria versprach, [das Büro zu pützen] German
Maria promised the office to.clean

b. Maria poobesh'ala [podmesti v ofise] Russian
Maria promised sweep.inf in office

A similar cross-linguistic contrast may be observed in children's questions. Whereas rates of root infinitive production fall close to zero in children's questions in German, Dutch and Swedish, as illustrated in (5-6), we find high percentages of uninflected verb forms in early *wh*-questions in English (18). We again find a related contrast when we look at infinitival clauses in the corresponding adult languages. English allows fronting of *wh*-phrases in infinitival clauses in indirect questions (19), but such constructions are impossible in adult German (20), and at best marginal in many dialects of Dutch.[6] The distribution of infinitives in questions has been documented in fewer languages than has the distribution of infinitives relative to null-subjects, for the simple reason that the relevant utterances are less common in transcripts of spontaneous speech. We need either large corpora, or highly inquisitive children.

(18) English: Finiteness in declaratives and questions English (Phillips, 1995b)

Adam 2;3–3;1	*inflected V*	*uninflected V*	*% inflected*
Declaratives	134	203	40%
wh-questions	69	92	43%

Total = 498, $\chi^2 = 0.43$, p = 0.51

(19) John knows which man to ask. *English*

(20) * Hans weiss, welchen Mann zu fragen. *German*
Hans knows which.acc man to ask.inf

Similarly, child German shows very low rates of root infinitives in sentences in which a non-subject is moved to sentence-initial position by topicalization (21). The

[6] There are certain circumstances where adult German allows infinitival *wh*-clauses as main clauses (Fries, 1983; Reis, 2002). However, these constructions are limited to root clauses, and are described as 'a comparatively rare species, even among RIs in German' (Reis, 2002: 288). An example is shown in (i):

(i) Wem noch trauen?
Who still trust.inf. 'Who can you trust anymore?'

widespread availability of topicalization in German is a result of the verb-second property of German. Adult German disallows verb second (and hence also topicalization) in all embedded clauses (22).[7]

(21) German: Finiteness and topicalization (Poeppel & Wexler, 1993)

Andreas 2;1	*+finite*	*-finite*
Subj. initial	130	24
Non-subj. initial	50	0

Total = 204, $\chi^2 = 8.83$, $p < 0.01$

(22) * Er sagt, daß diesen Film haben die Kinder gesehen.
He says that this.acc film have the children.nom seen (Vikner, 1995:66)

Taken together, these cross-language findings suggest an interesting language-internal constraint on the kinds of errors that normally developing children make. Despite the fact that children's root infinitives are not possible adult utterances, their errors generally respect broad constraints on the possible forms of infinitival clauses in the target language. The very rare appearance of overt subjects with root infinitives appears to be a property of child language only when the target language lacks overt subjects with infinitival clauses. Similarly, the disappearance of root infinitives in children's questions and topicalizations in some languages may be related to the absence of corresponding interrogative infinitival clauses in the target language.

The implication of this is that many of the root infinitive errors made by normally developing children are closer to the adult target language than one might at first suspect. The child's primary error is to allow an infinitival in the root clause, but beyond that, the child produces the infinitival clause with syntax that is overwhelmingly appropriate for infinitival clauses in the ambient adult language. This conclusion lends support to the proposal by Weissenborn (1994) that children's early multi-word utterances respect a 'local well-formedness' condition, and could also be viewed as an extreme version of Rizzi's (1994) widely discussed 'clausal truncation' hypothesis. It has the advantage of explaining cross-language variation in the distribution of children's root infinitives that has not previously been explained.[8]

Note that this claim applies specifically to children's infinitival clauses. It is not intended as a general claim that children's root clauses can freely adopt embedded clause syntax. This is not supported by the facts. For example, in adult English indirect questions, subject-auxiliary inversion and *do*-support are not required (23), but children's

[7] I illustrate this property with a finite embedded clause, because the effects of topicalization are easier to see in a clause that contains an overt subject. Since German lacks ECM constructions, we must rely upon finite embedded clauses in order to construct examples with an overt subject.

[8] In an earlier paper (Phillips, 1995b) I offered an account of a subset of the cross-language facts reviewed here, based on cross-language differences in verb placement and verb movement. However, that account faces difficulties when faced with the range of facts presented here. In particular, the facts about overt subjects of children's root infinitives in Scandinavian languages favors the current account based on ECM constructions in the corresponding adult languages. Icelandic and Mainland Scandinavian languages pattern together in allowing ECM constructions, but diverge with respect to independent verb movement. The distribution of overt subjects in children's root infinitives appears to be similar across all Scandinavian languages, and different from German, Dutch, and Russian.

questions do not show frequent non-inversion (24a) or finite verbs without *do*-support (24b).[9]

(23) a. Bill understands what he has done.
b. Bill understands what Sally does.

(24) a. * What he has done?
b. * What Sally does?

Also, the generalization about the syntax of children's infinitival clauses does not provide a general answer to the question of why children produce infinitival root clauses in the first place; it merely explains how these clauses are structured to conform maximally to the adult grammar.[10] Nevertheless, these remaining questions do not undermine the moral of this section, which is that the understanding of the specific properties of children's morphosyntactic errors depends on a detailed understanding of the structure of the relevant adult languages.

It remains to be seen whether the 'extended' period of root infinitive production observed in SLI (Rice, Wexler, & Cleave, 1995; Leonard, 2003) shows the same specific syntactic properties as the root infinitives found in normally developing children. If SLI genuinely reflects selective language delay, then we should expect to find the same distribution of facts discussed here in the speech of SLI children across languages. Alternatively, if SLI children do not show the same pattern of cross-language variation in root infinitives observed in normally developing children, then this is a challenge for the claim that SLI syntax is simply selectively delayed.

#2: Universal Constraints I: Verb Argument Structure

We also find cases where systematic patterns of errors in normally developing children reflect universal constraints on adult languages. Two examples serve to illustrate this point.

The first example, based on work conducted with Meesook Kim and Barbara Landau, concerns the argument structure of so-called *locative verbs*, verbs that describe the movement of an object, typically known as the 'figure', to a location, typically known as the 'ground'. In English and in many other languages, locative verbs allow their arguments to appear in two different configurations. In the *figure frame*, the figure is the direct object of the verb and the ground is marked by an oblique phrase, such as a PP. In the *ground frame*, the ground appears as the direct object, and the figure is marked by an

[9] Forms such as these do occur in child English, but with very low frequency. However, we cannot exclude the possibility that the presence of such forms in child English is masked by the independent fact of auxiliary omission at early stages of development (e.g., *What doing?*). For further discussion of questions in child English, see Roeper & Rohrbacher (2000).

[10] Note that my generalization about the syntax of root infinitives makes a prediction about the overt subjects of children's infinitives that is probably too strong. The overt subjects of infinitives in adult languages are typically accusative-marked ECM subjects. Although it is true that English-speaking children often produce sentences with accusative subject pronouns (e.g. *'him go'*), and that these non-nominative subjects are mostly restricted to infinitival clauses (cf. Schütze, 1997; Wexler, Schütze, & Rice, 1998), there are also many instances of nominative subjects of infinitival clauses.

oblique phrase. In English, verbs that describe a manner-of-motion, such as *pour*, *spill*, and *shake*, allow the figure frame (25). Verbs that describe a change-of-state, such as *fill*, *cover*, and *decorate*, allow the ground frame (26). Verbs that describe both a manner-of-motion and a change-of-state, such as *pile*, *load*, and *stuff*, allow both figure and ground frames, and are known as alternating verbs (27).

(25) a. Jane poured the water into the glass. *figure frame*
b. * Jane poured the glass with water. *ground frame*

(26) a. * Jane filled the water into the glass. *figure frame*
b. Jane filled the glass with water. *ground frame*

(27) a. Jane stuffed the feathers into the pillow. *figure frame*
b. Jane stuffed the pillow with feathers. *ground frame*

In light of the fact that the structural frames that these verbs allow are determined by the semantics of the verbs, studies of the acquisition of these verbs have focused on demonstrating that children are able to use this syntax-semantics correspondence to constrain their choices of argument structure (Pinker, 1989; Gropen et al., 1991ab). Nevertheless, it has also been found that children make errors with locative verbs, and produce argument structures that do not occur in adult English. Bowerman (1982) reported examples of the ground verbs *fill* and *cover* used in the figure frame in the spontaneous speech of 4-5 year olds (e.g., **I'm going to cover a screen over me*). Bowerman characterized these examples as overgeneralizations to ground verbs of structures that the children had observed with figure verbs. Gropen et al. (1991b) replicated the errors with *fill* in an elicited production study, and Kim, Landau & Phillips (1999) showed figure frame errors with *fill*, *cover* and *decorate* in another elicited production study. In that study, the errors with *fill* were so frequent that children almost never used the correct ground frame. This in no way reflects the properties of the input to children - we also tested the children's own mothers, who made no errors at all. Importantly, however, the high frequency of errors with ground verbs stands in clear contrast with the children's high performance on figure verbs, such as *pour*, *spill*, and *stick*, where they never produced figure verbs in the ground frame. Therefore, this is another case of a speech production error in children that is syntactically highly specific.

