It looks, then, as Chomskyans are gradually abandoning the idea of parameters. But if it is abandoned, grammar acquisition is not a matter of parameter-setting. Hence, it is not clear that Chomskyans can invoke any mechanisms that are not available to HPSG.

This might suggest that HPSG and Minimalism are essentially in the same boat where acquisition is concerned. However, this is not the case given the very different nature of grammatical systems in the two frameworks. The complex and abstract structures that are the hallmark of Minimalism and earlier Chomskyan frameworks pose major problems for acquisition. Furthermore the machinery that is assumed in addition to the basic operations Internal and External Merge are by no means trivial. There are numerations (subsets of the lexicon) that are assumed to play a role in a derivation, there is Agree and it has to be somehow acquired what the restriction on possible probe/goal relations is and which features are interpretable and which uninterpretable. Certain categories are Phase boundaries, others are not. There are complex conditions on Labeling. It is this that has led to the assumption that acquisition must be assisted by a complex language faculty. In contrast, HPSG structures are quite closely related to the observable data and so pose less of a problem for acquisition and hence create less need for some innate apparatus. Thus, HPSG probably has an advantage over Minimalism in this area too.

5.3 Restrictiveness

There is one further issue that we should discuss here. It appears to be quite widely assumed that one advantage that Minimalism has over alternatives like HPSG is that it is more "restrictive", in other words that it makes more claims about what is and is not possible in language. It looks then as if there might be an argument for Minimalism here. It is not clear, however, that this is really the case.

Minimalism would be a restrictive theory making interesting claims about language if it assumed a relatively small number of parameters. However, the idea that there is just a small number of parameters seems to have been abandoned, and at least some minimalists have abandoned the idea of parameters altogether (see Section 5.2). If there is either a large number of parameters or no parameters at all, Minimalism is not restrictive in the way that it once was. However, it does still embody some restrictions on grammatical systems. The assumption that syntactic structures are confined to binary branching is an important restriction, as is the assumption that expressions produced by Merge have the same label as one of the expressions that they consist of. But we have argued that both assump-

tions are quite dubious. It also seems to be assumed that case and agreement are features of all grammatical systems. This would be another important restriction, but this also seems dubious given that many languages show no clear evidence for one or both of these features. It looks to us, then, as if the restrictiveness of Minimalism is largely a matter of imposing certain dubious restrictions on grammatical systems.

Note also that there are problems with restrictiveness of a more formal nature. Earlier versions of MGG assumed $\overline{\text{X}}$ theory and although this was not assumed initially it was quickly argued that the $\overline{\text{X}}$ scheme is universal and that this is a restriction on grammatical systems that aids language acquisition (Haegeman 1994: 106). However, Kornai & Pullum (1990: 41, 47) show that $\overline{\text{X}}$ theory is not restrictive at all as soon as empty elements are allowed in grammars: all languages that can be analyzed with a context-free grammar can be analyzed with an $\overline{\text{X}}$ grammar with empty heads. Chomsky (1995b: Section 4.3) abandoned $\overline{\text{X}}$ theory and replaced it by notions like first-merged and later-merged (Chomsky 1995b: 245; 2008) but the principled problem remains. Since as many empty heads as needed can be assumed in any position the predictions as far as restrictiveness is concerned are limited. See also Hornstein (2009: 165) and Starke (2014: 140) on heads and features and restrictiveness.

An example that is usually discussed when it comes to restrictiveness is question formation (Musso et al. 2003). Researchers in MGG state that certain ways of expressing things never occur although they may be imaginable. So the question is asked why questions are never formed by reversing the order of words in a string. So rather than (55b) the question that would correspond to (55a) would be (55c):

(55)   a. Kim saw Sandy near the swimming pool.
        b. Did Kim see Sandy near the swimming pool?
        c. Pool swimming the near Sandy saw Kim?