In a survey of locative verb syntax in twenty different languages,[11] drawn from a wide variety of language families, we found a contrast that resembles the pattern of errors observed in children. In every language in the sample, manner-of-motion verbs allow the figure frame, but do not allow the ground frame (28-30), exactly as in English. On the other hand, change-of-state verbs show more cross-language variation. Many languages pattern with English, in allowing only ground frames with change-of-state verbs. But

[11] The languages surveyed were English, French, Spanish (Castialian and Argentinian), Italian, Brazilian Portuguese, Polish, Russian, Mandarin Chinese, Japanese, Korean, Thai, Malay, Hindi, Hebrew, Arabic, Luganda, Yoruba, Ewe. Thanks to Beth Rabbin for her help in conducting this survey. Detailed results of the survey are available on request.

there are many other languages that allow change-of-state verbs with both figure and ground frames (31-33).[12]

(28) a. Juan vertió agua en el vaso. Spanish
J. poured water in the glass
b. * Juan vertió el vaso con agua.
J. poured the glass with water

(29) a. Dani shafax mayim letox ha-kos Hebrew
D. poured water into the-glass
b. * Dani shafax et ha-kos be-mayin
D. poured acc.the-glass with-water

(30) a. Yumi-ka mwul-ul cep-ey pwu-ess-ta. Korean
Nom water-Acc cup-Loc pour-Past-Dec
'Yumi poured water into the cup.'
b. *Yumi-ka cep-ul mwul-lo pwu-ess-ta.
Nom cup-Acc water-with pour-Past-Dec
'*Yumi poured the cup with water.'

(31) a. Yumi-ka mwul-ul cep-ey chaywu-ess-ta. Korean
Nom water-Acc cup-Loc fill-Past-Dec
'*Yumi filled water into the cup.'
b. Yumi-ka cep-ul mwul-lo chaywu-ess-ta.
Nom cup-Acc water-with fill-Past-Dec
'Yumi filled the cup with water.'

(32) a. John bardag-a su-ylu doldur-du. Turkish
John glass-Dat water-Acc filled-Past
'*John filled water into the glass.'
b. John bardag-I su-yla doldur-du.
John glass-Acc water-with filled-Past
"John filled the glass with water.'

(33) a. Petero ya-jju a-mazzi mu-gilaasi. Luganda
Petero filled the water into-glass
'*Petero filled water into the glass.'
b. Petero ya-jjuza gilaasi na-mazzi.
Petero filled glass with-water
'Petero filled the glass with water.'

[12] See Kim (1999) and Kim, Landau, & Phillips (1999) for an account of what determines this cross-language variation. The account is based upon an additional syntactic property of the languages in which change-of-state verbs allow both figure and ground frames. All of these languages allow serial verb constructions, i.e., complex predicate constructions in which a single clause contains more than one lexical verb, while none of the other languages in the sample allow this.

Therefore, the accuracy of English-speaking children with verbs like *pour* reflects a cross-language universal. The frequent errors that the same children make with verbs like *fill* is consistent with the variability observed in the languages of the world. The range of errors that children produce is constrained by the range of forms that are possible in adult languages. This typological observation does not answer the question of why children do not immediately converge on the target-language forms for the *fill*-class, but it provides important clues to why the children's errors are so selective.

#3: Universal Constraints II - Pronoun Interpretation

A second example of the impact of cross-language universals comes from work with Nina Kazanina on children's interpretation of pronouns (Kazanina & Phillips, 2001), which shows that children distinguish universal and language-particular constraints, even when the surface consequences of the two types of constraints are broadly similar in the target language.

A pronoun may (but need not) co-refer with another noun phrase in the same sentence. Importantly, the pronoun may either follow its antecedent ('forwards anaphora', 34a), or precede its antecedent ('backwards anaphora', 34b). Co-referring NPs are indicated by subscripting.

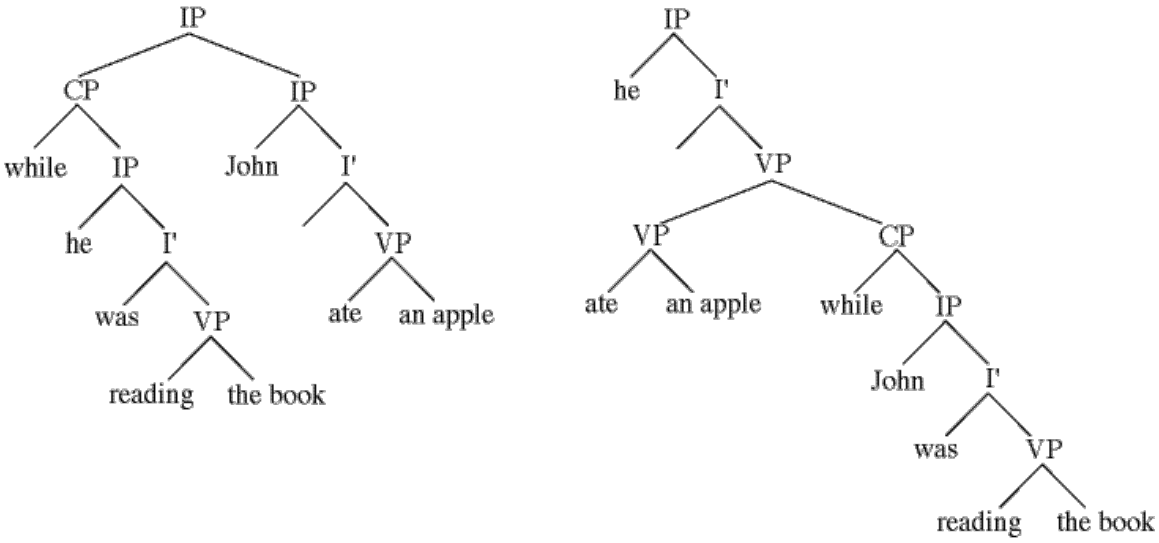
(34) a. John$_i$ thinks that Sue likes him$_i$.
b. The man that he$_i$ met at the bus stop told John$_i$ that it would rain.

However, there are also a number of constraints on the possible configurations of pronouns and their antecedents. These constraints have been the subject of intensive investigation in linguistics. For example, a pronoun cannot co-refer with a noun phrase that is structurally within the scope of the pronoun (i.e., contained within the structural sister of the pronoun). This constraint, which in the syntax literature is known cryptically as 'Condition C' (Chomsky, 1981), accounts for the fact that (35a) and (36a) allow co-reference, whereas (35b) and (36b) do not. In each of the examples in (35-36) the phrase that is the structural sister of the pronoun is italicized. The noun phrase *John* cannot serve as the antecedent of the pronoun when it appears within the italicized region. Corresponding structures are shown in (37a-b).

(35) a. The woman that he$_i$ *met* likes John$_i$.
b. * He$_i$ *likes John$_i$*.

(36) a. While he$_i$ *was reading the book*, John$_i$ ate an apple. (structure = 4a)
b. * He$_i$ *ate an apple while John$_i$ was reading the book*. (structure = 4b)

(37) a. b.



Cross-language research has shown that Condition C is a good candidate for a universal constraint on interpretation. Its effects have been found in a large number of typologically diverse languages, including even polysynthetic languages such as Mohawk, where the effects of Condition C are extremely difficult to observe (Baker, 1991). Consistent with the universal status of this constraint, language acquisition studies have shown that children respect the constraint at a very early age. In a pioneering study, Stephen Crain and Cecile McKee showed that English-speaking children as young as 3 years of age disallow a co-reference interpretation for sentences like (36b) that violate Condition C (Crain & McKee, 1985), while allowing co-reference of the type in (36a).

We have recently extended this line of language acquisition research to Russian, which provides an interesting additional twist to the story. Although there is a sharp contrast in the acceptability of co-reference in (36a) and (36b) in English, their Russian counterparts (38a-b) are both reliably rated as unacceptable by Russian adults. (38b) is ruled out by the universal Condition C constraint, whereas (38a) is ruled out by an additional constraint that is particular to Russian (Kazanina & Phillips, 2001; Avrutin & Reuland, 2002).[13]

(38) a. *Poka on$_i$ chital knigu, Pooh$_i$ s'el yabloko.
while he was reading.imp the book Pooh ate.perf the apple
b. * On$_i$ s'el yabloko, poka Pooh$_i$ chital knigu.
he ate.perf the apple while Pooh was reading.imp the book

Using a similar truth-value judgment task to Crain & McKee's study, we investigated what pronoun interpretations are available to Russian 3-5 year olds (Kazanina & Phillips, 2001). Children watched a set of stories in the company of an experimenter and a puppet, and after each story the puppet made a statement about something that happened in the story. The child's task was simply to judge whether the

[13] It is not the case that Russian excludes (38a) simply because it disallows all backwards anaphora. The Russian counterparts of (35a) and (35b) show exactly the same contrast in acceptability as in English.

puppet's statement was true or not. We tested possible pronoun interpretations by asking children to judge the truth of sentences like (38a) and (38b) following stories in which the sentences would be *true*, if the coreference interpretation were available, but *false* under a reading where the pronoun is taken to refer to another character, e.g. Eeyore. Therefore, if children judge that the puppet told the truth, it must be that they allow the co-reference interpretation; if they judge that the puppet did not tell the truth, then it must be that the co-reference interpretation is blocked by a constraint (see Crain & Thornton, 1998, for full details of this technique). We found that Russian 5-6 year olds disallow co-reference in both (38a) and (38b), just like Russian adults. However, Russian 3-year olds (n=9) showed a clear contrast between (38a) and (38b), by rejecting co-reference in sentences like (38b) in 85% of trials, but rejecting co-reference in sentences like (38a) in only 13% of trials. These percentages of acceptance and rejection are almost identical to those obtained for the youngest group of children in Crain & McKee's study on Condition C in English. The Russian 4-year olds showed an intermediate pattern of judgments, overwhelmingly rejecting co-reference in (38b), but allowing co-reference in (38a) in around 50% of trials.

Therefore, the Russian 3-year olds show a contrast in pronoun interpretation possibilities that is present in child and adult English, but is not evident in the judgments of their own parents. They adhere to the universal constraint on co-reference that rules out (38b), but do not yet respect the Russian-specific constraint on co-reference that applies in minimally different sentences like (38a). This is a particularly striking example of a selective pattern of errors in children that reflects the operation of cross-language constraints. The information that leads young children to distinguish (38a) from (38b) is presumably not available in the speech input to Russian children. Even in the unlikely event that the two types of sentences were present in the input, with pronouns in the relevant positions, children would never receive explicit information on which pronoun-interpretations are unavailable.

#4: Cross-Language Semantic Contrasts - Aspect

A fourth example of the connection between cross-language variation and selective errors in children comes from a series of recent studies with Nina Kazanina on children's understanding of the semantics of aspect (Kazanina & Phillips, 2003ab). In this case, we observe errors in young children that at first glance appear to reflect a general cognitive limitation, but which on closer inspection turn out to again reflect the structure of cross-language variation.

Grammatical aspect is a morphosyntactic category that encodes a speaker's perspective on an event. Intuitively, perfective aspect presents an 'external' perspective upon an event, whereas imperfective aspect presents an 'internal' perspective upon the event, viewing it as an ongoing process. These differences in perspective have important consequences for the semantic entailments of perfective and imperfective sentences. Consider the implications of the English simple past and past progressive sentences in (39a) and (39b).

(39) a. Sue drove from Washington to Boston.
b. Sue was driving from Washington to Boston.

Both (39a) and (39b) refer to an event of driving from Washington to Boston. However, (39a) implies that the event reached completion, i.e., Sue did reach Boston, whereas (39b) is compatible with a situation in which Sue's car broke down in New York and she never made it to Boston. Although the event of driving to Boston does not reach completion, speakers understand that it is nevertheless appropriate to describe it using the predicate *driving from Washington to Boston*, since this appropriately describes what Sue intended to do and what she was on the way to achieving. In fact, it even sounds misleading to describe what happened as *Sue was driving from Washington to New York*. Thus, whereas perfective predicates carry completion entailments, imperfective predicates lack completion entailments.[14] The fact that imperfectives do not entail the existence of the event that they intuitively refer to gives rise to what is sometimes known as the *Imperfective Paradox* (Dowty, 1979; Parsons, 1991).

It is well known that grammatical aspect is highly salient in Russian. Each verb has distinct perfective and imperfective roots (e.g., *pisat'* 'read.imp', *napisat'* 'read.perf', *govorit'* 'say.imp', *skazat'*, 'say.perf'), and the morphological marking of tense and aspect is clearly distinct. Previous studies have shown that Russian two-year olds already use both perfective and imperfective forms frequently and overwhelmingly appropriately in their spontaneous speech, suggesting early mastery of grammatical aspect (Gvozdev, 1961; Brun et al., 1999; Bar-Shalom, *in press*). However, our experiments on Russian children's comprehension of the *semantics* of aspect reveal strikingly non-adultlike performance.

In a series of studies, we tested Russian 3-5 year olds' understanding of the completion entailments of perfective and imperfective forms in the past tense. For example, we wanted to know whether children know that the perfective statement *Obez'yanka postroila dom* 'The monkey built.perf a house' entails that a house was built to completion, whereas the imperfective statement *Obez'yanka stroila dom* 'The monkey built.imperf. a house' does not entail the completion of the house-building event. In a first pair of studies, we investigated this by asking children questions about stories in which a toy animal took a journey down a road and performed a given action to varying degrees of completion at different landmarks along the road. At the end of each story, the child was asked questions like *Where did the monkey build the house?* using either perfective or imperfective verb forms. All children gave adultlike responses to perfective questions, naming only locations where the event reached completion. However, many children (including most of the 3-year olds) gave non-adultlike answers to imperfective questions, consistently failing to choose the location where the event happened incompletely.[15] Older children and adults performed exactly as predicted. We have

[14] The contrast in (39) between the English simple past and past progressive is presented for illustrative purposes only, and is not intended as a genuine perfective/imperfective contrast. Although the imperfective and progressive are similar in many respects, there are also important differences (cf. Klein, 1995).

[15] We have run a number of control tasks that show that the failure to name the incomplete location is not a task-related artifact. First, the stories all contained interrupting events that took place at two different locations. All children successfully named both locations when asked where the interrupting events occurred. This shows that all children are able to name multiple locations in their answers. Second, children in this study also gave truth-value judgments to statements made by a puppet, such as 'The monkey built a house by the tree': the same children who rejected incomplete events in responding to imperfective *where*-questions also rejected imperfective statements about incomplete events in the truth-value judgment task.

observed the failures in younger children for a number of different predicate-types, including creation predicates (e.g., *build a smurf*), change-of-state verbs (e.g., *color in a flower*), and motion predicates (e.g., *bike to the farm*).

The results of our first set of studies suggest that younger children fail the Imperfective Paradox, and have not yet learned that imperfectives lack completion entailments. This error was not noticed in previous studies of aspectual development in Russian (e.g. Vinnitskaya & Wexler, 2001), due to the fact that children were tested on their ability to associate imperfectives with events that were in progress, rather than with events that specifically failed to reach completion. One might conclude from this that the younger Russian children are missing a fundamental piece of the semantics of the imperfective, or that their failures reflect a conceptual problem, which prevents them from recognizing the relationship between partial and complete events, or which forces them to consider only what the protagonist actually did, rather than what he intended to do. One might even suppose that the younger children have yet to learn that imperfectives and perfectives are semantically distinct. We were ourselves attracted by all of these possibilities, and ran a series of follow-up studies to test possibilities such as these. In the end, though, none of these possible explanations turned out to be viable, and we were led back to an explanation that again links specific child errors to specific patterns of variation in the adult languages of the world.

The crucial follow-up studies were ones in which the children again judged perfective and imperfective statements, but now in the context of additional clauses that specified a temporal 'frame-of-reference', as in (40).

(40) a. Poka malchik polival cvety, devochka vyterla stol. *perfective*
while boy water.past.imp flowers girl clean.past.perf table
While the boy was watering flowers, the girl cleaned the table.

b. Poka malchik polival cvety, devochka vytirala stol. *imperfective*
while boy water.past.imp flowers girl clean.past.imp table
While the boy was watering flowers, the girl was cleaning the table.

Children judged sentences like (40a) or (40b) in a truth-value judgment setting (Crain & Thornton, 1998), after watching stories in which the event described by the main clause extended beyond the time interval specified by the *while*-clause. In one study the main clause event did ultimately reach completion. In another study, it did not reach completion, and remained incomplete at the end of the story. This manipulation had no effect on the children's responses, which were overwhelmingly adultlike at all ages. When tested on perfective sentences like (40a), children consistently responded *No!* because the main clause event did not reach completion during the interval described by the *while*-clause. When tested on imperfective sentences like (40b), on the other hand, children consistently responded *Yes!* because the main clause event was occurring during the interval described by the *while*-clause. They also responded *Yes!* to imperfective

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Third, we ran another study in which each protagonist carried out only one complete or incomplete event. Younger children still showed errors in associating imperfective statements with incomplete events. This shows that the children do not fail simply because they only choose the event that is the 'best match' to the target statement, and prefer complete events to incomplete events.

sentences in situations where the main clause event failed to reach completion at some time following the frame-of-reference. Many of the children who showed consistent adultlike performance on these tasks were among the children who consistently gave non-adultlike answers in the earlier experiments when judging statements with no explicit frame-of-reference.

These results show that young Russian children do know about key differences between the semantics of perfective and imperfective aspect. More importantly, they know that the imperfective can be used to describe a part of an event, and does not require that the event ultimately reach completion. Therefore, they do not fail the Imperfective Paradox, after all. This is encouraging, but it also begs the question of why so many young children fail to match imperfectives to incomplete events when judging simple sentences. Interestingly, van der Feest & van Hout (2002) observe that the simple past in adult Dutch shows a very similar semantics. Simple past carries completion entailments in the absence of a temporal frame-of-reference, as in (41a). The completion entailments disappear when an explicit frame-of-reference is provided, as in (41b). We have confirmed these judgments with a number of Dutch speakers.