Interestingly, such reorderings can be derived in systems that allow for so-called *remnant movement*, as Hubert Haider (p. c. 2018) pointed out. Remnant movement analyses are sometimes suggested for partial verb phrase fronting (G. Müller 1998). In the analysis of the following sentence, the object of *gelesen* 'read' is moved out of the VP and the VP remnant is then fronted:

(56)   [$_{\text{VP}}$ _$_j$ Gelesen]$_i$ hat [das Buch]$_j$ [keiner   _$_i$].
           read   has the book   nobody
    'Nobody read the book.'

With such a system in place the reorderings can be derived as follows: the element 5 can move to the left of 4. The unit containing 4 and 5 can move to the left of 3 and [[5 [4 _]] [3 _]] can move to the left of 2 and so on.

(57)   a.   [1 [2 [3 4]]]

       b.   [3 4] → [4 [3 _]] → [2 [4 [3 _]]] → [[4 [3 _]] [2 _]] →
          [1 [[4 [3 _]] [2 _]]] → [[[4 [3 _]] [2 _]] [1 _]]

Of course there are reasons for the absence of certain imaginable constructions in the languages of the world. The reason for the absence of question formation like (55c) is simply short-term memory. Operations like those are ruled out due to performance constraints and hence should not be modeled in competence grammars. So it is unproblematic that remnant movement systems allow the derivation of strings with reverse order and it is unproblematic that one might develop HPSG analyses that reverse strings. Similarly certain other restrictions have been argued not to be part of the grammar proper. For instance Subjacency (Baltin 1981: 262; 2017; Rizzi 1982: 57; Chomsky 1986: 38–40) does not hold in the form stated in MGG (Müller 2004; 2016a: Section 13.1.5) and it is argued that several of the island constraints should not be modeled by hard constraints in competence grammars. See Chaves (2019), Chapter 16 of this volume for further discussion.

It is true that the basic formalism does not pose any strong restrictions on what could be said in an HPSG theory. As Pollard (1996) points out, this is the way it should be. The formalism should not be the constraining factor. It should be powerful enough to allow everything to be expressed in insightful ways and in fact, the basic formalism of HPSG has Turing-power, the highest power in the Chomsky hierarchy (Pollard 1999). This means that the general formalism is above the complexity that is usually assumed for natural languages: mildly context-sensitive. What is important though is that theories of individual languages are much more restrictive, getting the generative power down (Müller 2016a: Chapter 17).

These remarks should not be understood as a suggestion that languages vary without limit, as Joos (1958: 96) suggested. No doubt there are universal tendencies and variation is limited, but the question is whether this is due to innate linguistic constraints or a consequence of what we do with language and how our general cognitive capabilities are structured. While Minimalism starts out with claims about universal features about languages and tries to confirm these claims in language after language, researchers working in HPSG aim to develop fragments of languages that are motivated by facts from these languages and gen-

eralize over several internally motivated grammars. This leaves the option open that languages have very little in common as far as syntax is concerned. For example, Koenig & Michelson (2012) discuss the Northern Iroquoian language Oneida and argue that this language does not have syntactic valence. If they are correct, not even central concepts like valence and argument structure would be universal. The only remaining universal would be that we combine linguistic objects. This corresponds to Merge in Minimalism, without the restriction to binarity.

Acknowledgements

References

Abeillé, Anne. 2006. In defense of lexical coordination. In Olivier Bonami & Patricia Cabredo Hofherr (eds.), *Empirical issues in formal syntax and semantics*, vol. 6, 7–36. Paris: CNRS. http://www.cssp.cnrs.fr/eiss6/, accessed 2018-2-25.

Abeillé, Anne & Rui P. Chaves. 2019. Coordination. In Stefan Müller, Anne Abeillé, Robert D. Borsley & Jean-Pierre Koenig (eds.), *Head-Driven Phrase Structure Grammar*, i–xxxviii. Berlin: Language Science Press. DOI:??

Abeillé, Anne, Berthold Crysmann & Aoi Shiraıshi. 2016. Syntactic mismatch in french peripheral ellipsis. In Christopher Piñón (ed.), *Empirical issues in syntax and semantics*, 1–30. Paris: CSSP.