(41) a. Maria maakte de tafel schoon. [completion entailment]
'*Maria cleaned the table.*'

b. Terwijl Hans de bloemen aan het water geven was, maakte Maria de tafel schoon. [no completion entailment]
'While the boy was watering the flowers, Maria cleaned the table.'

Why does the presence of the frame-of-reference matter to the completion entailments of the imperfective? Recall from above that a function of imperfective aspect is to convey a specific perspective upon an event. An 'internal' perspective upon a past event has the effect of suspending completion entailments. We suggest that adult Dutch, and child Russian, require that this temporal perspective be explicitly provided by prior discourse, whereas adult Russian is more liberal and does not impose this constraint (see Kazanina & Phillips (2003b) for a more detailed account). The Dutch system has the advantage of being a more restrictive semantics, and hence a young Russian child should be able to move from the initial 'Dutch' semantics to the adult Russian semantics based on hearing examples of past imperfectives used with incomplete events in simple sentences.

This case provides a good example of how non-adultlike language performance in children can be either overlooked or misinterpreted. Earlier studies suggested that Russian children had mastered grammatical aspect by age 3, because they never tested whether children understand the completion entailments of perfective and imperfective. Our initial experiments suggested that younger children have a deviant semantics for the imperfective, but subsequent testing on more complex sentences revealed that children's semantics for imperfective is in fact very close to adultlike, and that their initial semantics for the imperfective is a good starting point, from the perspective of cross-language learning considerations.

Implications and Questions

The four examples from normal language development reviewed in this section all reinforce the common observation that the errors that children make are highly specific. Some errors are quite robust, whereas other potential errors are not found at all. This specificity in error patterns matches the emerging picture in research on developmental language disorders, but it has been established in a far broader set of cases among normally developing children. In each of the four examples, we observed that children deviate from the language of their parents, but that their errors closely match forms that are possible in other languages, or in other parts of the grammar of their own language. Children's errors respect universal constraints on language.

It is important to note that it was only through detailed linguistic research that it was possible for us to notice connections between the children's errors and cross-language variation in adult languages. The relevant facts were not available in off-the-shelf reference works, and in all of the examples described above, there are crucial cross-linguistic generalizations that were uncovered only as a result of questions arising from developmental investigations.

Therefore, amidst the enthusiasm for investigating language development using sophisticated brain-imaging tools, we should not lose sight of the continuing value of low-tech cross-linguistic research, which continues to yield results that are clearly relevant to questions about the specificity of developmental errors, and at a fraction of the cost of more high-tech approaches.

The examples from normal language development reviewed here also raise questions about developmental language impairments (DLI). We have seen that normal language learning is guided by a number of constraints that lead to highly specific error patterns. It is important to establish whether children with developmental impairments are guided by the same constraints. Current indications suggest that language-impaired and normally developing children make similar kinds of errors in the area of morphosyntax, but it remains to be seen whether the parallels extend to other areas of language. It is important to know whether normal and DLI children are similarly constrained, because this will help to indicate whether the affected children are guided by the same language learning mechanisms as the general population. It is even possible that we will reach different conclusions in different areas of language. In the area of morphosyntax, the constraint that we observed comes primarily from the grammar of the adult language that the child is exposed to. In order for a DLI child to follow the same constraint, he must be able to successfully internalize the details of embedded clauses in his input. In the areas of argument structure and pronoun interpretation, on the other hand, the constraints that we observed are not apparent in the particular language that the child is exposed to; rather, they reflect universal constraints that the child brings to the learning task. In the area of grammatical aspect, the children's errors reflect constraints on possible adult tense/aspect systems. Before we can conclude that DLI children are guided by the same language learning mechanisms that guide normally developing children, it is necessary to demonstrate parallel constraints on the learners in multiple sub-areas of language.

Real-Time Knowledge of Language

In the first part of the paper, I argued that detailed linguistic studies can provide valuable information about the causes of the specificity of linguistic deficits. This argument was based entirely on connections between developmental errors and standard theoretical and typological approaches to linguistics. The aim of Part II is to argue that a basic change in how we normally think about linguistic knowledge can pave the way for more ambitious attempts to draw deep links between genetics and neuroscience on the one hand and specific developmental disorders on the other hand.

Even if we were presented with a complete description of the phenotype of a developmental language disorder, together with an accurate description of the corresponding genotype, we would still have a long way to go, in order to understand how specific genetic causes give rise to specific linguistic outcomes. The challenge is to make a seamless connection between our understanding at the level of genes and our understanding at the level of linguistic behavior. This connection will involve a number of different levels of description.

It will certainly be important to understand how specific genetic changes give rise to specific changes in brain development, but it would be foolish of me to speculate on what this might involve. On the other hand, I think that the task of linking neuroscience with linguistic behavior presents some fairly well-defined challenges, which I believe we are now in a position to address. I would argue that central among these challenges is the need to understand linguistic knowledge from the perspective of *real-time computation*.

The Need for a Real-Time Perspective

There are a couple of reasons why a real-time perspective is so important. The first involves a basic theoretical issue. The second involves more practical considerations.

Discrete Infinity Problem. Linguists often use the term 'discrete infinity' to refer to the property of human language that allows generation of infinitely many different expressions, using finitely many stored elements. This property has implications for the importance of time in understanding language. In light of speakers' facility with novel sentences, and given the infinitely large range of sentences that are possible in any natural language, it is clear that all but the most formulaic of utterances must be constructed in real-time, and cannot simply be retrieved from long-term memory. Therefore, a full account of speakers' knowledge of sentences must include an explanation of how sentence structures are assembled in time.

Granularity Problem. The second motivation for a detailed understanding of real-time structure-building processes is more practical. Put simply, the granularity of our theories must match the granularity of our tools. A variety of new brain-recording tools hold great promise for bridging the gap between brain and behavior, and it is likely that these tools will play an important role in the task of linking phenotypes and genotypes for language disorders. Also, it is certainly true that the millimeter precision of techniques such as PET and fMRI, or the millisecond precision of techniques such as EEG, MEG, and TMS ('transcranial magnetic stimulation'), will play an important role in the search

to understand how the brain supports language. However, the high resolution in space and time that these tools offer is of limited value unless the theoretical models that we use to make sense of the brain-recordings have similarly high resolution. In order to take full advantage of millisecond-accuracy data, we need millisecond-accuracy models of language. Our current models do not provide this resolution. Although it is sometimes assumed that we could make great strides in our understanding of language in the brain, if only we had more precise brain-recording tools, the mismatch in granularity between tools and theories suggests that we may currently be more limited by the precision of our hypotheses than by the precision of our tools.

The standard conception of linguistic knowledge is built around a core system for representing sentence structures that does not operate in real-time. The standard assumption in linguistics and psycholinguistics for at least the past 30 years has been that each speaker has multiple different structure-building systems: the 'grammar', the 'parser', and the 'producer' are all viewed as related-but-independent mental systems that each incorporates a structure-building mechanism of its own. The parser and producer are assumed to operate in real-time, and to somehow draw upon the knowledge that is represented in the grammar, but the grammar itself is assumed to operate independently of real-time processing. It may be possible to specify the operations of the grammar as a sequence of well-defined structure-building actions, as, for example, in recent incarnations of transformational grammar (Chomsky, 1995), but these are not assumed to be amenable to real-time investigation. Meanwhile, in non-transformational approaches to syntax (e.g., Pollard & Sag, 1994; Brody, 1995; Bresnan, 2000), the irrelevance of timing in the creation of structure is often argued to be a virtue.

However, this standard architecture creates significant obstacles for efforts to link phenotypes and genotypes, and for bridging brain and behavior, particularly with regard to grammatical knowledge. If knowledge of grammar consists of knowledge of a procedure for building sentences, and if this procedure operates on a time scale that is independent of speaking and understanding, then it is going to be extremely difficult to ever pinpoint this process in time. This in turn will make it almost impossible to test or confirm detailed linking hypotheses about grammatical encoding in the brain.

In light of considerations such as these, a solution to the linking problem for linguistic knowledge would be more within reach if it could be shown that there is just a single structure-building system in the brain, which works across comprehension, production and grammaticality judgments. The linking problem would be more tractable if it could also be shown that this system operates on a time-course that closely tracks the word-by-word unfolding of sentences, both in comprehension and production. If this were true, then it would become feasible to generate highly specific predictions about the nature and timing of structure-building operations, and therefore also more feasible to test and verify these predictions, using a variety of behavioral, computational, and neuroscientific tools. In this way it would be possible to identify the specific brain processes associated with individual structure-building operations. This would be a valuable starting point for efforts to pinpoint exactly which brain processes are disrupted in developmental language disorders.

Of course, it is already possible to make brain recordings of both normally developing children and children with language disorders during a variety of tasks, and to

observe differences in these recordings. But there are clear limits to our ability to interpret such findings, in the absence of theoretical and computational models that match the granularity of the brain recordings.

Of course, these considerations do not guarantee that knowledge of sentence structure is a parsimonious real-time system. They only show that it would be convenient, if true. However, the biological world is not always so kind. It is possible that linguistic knowledge may turn out to be the kind of cognitive system that is very hard to pin down in terms of real-time computation. This is almost certainly true for a number of other cognitive abilities, particularly 'non-automatic' cognitive abilities, such as reasoning and arithmetical knowledge. If language turns out to be like these other abilities, and cannot be characterized in terms of consistent real-time computation, then the task of linking linguistic behavior to neuroscience and to genetics will be vastly more difficult. Therefore, the question of the real-time status of linguistic knowledge is of central importance for efforts to link linguistic abilities with brain-level models of language.

Nevertheless, the promise that the real-time perspective holds for the linking problem is of little consequence, unless it can be shown that it is possible to characterize knowledge of sentence structure as a single structure-building procedure, and unless the classic arguments against this architecture can be answered. I sketch the outline of such an answer in what follows.

Challenges for the Simple Architecture

There are a number of arguments in favor of the standard view of linguistic knowledge as a set of distinct, task-specific systems, with a 'parser' and 'producer' that operate in real-time, and a 'grammar' that operates more slowly, but is highly accurate. Many of these arguments go back 30 years or more, to a period in the late 1960s and early 1970s when the question of the relation between 'competence systems' and 'performance systems' for language received a good deal of attention (see Fodor, Bever & Garrett, 1974; Levelt, 1974; for more recent reviews, see Phillips, 1996; Townsend & Bever, 2001).

The list of arguments includes:

#1: Available grammars do not appear suitable for direct deployment in speaking and understanding.
#2: Available evidence on parsing and production suggests systems that they lack the precision required of a grammar.
#3: Furthermore, grammars typically do not provide the tools needed to account for well-studied parsing phenomena such as garden-path sentences.
#4: The apparently slow and effortful nature of many grammaticality judgments suggests the existence of a system that operates on a different time-scale from parsing and production.
#5: Speaking and understanding are clearly different processes, which breakdown in different ways. This is unsurprising if they are the product of different systems.
#6: It is widely assumed that a famous set of studies from the 1960s (on the 'Derivational Theory of Complexity') confirmed the need for distinct grammars and parsers.

Each of these arguments appears compelling, and together they have been decisive in thinking about the architecture of linguistic knowledge in recent decades. However, I think that all of them can be overcome, and that it is worthwhile to pursue this possibility, given the enormous potential benefit of a real-time architecture for linguistic knowledge.

#1: Grammars don't look like Parsers

Perhaps the most straightforward argument for separation of grammars and parsers has been that grammars tend not to look much like effective parsing devices. In particular, they do not build structure in a left-to-right fashion, as parsing and production devices clearly must. This argument was developed quite clearly by Fodor, Bever & Garrett (1974), and applies to a broad range of grammatical frameworks, not just to transformational grammars.

Therefore, the first piece of the argument for the unified architecture comes from evidence that grammars look more like real-time systems than previously thought. A number of pieces of evidence of this kind have appeared in recent years. In each case, the argument is that problems from within the traditional domain of syntax can be better understood if they are recast in an approach that more closely matches the incremental structure-building found in speaking and understanding.

For example, I have argued that it is possible to make sense of a long-standing mystery about the constituent structure of sentences, simply by viewing sentence construction from a real-time perspective (Phillips, 1996, 2003). The argument focuses on a long-standing puzzle about sentence structure.

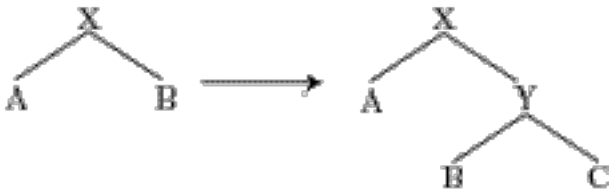
A basic tool of syntactic research is a series of tests of constituency, which are used to diagnose the structural organization of sentences. These include tests based on coordination, deletion ('ellipsis'), movement of phrases, and co-reference possibilities ('binding'), to name but a few. Although the logic of the tests dictates that their results should converge, and in some cases they do, it is well known that there are many situations where different tests yield different results, sometimes even contradictory results. One simple example of this comes from coordination, which tends to be a rather 'liberal' diagnostic of constituency. Sentences like (42a) show that it is possible to coordinate a subject-verb sequence, to the exclusion of the direct object of the verb. This contradicts the general assumption that the verb and its object form a unit, to the exclusion of the subject ('verb phrase'), and also contradicts the results of a number of other constituency diagnostics, and even contradicts the result of the coordination in (42b).

(42) a. [Sarah chopped] and [Harry fried] the large pile of vegetables.
b. Sarah [chopped the vegetables] and [fried the chicken].

However, if we make the assumption that sentences are assembled incrementally, from left-to-right, we can explain the conflicts. As a standard right-branching sentence structure is built-up, there will be sequences of words that are constituents at one stage, but are no longer constituents at a later point. This can be seen in the example of the hypothetical sequence 'ABC' in (43). The string 'AB' is a constituent at one stage (43a),

but ceases to be a constituent at a later point, when the element C is added at the right (43b).

(43) a. b.



This transient property of constituents in an incremental derivation of a sentence can explain why different constituency diagnostics yield different results. Diagnostics that are able to look at an early stage in the derivation may be able to see constituents that are not visible to diagnostics that only see later stages in the derivation. Coordination is a diagnostic that can see early, temporary constituents, because it has the property that it applies to pairs of linearly adjacent phrases, and therefore can apply to a piece of structure before that structure is destroyed. This is why it can apply to subject-verb sequences as in (42a), since they form a constituent at the point in the assembly of the structure before the direct object is added. Diagnostics that rely on between-sentence relations, on the other hand, necessarily apply to later stages in the derivation, and therefore fail to see some constituents that were present at earlier stages. The logic of this argument is developed elsewhere in much more detail, with many more examples (Phillips, 1996, 2003).

Related arguments for left-to-right structure-building have been presented in the domains of *wh*-movement (Richards, 1999, 2002), prosodic phrasing (Guimaraes, 1999) and agreement processes (Schlenker, 1999; Legate, 1999). Meanwhile, a number of independent proposals have emerged from other grammatical frameworks, that also allow for incremental derivations, and hence closer links with parsing systems (e,g., Kempson, Meyer-Viol & Gabbay, 2001; Steedman, 2000; Milward, 1994). All of these approaches make it seem more feasible to view knowledge of sentence structure as knowledge of a real-time computational process, and hence remove one of the primary motivations for assuming multiple syntactic systems.

#2: Parsers don't look like Grammars

The second argument for multiple syntactic systems is the mirror-image of the first. A good deal of research on parsing and production has focused on errors that arise in speaking and understanding. The literature on sentence comprehension is dominated by studies of studies of breakdown in 'garden path' sentences and complexity-induced processing overload, such as occurs in multiply center-embedded sentences like *The dog the cat the mouse feared chased fled*. In work on sentence production, a good deal of attention has been paid to 'slips of the tongue' and other dysfluencies. To the extent that the systems for comprehension and production are fallible and grammatically inaccurate, they do not like good candidates to be the grammar itself, which is generally assumed to be robust and precise, if not particularly fast. The parser and the producer have sometimes been viewed as covering grammars, which perhaps imperfectly capture the

detail of the 'true' grammar (Townsend & Bever, 2001; Ferreira, Bailey, & Ferraro, 2002).

However, this argument is less convincing than it may first appear. In order to show that the parser lacks the precision of the grammar, it would need to be shown that it builds structures that are ungrammatical, or that it systematically avoids building structures that are grammatical. Garden path sentences and center-embedded sentences are cases where certain grammatical structures fail to be constructed, but in neither case can this be blamed on lack of grammatical detail. Garden path sentences arise in circumstances of structural ambiguity, where two or more possible grammatical analyses are available. If the parser makes the wrong choice, and subsequently breaks down when it becomes clear that the choice was the wrong one, then this reflects lack of telepathy, not lack of grammatical precision. Center-embedded sentences often lead to processing breakdown, but this more likely reflects resource limitations than specific grammatical details of the parser. Meanwhile, there is a good deal of evidence that the parser is highly grammatically accurate, provided that it is operating within the bounds of available resources and is not misled by structural ambiguity. Many studies of comprehension have shown that the parser is grammatically precise, in such domains as verb argument structure (e.g., Boland et al. 1995; Phillips, Edgar, & Kabak, 2000), co-reference relations (Nicol & Swinney, 1989; Sturt, 2003), and long-distance dependencies (Stowe, 1986; Traxler & Pickering, 1996; Phillips, Rabbin, Pablos, & Wong, 2003).

The most serious challenge to this conclusion in recent work comes from a series of studies by Ferreira and colleagues that appear to show that speakers construct clearly ungrammatical sentence structures during parsing (Christianson, Hollingworth, Halliwell, & Ferreira, 2001; Ferreira, Christianson, & Hollingworth, 2001). The evidence comes from the inferences that speakers draw after reading garden path sentences like (44).

(44) While the man hunted the deer ran into the woods.