An, Aixiu & Anne Abeillé. 2017. Agreement and interpretation of binomials in french. In Stefan Müller (ed.), *Proceedings of the 24th International Conference on Head-Driven Phrase Structure Grammar, University of Kentucky, Lexington*, 26–43. Stanford, CA: CSLI Publications. http://cslipublications.stanford.edu/HPSG/2017/hpsg2017-an-abeille.pdf.

Aoun, Joseph E. & Yen-hui Audrey Li. 2003. *Essays on the representational and derivational nature of grammar*. Cambridge, MA: MIT Press.

Aoun, Joseph, Lina Choueiri & Norbert Hornstein. 2001. Resumption, movement, and derivational economy. *Linguistic Inquiry* 32(3). 371–404.

Baker, Mark C. 1988. *Incorporation: A theory of grammatical function change.* Chicago: The University of Chicago Press.

Baltin, Mark. 1981. Strict bounding. In Carl Lee Baker & John J. McCarthy (eds.), *The logical problem of language acquisition*, 257–295. Cambridge, MA: MIT Press.

Baltin, Mark. 2017. Extraposition. In Martin Everaert & Henk van Riemsdijk (eds.), *The Blackwell companion to syntax*, 2nd edn. (Blackwell Handbooks in Linguistics), 237–271. Oxford: Blackwell Publishers Ltd. DOI:10.1002/9781118358733

Bargmann, Sascha. 2015. *Syntactically flexible VP-idioms and the N-after-N Construction.* Poster presentation at the 5th General Meeting of PARSEME, Iasi, 23–24 September 2015.

Bausewein, Karin. 1990. Haben kopflose Relativsätze tatsächlich keine Köpfe? In Gisbert Fanselow & Sascha W. Felix (eds.), *Strukturen und Merkmale syntaktischer Kategorien* (Studien zur deutschen Grammatik 39), 144–158. Tübingen: originally Gunter Narr Verlag now Stauffenburg Verlag.

Bender, Emily M. 2000. *Syntactic variation and linguistic competence: The case of AAVE copula absence.* Stanford University dissertation. http : / / faculty . washington.edu/ebender/dissertation/, accessed 2018-2-25.

Bender, Emily M. 2002. Review of *Step by step: Essays on Minimalist Syntax in honor of Howard Lasnik* by Roger Martin, David Michaels, and Juan Uriagereka. *Journal of Linguistics* 38(2). 432–439.

Bender, Emily M. & Guy Emerson. 2019. Computational linguistics and grammar engineering. In Stefan Müller, Anne Abeillé, Robert D. Borsley & Jean-Pierre Koenig (eds.), *Head-Driven Phrase Structure Grammar*, i–xxvi. Berlin: Language Science Press. DOI:??

Berwick, Robert C. & Samuel David Epstein. 1995. On the convergence of 'Minimalist' Syntax and Categorial Grammar. In Anton Nijholt, Giuseppe Scollo & Rene Steetskamp (eds.), *Algebraic methods in language processing*, 143–148. Enschede: University of Twente. http://eprints.eemcs.utwente.nl/9555/01/twlt10.pdf, accessed 2018-9-25.

Berwick, Robert C., Paul Pietroski, Beracah Yankama & Noam Chomsky. 2011. Poverty of the Stimulus revisited. *Cognitive Science* 35(7). 1207–1242.

Bildhauer, Felix & Philippa Cook. 2010. German multiple fronting and expected topic-hood. In Stefan Müller (ed.), *Proceedings of the 17th International Conference on Head-Driven Phrase Structure Grammar, Université Paris Diderot*, 68–79.

Stanford, CA: CSLI Publications. http://csli-publications.stanford.edu/HPSG/ 2010/, accessed 2018-2-25.

Boeckx, Cedric. 2003. *Islands and chains*. Amsterdam: John Benjamins Publishing Co.

Boeckx, Cedric. 2011. Approaching parameters from below. In Anna Maria Di Sciullo & Cedric Boeckx (eds.), *The biolinguistic enterprise: New perspectives on the evolution and nature of the human language faculty*, 205–221. Oxford: Oxford University Press.

Borsley, Bob & Berthold Crysmann. 2019. Unbounded dependencies. In Stefan Müller, Anne Abeillé, Robert D. Borsley & Jean-Pierre Koenig (eds.), *Head-Driven Phrase Structure Grammar*, i–i. Berlin: Language Science Press. DOI:??