As is well-known, in sentences like (44), speakers often initially misinterpret the subject NP of the main clause ('the deer') as the object of the embedded clause verb ('hunted'). This gives rise to a garden-path effect, from which speakers must recover (Frazier & Rayner, 1982; Ferreira & Henderson, 1991; Sturt, Pickering, & Crocker, 1999). Ferreira and colleagues used comprehension questions to investigate what interpretations speakers arrive at by the end of the sentence. They found that even after recovery from the garden path, when the NP 'the deer' is correctly analyzed as the main clause subject, many speakers continue to believe that the man hunted the deer, something that the sentence does not, in fact, assert. Ferreira and colleagues argue that these findings show that speakers construct 'good enough' sentence structures that do not fully conform to the grammatical analysis of the input sentence.

If true, these findings present a serious challenge to the widespread assumption that the parser constructs only grammatically-sanctioned representations, and would therefore also constitute a strong motivation for a parser-grammar distinction. However, I do not think that we are forced into this conclusion by these results. What these findings may instead show is that syntactic reanalysis is insufficient to cause the dismantling of previously constructed semantic analyses. In the case of sentences like (44), this would mean that although the sentence undergoes correct syntactic reanalysis, such that 'the

deer' becomes the main clause subject, and 'hunted' becomes intransitive, this does not trigger corresponding retraction of prior semantic commitments.[16] Nevertheless, these examples are important, and deserve further investigation.

In sum, although much work has focused on the ways in which real-time language systems fail, it is important to distinguish failure in general from lack of grammatical precision. A good deal of evidence supports the notion that the real-time systems are, in fact, highly grammatically precise. This conclusion is entirely expected if the real-time system is the grammar itself. To the extent that a real-time analysis system (i.e., parser or producer) is able to capture all of the distinctions that are required of the grammar, it becomes less clear why there is a separate need for an independent grammar that does not operate in real-time.

#3: Grammars fail to explain ambiguity resolution phenomena

A further source of evidence for assuming the existence of multiple structure building systems comes from investigations of parsing. At least since the late 1960s and early 1970s, it has commonly been assumed that the parser incorporates mechanisms and principles that are by their nature specialized for the task of parsing. This is implicit in the 'heuristics and strategies' approach proposed by Bever and colleagues (Bever, 1970; Fodor, Bever & Garrett, 1974; see also Townsend & Bever, 2001), which incorporates a series of parsing heuristics (e.g. NP V → subject verb) that are specifically tailored for the task of parsing unambiguous input. Meanwhile, principles such as 'Minimal Attachment', 'Late Closure', and the 'Active Filler Strategy' proposed later by Frazier and colleagues (Frazier & Fodor, 1978; Frazier, 1987a; Frazier, 1987b) are designed specifically for resolving structural ambiguities that arise during parsing. If these assumptions are correct – and what is important here is the general approach that they represent, rather than the specifics of the individual models[17] – then they provide another good reason to distinguish systems for parsing, production, and grammar.

However, even in this area there is reason for optimism. Bever's heuristics and strategies were designed to handle the parsing of unambiguous input, given that grammars available at the time did not seem to be equal to that task. As we have already seen, we now have grammars that can more plausibly be deployed for real-time processes. Meanwhile, the literature on structural ambiguity resolution now contains a number of alternatives to the parsing-specific strategies proposed by Frazier and

[16] Note that Ferreira and colleagues are aware of this kind of possibility, and construct an ingenious control study in which optionally transitive verbs like 'hunt' in (44) are replaced with transitive/reflexive verbs like 'bathe', 'scratch', and 'hide'. Importantly, when these verbs are used without an overt direct object, they must be understood as reflexive: *John bathed* means that John bathed himself, not that he bathed something or other. Ferreira and colleagues show that speakers still hold onto incorrect interpretations in sentences with this type of verb. I agree that this shows that the persistent misinterpretations do not simply arise from inferential processes (e.g., 'he hunted something, and a deer is mentioned, so he probably hunted a deer'), and it also shows that speakers do not reliably *reinterpret* the first clause after syntactic reanalysis. However, I am not sure that this shows that speakers maintain an impossible syntactic representation.

[17] In particular, this argument does not depend on the modular, 'syntax first' property of Frazier's model which has been highly controversial in language processing research. All that is required for this argument is that there be some parser-specific structural constraints, regardless of how they interact with other sources of information in ambiguity resolution.

colleagues. Of particular interest are suggestions that the parsing biases that at one time appeared to be the result of general structural simplicity metrics, are in fact the result of the need to satisfy lexical and grammatical requirements.[18] One example from our recent work shows that it is not only possible to replace parsing-specific strategies with independently motivated principles; it is in fact preferable to do so. This example involves a cross-language comparison of parsing in English and Japanese (Aoshima, Phillips, & Weinberg, 2003).

In English *wh*-questions, *wh*-phrases such as *who*, *what*, or *which dog* appear in sentence-initial position, displaced from their canonical argument position. It is well known that when English speakers process *wh*-questions, they attempt to associate the *wh*-phrase with the verb in the main clause, provided that the verb is semantically compatible. In standard parlance, they attempt to locate the *gap* position, from which the *filler wh*-phrase was displaced. The relationship between the surface position of the *wh*-phrase and the gap is known as a *filler-gap dependency*. Thus, when speakers incrementally process a sentence like (45), they initially interpret the *wh*-phrase filler as the object of the main verb 'say' (45a), and are then forced to revise this analysis when they encounter the complementizer 'that', which signals the presence of an embedded clause. The *wh*-phrase is ultimately interpreted as the object of the embedded verb 'read' (45b).

(45) a. What did you say ___
b. What did you say that Bill read ___

The generalization that speakers attempt to posit a gap for the fronted phrase at the first available opportunity is well established, and has been documented in a number of languages (Frazier & Flores d'Arcais, 1989; de Vincenzi, 1991; Schlesewsky et al., 2000). In order to capture this generalization, Frazier and colleagues proposed that there is a parsing-specific strategy that leads the parser to create a gap for a displaced phrase in the first possible position ('Active Filler Strategy': Frazier, 1987b; de Vincenzi, 1991). An alternative approach to this generalization argues that there is no specialized strategy for creating filler-gap dependencies. Rather, the observed effects arise as a direct consequence of the need to satisfy thematic role assignment constraints as soon as possible (Pritchett, 1992; Gibson, Hickok, & Schütze, 1994). A *wh*-phrase is preferably associated with a gap position in the main clause, because that is the first position where thematic role assignment is possible.

Unfortunately, these two approaches to the processing of filler-gap relations make very similar predictions in English, and so it is hard to distinguish between them empirically. However, the two approaches make clearly different predictions in Japanese, due to the strongly verb-final word order of Japanese. As illustrated in (46), the main verb of a multi-clause sentence is the very final word of the sentence. The embedded clause precedes the main verb, with the consequence that the first verb in the sentence is

[18] This claim is independent of the question of how parsing decisions are affected by non-syntactic cues based on plausibility, frequency, prosody, etc. For this reason, the kind of 'principle-based' parsing mechanisms that I am describing here may be understood as the syntactic sub-component of the 'constraint based' parsing architectures that currently dominate psychological research on sentence comprehension (MacDonald, Pearlmutter, & Seidenberg, 1994; Gibson & Pearlmutter, 1998).

the most deeply embedded verb, in contrast to English, where the first verb in the linear order of the sentence is typically the least deeply embedded verb.

(46) John-wa Mary-ga sono hon-o nakusita-to omotteiru.
John-top Mary-nom that book-acc lost-that thinks
'John thinks that Mary lost that book.'

In order to explain how the key predictions, some preliminaries on Japanese word order are needed. In Japanese, *wh*-phrases may appear either in their canonical argument position (i.e., Japanese is a 'wh-in-situ' language) or they may be displaced leftwards ('scrambling'), including to sentence-initial position. Whereas in English the position of the *wh*-phrase indicates whether the question is a direct or indirect question (47), in Japanese the position of the *wh*-phrase does not indicate whether the question is a direct or indirect question. This is, instead, indicated by the position of a question particle suffix *-ka* on either the main clause verb (direct question: 48a) or on the embedded verb (indirect question: 48b). This device is common cross-linguistically. If the *wh*-phrase appears in the main clause, but the question particle is in the embedded clause, the sentence is understood as an indirect question (48c).

(47) a. Who did John say that Mary saw? *direct question*
b. John said who Mary saw. *indirect question*

(48) a. John-wa [Mary-ga dare-ni sono hon-o ageta-to] itta-no?
John-top Mary-nom whom-dat that book-acc gave-Comp said-Q
'Who did John say Mary gave that book to?'

b. John-wa [Mary-ga dare-ni sono hon-o ageta-ka] itta.
John-top Mary-nom whom-dat that book-acc gave-Q said
'John said who Mary gave that book to.'

c. Dare-ni John-wa [Mary-ga sono hon-o ageta-ka] itta.
whom-dat John-top Mary-nom that book-acc gave-Q said
'John said to whom Mary gave that book.'

These properties of Japanese word order make it possible to distinguish the predictions of the two approaches to parsing *wh*-phrases outlined above. In the sentence in (49) below, the fronted dative *wh*-phrase could be associated with either of the two gap positions marked. The gap position that is closest to the *wh*-phrase is in the main clause, but the gap position that allows earliest satisfaction of thematic role assignment requirements is in the embedded clause, due to the fact that the embedded verb is the first verb.

(49) Dono-seito-ni tannin-wa _____gap1 [koocyoo-ga _____gap2
which student-dat class teacher-top principal-nom
hon-o yonda-ka] tosyositu-de sisyo-ni iimasita
book-acc read-Q library-at librarian-dat told

'The class teacher told the librarian at the library which student the principal read a book for.'

Therefore, the account of parsing *wh*-phrases that is based upon independently motivated grammatical principles makes the striking prediction that Japanese speakers should prefer to interpret the sentence-initial *wh*-phrase in (49) as if it is displaced from the *most deeply embedded clause* of the sentence. In fact, this is exactly what Japanese speakers do, as we have shown in 3 different experiments (Aoshima et al., 2003). In contrast, if Japanese speakers were simply trying to create a gap position as soon as possible, due to a parser-specific routine such as the Active Filler Strategy, there would be no reason for them to interpret the *wh*-phrase in the embedded clause.

Our example from Japanese reiterates the value of cross-language comparisons, and shows just one example of a situation where parsing-specific mechanisms can be replaced by independently motivated grammatical principles. Of course, this is just one example, and much more evidence is needed in order to show that parsing-specific syntactic mechanisms are unnecessary in general. However, as I have outlined above, there are currently fewer reasons to assume a set of task-specific parsing strategies than there may have been 25 years ago. This is good news for attempts to unify the different subcomponents of linguistic knowledge.

#4: Parsing and Production are fast, Grammaticality Judgment is slow

A fourth argument for separation of systems is based upon the fact that many grammaticality judgments, particularly ones involving subtle semantic contrasts, are slow and difficult. This would appear to fit naturally with the assumption that the grammar operates in a different time domain from systems for real-time parsing and production. Again, this apparently compelling argument does not survive closer scrutiny. In order for this argument to go through, it would need to be shown that grammaticality judgment involves a slow process that follows a *different sequence of operations* than parsing or production. I am not aware of evidence of this kind.

Much of the available evidence points to a different conclusion. A number of different experimental paradigms based on violation-detection indicate that grammaticality violations are detected within a few hundred milliseconds of the presentation of the offending word. This can be observed in studies that have used a 'stops making sense' task, in which participants read a sentence word by word and must respond as soon as they detect an anomaly. This technique has been used to show rapid detection of violations involving verb-argument structure (e.g. Boland et al., 1995). More fine-grained information about the speed of violation detection is provided by speed-accuracy trade-off studies, in which participants are required to make well-formedness judgments under varying degrees of time-pressure. This technique has shown rapid detection of violations involving verb-argument structure (McElree & Griffith, 1995) and

constraints on long-distance dependencies (McElree & Griffith, 1998). Even more fine-grained information comes from electrophysiological studies of syntactic anomaly detection. Studies using this technique have shown detection of violations within 300-600ms in areas such as word-order (Neville et al. 1991; Friederici, Pfeifer, & Hahne, 1993), subject-verb agreement (Hagoort, Brown, & Groothusen, 1993; Osterhout & Holcomb, 1992), case marking (Coulson, King, & Kutas, 1998), verb-argument structure (Friederici & Frisch, 2000; Osterhout, Holcomb, & Swinney, 1994), coreference (Osterhout & Mobley, 1995), and question formation (Neville et al., 1991; Kluender & Kutas, 1993), to list but a few. Based on all of these studies, it seems clear that a good number of grammaticality judgments – negative judgments, at least – can be delivered extremely quickly.

There remain, of course, many situations where grammaticality judgments are reliable, but slow. These are the cases that give rise to the assumption that grammaticality judgments are the product of a system that operates on an independent time-scale from normal parsing or production. However, even slow judgments do not entail a separate system. It is important to consider why such judgments take a long time. I suspect that the slowness of such judgments simply reflects repeated attempts to re-parse the sentence, which may be necessary for at least two reasons.

Re-parsing may be necessary in order to avoid an irrelevant initial parse. For example, there is a robust contrast between (50a) and (50b) in the availability of an interpretation in which the question word *why* is construed with the embedded verb *fix*, i.e., as a question about the reason for fixing the drain. The embedded clause interpretation is available in (50a), but not in (50b). The unavailability of this interpretation in (50b) reflects a characteristic of a 'factive' verb like *remember*, i.e., a verb that gives rise to the presupposition that its complement is true (Kiparsky & Kiparsky, 1971; Cinque, 1990; Melvold, 1991). Although the contrast between (50a) and (50b) is robust, it typically takes time for a speaker to make this judgment, because re-parsing is necessary, in order to avoid the dominant-but-irrelevant reading in which *why* is interpreted with the main clause verb.

(50) a. Why did you think that John fixed the drain?
b. Why did you remember that John fixed the drain?

A second situation where re-parsing may be needed is when the speaker attempts to construct a mental scenario that makes the target reading felicitous. This is particularly relevant in sentences that involve scope ambiguities. (51) and (52) illustrate a well-known contrast in the interpretations available for sentences that contain a *wh*-phrase and a quantifier. (51) exhibits a scope ambiguity that is not available in (52). Specifically, (51) can be understood as a question that invites a list of answers (the so-called 'pair-list reading'), documenting who each person met.[19] In contrast, (52) can only be understood as a question about which individuals met every single member of the group, and does not allow the pair-list reading (May, 1985).

[19] Questions with the form of (51) are commonly used in naturally occurring speech with the expectation of a pair-list reading. Imagine, for example, a teacher asking a group of students on Monday morning *What did everybody do on the weekend?* This is understood as an invitation for each student to list what he or she did on the weekend, and not as a question about what all the students did in common on the weekend.

(51) Who did everyone meet?
a. *Who is the person such that everyone met him?*
b. *For each person, who is the person that he met?*

(52) Who met everyone?
a. *Who is the person such that he met everyone?*
b. * *For each person, who met him?*

Although this contrast in scope possibilities is clear and consistent across speakers of English, it may take some time for any individual to confirm this judgment for himself, because the judgment typically requires the speaker to first construct in his mind an appropriate context for each of the scope readings under consideration, and then judge whether the sentence could be used in that context. For each context, the judgment step itself does not take very long. It takes a long while to judge whether a question contains a scope ambiguity because this judgment involves a number of sub-tasks, requiring construction of multiple contexts, and a separate judgment of the appropriateness of the question form for each different context. Trained semanticists can often make these judgments quickly - not because they have out-of-the-ordinary language processing abilities, but because they are experienced at imagining exactly the right kinds of contexts that are needed to test such judgments.

For reasons such as these, I see little reason at present to assume that grammaticality judgments, however long they might take, reflect the operation of a separate syntactic system that follows a different time-course from real-time parsing and production systems. Furthermore, I am not aware of any evidence that sentences are constructed in a different sequence of steps, depending on whether they are being parsed or being judged on their well-formedness.

Another observation that is sometimes used to motivate a grammar-parser distinction is the fact that there are many ungrammatical sentences that are readily comprehensible, such as violations of subject-verb agreement (53), violations of restrictions on double object constructions (54), or so-called *that-trace* effects (55).

(53) * The cats likes fish.

(54) * The millionaire donated the museum a painting.

(55) * Who do you think that __ appreciates hockey?

The examples in (53-55) can be accounted for easily, without recourse to separate structure-building systems. All that is required is to assume that the grammar can use its standard structure-building mechanisms to construct combinations of words and phrases that are *almost* fully compatible in their lexical-grammatical features (e.g., number mismatch in (53)), and somehow mark the fact that the ungrammatical feature combination is recognized to be illicit. In fact, it would be unhelpful to treat (53-55) as evidence for a separate parsing system, since that move would beg the question of why it is that speakers are so good at identifying and diagnosing the anomalies in the sentences.

More troubling are sentences that appear at first to be entirely natural, but that turn out upon further reflection to be ungrammatical, even incomprehensible. (56) is a notorious example, due to Mario Montalbetti (1984), which sounds seductively natural, until one stops to reflect upon what it actually means. Surely the fact that speakers can readily parse sentences that turn out to be both ungrammatical and uninterpretable implies the existence of a real-time structure-building system that is distinct from the grammar? (See Townsend & Bever, 2001: p. 184 for an explicit argument to that effect.)

(56) * More people have visited Russia than I have.

Although I cannot present a full account at present of why such sentences sound so good, it is interesting to note that there are minimally different sentences that either have a fairly clear interpretation (57), or that are much more quickly detected as odd (58). This indicates that whatever is special about (56) is subject to detailed grammatical restrictions, and cannot therefore be simply a reflection of a 'dumb' first-pass parsing mechanism.

(57) More Italians have visited Rome than Germans have.