Borsley, Robert D. 2005. Against ConjP. *Lingua* 115(4). 461–482.

Borsley, Robert D. 2006a. On the nature of Welsh VSO clauses. *Lingua* 116(4). 462–490.

Borsley, Robert D. 2006b. *Syntactic and lexical approaches to unbounded dependencies*. Essex Research Reports in Linguistics 49. University of Essex. 31–57. http://core.ac.uk/download/pdf/4187949.pdf#page=35, accessed 2018-2-25.

Borsley, Robert D. 2009. On the superficiality of Welsh agreement. *Natural Language and Linguistic Theory* 27(2). 225–265.

Borsley, Robert D. 2010. An HPSG approach to Welsh unbounded dependencies. In Stefan Müller (ed.), *Proceedings of the 17th International Conference on Head-Driven Phrase Structure Grammar, Université Paris Diderot*, 47–67. Stanford, CA: CSLI Publications. http://csli-publications.stanford.edu/HPSG/2010/, accessed 2018-2-25.

Borsley, Robert D. 2011. Constructions, functional heads, and comparative correlatives. In Olivier Bonami & Patricia Cabredo Hofherr (eds.), *Empirical issues in syntax and semantics*, vol. 8, 7–20. Paris: CNRS. http://www.cssp.cnrs.fr/eiss8/ borsley-eiss8.pdf, accessed 2018-8-23.

Borsley, Robert D. 2013. On the nature of Welsh unbounded dependencies. *Lingua* 133. 1–29. DOI:10.1016/j.lingua.2013.03.005

Borsley, Robert D. 2016. HPSG and the nature of agreement in Archi. In Oliver Bond, Greville G. Corbett, Marina Chumakina & Dunstan Brown (eds.), *Archi: Complexities of agreement in cross-theoretical perspective*, 118–149. Oxford: Oxford University Press.

Borsley, Robert D. 2017. Explanations and 'engineering solutions'? Aspects of the relation between Minimalism and HPSG. In Stefan Müller (ed.), *Proceedings of the 24th International Conference on Head-Driven Phrase Structure Grammar, University of Kentucky, Lexington*, 82–102. Stanford, CA: CSLI Publications.

http://cslipublications.stanford.edu/HPSG/2017/hpsg2017-borsley.pdf, accessed 2018-9-9.

Borsley, Robert D. 2018. Comparative syntax: An HPSG perspective. In András Bárány, Theresa Biberauer, Jamie Douglas & Sten Vikner (eds.), *Clausal architecture and its consequences: Synchronic and diachronic perspectives*, vol. 1. In Preparation.

Bošković, Željko. 2009. Unifying first and last conjunct agreement. *Natural Language and Linguistic Theory* 27(3). 455–496. DOI:10.1007/s11049-009-9072-6

Bouma, Gosse & Gertjan van Noord. 1998. Word order constraints on verb clusters in German and Dutch. In Erhard W. Hinrichs, Andreas Kathol & Tsuneko Nakazawa (eds.), *Complex predicates in nonderivational syntax* (Syntax and Semantics 30), 43–72. San Diego: Academic Press.

Bresnan, Joan & Jane Grimshaw. 1978. The syntax of free relatives in English. *Linguistic Inquiry* 9. 331–392.

Bresnan, Joan & Ronald M. Kaplan. 1982. Introduction: grammars as mental representations of language. In Joan Bresnan (ed.), *The mental representation of grammatical relations* (MIT Press Series on Cognitive Theory and Mental Representation), xvii–lii. Cambridge, MA/London: MIT Press.

Bruening, Benjamin. 2018. The lexicalist hypothesis: Both wrong and superfluous. *Language* 94(1). 1–42. DOI:10.1353/lan.2018.0000

Chaves, Rui. 2019. Island phenomena and related matters. In Stefan Müller, Anne Abeillé, Robert D. Borsley & Jean-Pierre Koenig (eds.), *Head-Driven Phrase Structure Grammar*, i–xxxvi. Berlin: Language Science Press. DOI:??

Chesi, Cristiano. 2015. On directionality of phrase structure building. *Journal of Psycholinguistic Research* 44(1). 65–89. DOI:10.1007/s10936-014-9330-6

Chomsky, Noam. 1957. *Syntactic structures* (Janua Linguarum / Series Minor 4). The Hague/Paris: Mouton.

Chomsky, Noam. 1964. Degrees of grammaticalness. In Jerry A. Fodor & Jerrold J. Katz (eds.), *The structure of language*, 384–389. Englewood Cliffs, NJ: Prentice-Hall.

Chomsky, Noam. 1965. *Aspects of the theory of syntax*. Cambridge, MA: MIT Press.

Chomsky, Noam. 1975. *The logical structure of linguistic theory*. New York: Plenum Press.

Chomsky, Noam. 1977. On wh-movement. In P. W. Culicover, T. Wasow & A. Akmajian (eds.), *Formal syntax*, 71–132. New York: Academic Press.

Chomsky, Noam. 1981. *Lectures on government and binding*. Dordrecht: Foris Publications.

Chomsky, Noam. 1986. *Barriers* (Linguistic Inquiry Monographs 13). Cambridge, MA: MIT Press.

Chomsky, Noam. 1990. On formalization and formal linguistics. *Natural Language and Linguistic Theory* 8(1). 143–147.

Chomsky, Noam. 1993. A Minimalist Program for linguistic theory. In Kenneth Hale & Samuel Jay Keyser (eds.), *The view from building 20: Essays in linguistics in honor of Sylvain Bromberger* (Current Studies in Linguistics 24), 1–52. Cambridge, MA/London: MIT Press.

Chomsky, Noam. 1995a. Bare phrase structure. In Hector Campos & Paula Kempchinsky (eds.), *Evolution and revolution in linguistic theory: Essays in honor of Carlos Otero*, 51–109. Washington, DC: Georgetown U Press.

Chomsky, Noam. 1995b. *The Minimalist Program* (Current Studies in Linguistics 28). Cambridge, MA: MIT Press.

Chomsky, Noam. 2000. *New horizons in the study of language and mind*. Cambridge, UK: Cambridge University Press.

Chomsky, Noam. 2001. Derivation by phase. In Michael Kenstowicz (ed.), *Ken Hale: A life in language*, 1–52. Cambridge, MA: MIT Press.

Chomsky, Noam. 2002. *On nature and language*. Cambridge, UK: Cambridge University Press.

Chomsky, Noam. 2005. Three factors in language design. *Linguistic Inquiry* 36(1). 1–22.

Chomsky, Noam. 2008. On phases. In Robert Freidin, Carlos P. Otero & Maria Luisa Zubizarreta (eds.), *Foundational issues in linguistic theory: Essays in honor of Jean-Roger Vergnaud*, 133–166. Cambridge, MA: MIT Press.

Chomsky, Noam. 2013. Problems of projection. *Lingua* 130. 33–49. DOI:10.1016/j.lingua.2012.12.003

Chomsky, Noam & Howard Lasnik. 1995. The theory of principles and parameters. In Noam Chomsky (ed.), *The Minimalist Program*, chap. 1, 13–127. Cambridge, MA: MIT Press.

Cinque, Guglielmo. 1999. *Adverbs and functional heads: A cross-linguistic perspective*. New York, Oxford: Oxford University Press.

Cinque, Guglielmo & Luigi Rizzi. 2010. The cartography of syntactic structures. In Bernd Heine & Heiko Narrog (eds.), *The Oxford handbook of linguistic analysis*, 51–65. Oxford: Oxford University Press.

Citko, Barbara. 2008. Missing labels. *Lingua* 118(7). 907–944.

Citko, Barbara. 2011. *Symmetry in syntax: Merge, move and labels*. Vol. 129. Cambridge, UK: Cambridge University Press. DOI:10.1017/CBO9780511794278

Cole, Peter, Wayne Harbert & Gabriella Hermon. 1982. Headless relative clauses in Quechua. *International Journal of American Linguistics* 48(2). 113–124. http://www.jstor.org/stable/1264676, accessed 2018-9-13.