(58) * More people have visited Russia than I have visited.[20]

In sum, the double dissociation between grammaticality and parsability appears at first glance to present a compelling case for distinguishing a grammar and a parser. I was myself convinced by this argument at one time (cf. Phillips, 1995a). However, the argument does not go through, particularly if we are willing to assume that the structure-building system may be able to construct representations that it recognizes to be illicit in a specific way. Grammaticality judgment does not, therefore, eliminate the possibility of a single real-time grammar. Nevertheless, this does not change the fact that our current understanding of the process of grammaticality judgment is extremely limited, and there is a clear need for more systematic work on this topic (see Schütze (1996) for a detailed review of existing studies of grammaticality judgment).

#5: Speaking and understanding are different

A fifth argument for separation of systems derives from the fact that there are differences between speaking and understanding. Classic models of parsing and production look quite different from one another (parsing: Kimball, 1973; Frazier & Fodor, 1978; production: Garrett, 1976), and the kinds of errors that have attracted most attention in parsing, namely garden-path sentences, look rather different from the kinds of errors that have attracted most attention in production, namely slips-of-the-tongue. Also, research on language disorders commonly turns up cases where comprehension and production appear to be affected differently. These observations are widely taken to

[20] Note that there is a reading of (58) that is available for some speakers, in which the elided object of the second verb is understood as dependent on the subject of the first verb. Under this reading, the sentence asserts that the number of people that have visited Russia is greater than the number of people that I have visited.

motivate independent structure-building systems for comprehension and production. Furthermore, to the extent that parsing and production draw upon different syntactic systems, there is also need for an additional syntactic system – the grammar – in order to capture whatever is shared between parsing and production. Although the possibility of parser-producer parallels has not been investigated in great depth, both theoretical and empirical considerations suggest that uniting the syntactic aspect of these two systems may be more feasible now than previously thought.

The theoretical consideration is that differences between the *outcomes* of parsing and production tasks do not entail that the tasks are carried out by independent systems. The different outcomes may reflect a single sentence-generation system, which always incrementally generates structures that link up the sound of a sentence with its meaning. Such a system can be expected to encounter different types of 'bottleneck', depending on whether it faces a production task, in which a meaning is given, and the task is to generate a compatible syntax and phonology, or a comprehension task, in which a phonological input is provided, and the task is to generate a compatible syntax and semantics. In both situations, the task is to generate a structure to match a pre-specified semantic or phonological representation, but the more 'open-ended' part of the problem is different in the two situations.

It is interesting to note that in the area of lexical processing there are many differences between the tasks of picture naming and word recognition, yet this does not typically lead to the conclusion that there are different lexicons for speaking and for understanding. Rather, it is generally assumed that a single lexicon responds differently when deployed in different task situations. The same conclusion deserves more serious consideration in the area of sentence structure.

The empirical motivation for closing the gap between parsing and production is that research in the two areas has for a number of years been undergoing a quiet convergence. Traditional approaches to sentence production tended to emphasize the role of clause-sized 'templates', into which lexical material was inserted, in order to explain systematicities in slips-of-the-tongue (e.g., Fromkin, 1971; Garrett, 1976). Such an approach is hard to reconcile with models of sentence comprehension, which have almost always assumed that structures are built-up more incrementally, on a word-by-word basis. However, recent sentence production research has moved beyond a focus on speech errors and has uncovered evidence for more incremental encoding of structure (e.g., Ferreira, 1996; Ferreira & Dell, 2000). To the extent that syntactic encoding in production is shown to proceed incrementally, rather than by the filling-in of larger templates, it is more feasible to view the syntactic aspect of comprehension and the syntactic aspect of speaking as products of the same system.

Of course, these observations fall well short of demonstrating that a single structure-building system can capture the syntactic component of parsing and production. They show only that this is a feasible goal. Clearly, much work needs to be done to show whether this goal can actually be realized. (For some interesting computational models that move in this direction, see Kempen & Hoenkamp, 1987; Vosse & Kempen, 2000.)

#6: The implications of the 'Derivational Theory of Complexity'

Finally, there is an additional reason why grammar, parsing and production have been investigated as independent systems. This reason has exerted a more powerful influence on the field than should have been the case.

In the mid-1960s, collaborative efforts between George Miller and Noam Chomsky and their students gave rise to a famous set of experiments that suggested a close relationship between the mechanisms of transformational grammar and real-time sentence processing. This was followed by an equally famous set of experiments that led to widespread disillusionment about this enterprise, and substantial divergence between the fields of syntactic theory and language processing.

The crux of the matter was a very specific linking suggestion by Miller and Chomsky (Miller & Chomsky, 1963, p. 481) that the 'perceptual complexity' of a sentence, presumably reflected in its processing time, might be a predicted by the complexity of its derivation in a transformational grammar. For example, if it is assumed that active, declarative sentences are 'kernel' structures, and that passive sentences and questions are derived from the corresponding kernels by means of a transformation, then passive sentences should take longer to process than active sentences, questions should take longer than declaratives, and passive questions should take even longer. This linking hypothesis came to be known as the 'Derivational Theory of Complexity' (DTC). The initial experiments focused on transformations such as passivization, question-formation and negation, and produced results that were quite encouraging, even 'breathtaking' by some accounts (Townsend & Bever, 2001, p. 29). However, subsequent studies on a broader set of constructions produced results that appeared less consistent with the DTC hypothesis, and the DTC quickly acquired a reputation as a classic error in psycholinguistic theorizing. Although the DTC was just one specific linking hypothesis, and the problematic results appear much less problematic from a current perspective (see Phillips, 1996, ch. 5 for a detailed review), in practice the demise of the DTC had a chilling effect on attempts to provide clear linking hypotheses between grammar, parser and producer, and was instrumental in creating the separation between the fields of syntactic theory and sentence processing.

Since the demise of the DTC over 30 years ago, research in grammatical theory and sentence processing has been carried out by largely disparate groups of people, who in most cases occupy different academic departments. As a result, there has been only limited contact between the two subfields, and the divisions between them have become self-perpetuating. In this climate, it is perhaps not surprising that a consensus should have emerged that it must be the case that the two fields are investigating different systems.

Neither the conclusions about the DTC from the 1960s, nor the separation of disciplines that they engendered, amount to real arguments for the existence of multiple syntactic systems. It is unfortunate that they have had such a powerful effect on thinking about language, and in particular about the relation between linguistic knowledge and real-time processes.

I should emphasize that it is not my goal to revive the specific linking hypotheses that were entertained in the 1960s. There are good reasons not to do this. For example, the DTC provided only an index of perceptual complexity, something that does not amount to an explicit account of parsing or production. However, it is my goal to revive

the objectives of the 1960s work, which was to take very seriously the relationship between linguistic models and real-time models of comprehension and production.

Implications

If we want to understand how specific neural structures (and the genes that give rise to them) support human language, then it ought to go without saying that we need to have a proper understanding of human language. The same is clearly true for efforts to understand developmental language disorders. If we misconstrue the nature of a language disorder at the behavioral or cognitive level, then we run the risk of asking the wrong questions at the neural or genetic levels.

In the first part of the paper, I presented a series of examples from normal language development of how we can better understand the kinds of errors that children make, if we take into account either the detailed structure of the target adult language, or if we take into account facts about cross-language typology and universals of language. In each case, the children showed a highly systematic pattern of errors, which made more sense in light of detailed investigations of adult languages. The distribution of children's root infinitive clauses across languages appeared much less arbitrary once we observed the parallels with embedded infinitival clauses in the children's own target language. In the examples of English children's locative verb production and Russian children's pronoun interpretation, we saw that children make errors in areas that are subject to cross-language variation, but fail to make errors in closely related areas where all adult languages behave alike. In the case of Russian aspect, in particular, we saw that if we had only focused on children's interpretation of simple sentences, we could have severely underestimated the semantic sophistication of the children. In fact, there was a period in the evolution of this project where we did just that. It was only when our attention was drawn to a little-discussed detail of adult Dutch, and tested Russian 3-year olds on more complex sentences, that we were able to find that the children know a good deal more about the semantics of aspect than we had previously suspected.

If the developmental language disorders discussed elsewhere in this volume reflect language abilities that are fundamentally normal, but delayed, as many have argued, then we should expect the details of linguistic structure and linguistic typology to have a similar impact upon our understanding of language disorders.

In the second part of the paper, I argued that it is feasible to try to develop an account of sentence structure building that operates in real-time, and uses a single syntactic system, which underlies speaking, understanding, and grammaticality judgment alike. I also argued that it is well worth the effort to pursue this possibility, since it will make the goal of developing and testing explicit linking hypothesis for brain and language a good deal more attainable. This is because it represents our best chance of developing linguistic models that can match the temporal granularity of the tools that we can already use to observe the brain in action.

However, it should have been clear that most of my arguments in that section consisted in demonstrations of what *would* need to be explained, *if* we were to develop an explicit linking hypothesis for brain and language, and that in doing so I issued a number of promissory notes. Therefore, a good deal remains to be done, in order to more fully develop a dynamic model of structure building, and in order to connect a linguistic model

of this kind with studies in cognitive neuroscience and computational neuroscience. This is a project that we are currently engaged in, and we expect that it will take some time. However, I am confident that if this effort is at all successful in understanding how normally developed brains support normally acquired language, it will provide many new possibilities for understanding how atypical brain development leads to atypical language outcomes.

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