Copestake, Ann, Daniel P. Flickinger, Carl J. Pollard & Ivan A. Sag. 2005. Minimal Recursion Semantics: An introduction. *Research on Language and Computation* 3(2–3). 281–332. DOI:10.1007/s11168-006-6327-9

Crysmann, Berthold. 2012. Resumption and island-hood in Hausa. In Philippe de Groote & Mark-Jan Nederhof (eds.), *Formal Grammar. 15th and 16th International Conference on Formal Grammar, FG 2010 Copenhagen, Denmark, August 2010, FG 2011 Lubljana, Slovenia, August 2011*, vol. 7395 (Lecture Notes in Computer Science). Berlin: Springer Verlag.

Crysmann, Berthold. 2016. An underspecification approach to Hausa resumption. In Doug Arnold, Miriam Butt, Berthold Crysmann, Tracy Holloway-King & Stefan Müller (eds.), *Proceedings of the joint 2016 conference on Head-driven Phrase Structure Grammar and Lexical Functional Grammar*, 194–214. Stanford, CA: CSLI Publications.

Crysmann, Berthold. 2019. Morphology. In Stefan Müller, Anne Abeillé, Robert D. Borsley & Jean-Pierre Koenig (eds.), *Head-Driven Phrase Structure Grammar*, i–ii. Berlin: Language Science Press. DOI:??

Culicover, Peter W. 1999. *Syntactic nuts: Hard cases, syntactic theory, and language acquisition. foundations of syntax.* Vol. 1 (Oxford Linguistics). Oxford: Oxford University Press.

Culicover, Peter W. & Ray Jackendoff. 1999. The view from the periphery: The English comparative correlative. *Linguistic Inquiry* 30(4). 543–571. DOI:10.1162/002438999554200

Culicover, Peter W. & Ray S. Jackendoff. 2005. *Simpler Syntax.* Oxford: Oxford University Press.

Davis, Anthony & Jean-Pierre Koenig. 2019. The nature and role of the lexicon in HPSG. In Stefan Müller, Anne Abeillé, Robert D. Borsley & Jean-Pierre Koenig (eds.), *Head-Driven Phrase Structure Grammar*, i–xl. Berlin: Language Science Press. DOI:??

De Kuthy, Kordula. 2000. *Discontinuous NPs in German — A case study of the interaction of syntax, semantics and pragmatics.* Saarbrücken: Universität des Saarlandes dissertation.

Donati, Caterina. 2006. On *wh*-head-movement. In Lisa Lai-Shen Cheng & Norbert Corver (eds.), Wh-*movement: Moving on* (Current Studies in Linguistics 42), 21–46. Cambridge, MA: MIT Press.

Engdahl, Elisabet & Enric Vallduví. 1996. Information packaging in HPSG. In Claire Grover & Enric Vallduví (eds.), *Edinburgh Working Papers in Cognitive Science, vol. 12: Studies in HPSG*, chap. 1, 1–32. Edinburgh: Centre for Cognitive Science, University of Edinburgh. ftp://ftp.cogsci.ed.ac.uk/pub/CCS-WPs/wp-12.ps.gz, accessed 2018-3-20.

Engelkamp, Judith, Gregor Erbach & Hans Uszkoreit. 1992. Handling linear precedence constraints by unification. In Henry S. Thomson (ed.), *30th Annual Meeting of the Association for Computational Linguistics. Proceedings of the conference*, 201–208. Newark, DE: Association for Computational Linguistics. auch als CLAUS-Report, Nr. 19, Universität des Saarlandes erschienen.

Epstein, Samuel David & T. Daniel Seely. 2006. *Derivations in Minimalism* (Cambridge Studies in Linguistics 111). Cambridge, UK: Cambridge University Press.

Falk, Yehuda N. 2010. An unmediated analysis of relative clauses. In Miriam Butt & Tracy Holloway King (eds.), *Proceedings of the LFG 2010 conference*, 207–227. Stanford, CA: CSLI Publications. http://csli-publications.stanford.edu/LFG/15/, accessed 2018-3-20.

Fanselow, Gisbert. 2001. Features, θ-roles, and free constituent order. *Linguistic Inquiry* 32(3). 405–437.

Flickinger, Dan, Carl Pollard & Tom Wasow. 2019. The evolution of HPSG. In Stefan Müller, Anne Abeillé, Robert D. Borsley & Jean-Pierre Koenig (eds.), *Head-Driven Phrase Structure Grammar*, i–xxiv. Berlin: Language Science Press. DOI:??

Flickinger, Daniel P. 1987. *Lexical rules in the hierarchical lexicon*. Stanford University dissertation.

Flickinger, Daniel P. 2008. Transparent heads. In Stefan Müller (ed.), *Proceedings of the 15th International Conference on Head-Driven Phrase Structure Grammar*, 87–94. Stanford, CA: CSLI Publications. http://csli-publications.stanford.edu/HPSG/2008/abstr-flickinger.shtml, accessed 2018-2-25.

Flickinger, Daniel P., Carl J. Pollard & Thomas Wasow. 1985. Structure-sharing in lexical representation. In William C. Mann (ed.), *Proceedings of the Twenty-Third Annual Meeting of the Association for Computational Linguistics*, 262–267. Chicago, IL.

Fodor, Janet Dean. 2001. Setting syntactic parameters. In Mark Baltin & Chris Collins (eds.), *The handbook of contemporary syntactic theory*, 730–767. Oxford: Blackwell Publishers Ltd. DOI:10.1002/9780470756416.ch23

Fong, Sandiway. 2014. Unification and efficient computation in the Minimalist Program. In L. Francis & L. Laurent (eds.), *Language and recursion*, 129–138. Berlin: Springer Verlag.

Fong, Sandiway & Jason Ginsburg. 2012. Computation with doubling constituents: Pronouns and antecedents in Phase Theory. In Anna Maria Di Sciullo (ed.), *Towards a Biolinguistic understanding of grammar: Essays on interfaces* (Linguistik Aktuell/Linguistics Today 194), 303–338. Amsterdam: John Benjamins Publishing Co.

Frey, Werner. 1993. *Syntaktische Bedingungen für die semantische Interpretation: Über Bindung, implizite Argumente und Skopus* (studia grammatica 35). Berlin: Akademie Verlag.

Gazdar, Gerald. 1981. Unbounded dependencies and coordinate structure. *Linguistic Inquiry* 12. 155–184.

Gazdar, Gerald, Ewan Klein, Geoffrey K. Pullum & Ivan A. Sag. 1985. *Generalized Phrase Structure Grammar*. Cambridge, MA: Harvard University Press.

Ginzburg, Jonathan. 2019. Acquisition. In Stefan Müller, Anne Abeillé, Robert D. Borsley & Jean-Pierre Koenig (eds.), *Head-Driven Phrase Structure Grammar*, i–ii. Berlin: Language Science Press. DOI:??

Ginzburg, Jonathan & Ivan A. Sag. 2000. *Interrogative investigations: The form, meaning, and use of English interrogatives* (CSLI Lecture Notes 123). Stanford, CA: CSLI Publications.

Green, Georgia M. 2011. Modeling grammar growth: Universal Grammar without innate principles or parameters. In Robert D. Borsley & Kersti Börjars (eds.), *Non-transformational syntax: Formal and explicit models of grammar: A guide to current models*, 378–403. Oxford, UK/Cambridge, MA: Blackwell Publishers Ltd. DOI:10.1002/9781444395037.ch11

Grewendorf, Günther. 1993. German: A grammatical sketch. In Joachim Jacobs, Arnim von Stechow, Wolfgang Sternefeld & Theo Vennemann (eds.), *Syntax – Ein internationales Handbuch zeitgenössischer Forschung*, vol. 9.2 (Handbücher zur Sprach- und Kommunikationswissenschaft), 1288–1319. Berlin: Walter de Gruyter Verlag. DOI:10.1515/9783110095869.1

Groos, Anneke & Henk van Riemsdijk. 1981. Matching effects in free relatives: A parameter of core grammar. In A. Belletti, L. Brandi & L. Rizzi (eds.), *Theory of markedness in Generative Grammar*, 171–216. Pisa: Scuola Normale Superiore.

Gunji, Takao. 1986. Subcategorization and word order. In William J. Poser (ed.), *Papers from the Second International Workshop on Japanese Syntax*, 1–21. Stanford, CA: CSLI Publications.

Gussenhoven, Carlos. 1983. Focus, mode and the nucleus. *Journal of Linguistics* 19. 377–419.

Haegeman, Liliane. 1994. *Introduction to Government and Binding Theory*. 2nd edn. (Blackwell Textbooks in Linguistics 1). Oxford: Blackwell Publishers Ltd.

Haider, Hubert. 2018. *On Minimalist theorizing and scientific ideology in grammar theory*. Ms. Universität Salzburg.

Hale, Kenneth & Samuel Jay Keyser. 1993. On argument structure and the lexical expression of syntactic relations. In Kenneth Hale & Samuel Jay Keyser (eds.), *The view from building 20: Essays in linguistics in honor of Sylvain Bromberger* (Current Studies in Linguistics 24), 53–109. Cambridge, MA/London: MIT Press.

Halliday, Michael A. K. 1970. *A course in spoken English: intonation.* Oxford University Press.

Hauser, Marc D., Noam Chomsky & W. Tecumseh Fitch. 2002. The faculty of language: What is it, who has it, and how did it evolve? *Science* 298(5598). 1569–1579. DOI:10.1126/science.298.5598.1569

Hinrichs, Erhard W. & Tsuneko Nakazawa. 1994a. Linearizing AUXs in German verbal complexes. In John Nerbonne, Klaus Netter & Carl J. Pollard (eds.), *German in Head-Driven Phrase Structure Grammar* (CSLI Lecture Notes 46), 11–38. Stanford, CA: CSLI Publications.

Hinrichs, Erhard W. & Tsuneko Nakazawa. 1994b. Partial-VP and split-NP topicalization in German—An HPSG analysis. In Erhard W. Hinrichs, Walt Detmar Meurers & Tsuneko Nakazawa (eds.), *Partial-VP and split-NP topicalization in German—An HPSG analysis and its implementation* (Arbeitspapiere des SFB 340 No. 58). Eberhard-Karls-Universität Tübingen.

Höhle, Tilman N. 1982. Explikationen für „normale Betonung" und „normale Wortstellung". In Werner Abraham (ed.), *Satzglieder im Deutschen – Vorschläge zur syntaktischen, semantischen und pragmatischen Fundierung* (Studien zur deutschen Grammatik 15), 75–153. Tübingen: originally Gunter Narr Verlag now Stauffenburg Verlag. Republished as **Hoehle2015Explikation**.

Hornstein, Norbert. 2009. *A theory of syntax: Minimal operations and Universal Grammar*. Cambridge University Press. DOI:10.1017/CBO9780511575129

Hornstein, Norbert, Jairo Nunes & Kleantes K. Grohmann. 2005. *Understanding Minimalism* (Cambridge Textbooks in Linguistics). Cambridge, UK: Cambridge University Press. DOI:10.1017/CBO9780511840678

Huybregts, Riny & Henk van Riemsdijk. 1982. *Noam chomsky on the Generative Enterprise.* Dordrecht: Foris.

Jackendoff, Ray S. 2008. Construction after Construction and its theoretical challenges. *Language* 84(1). 8–28.

Johannessen, Janne Bondi. 1996. Partial agreement and coordination. *Linguistic Inquiry* 27(4). 661–676.

Johannessen, Janne Bondi. 1998. *Coordination* (Oxford Studies in Comparative Syntax). Oxford: Oxford University Press.

Jones, Morris & Alun R. Thomas. 1977. *The Welsh language: Studies in its syntax and semantics.* Cardiff: University of Wales Press.

Joos, Martin. 1958. Comment on *Phonemic overlapping* by Bernhard Bloch. In Martin Joos (ed.), *Readings in linguistics: The development of descriptive linguistics in America since 1925.* New York: American Council of Learned Societies. https://archive.org/details/readingsinlingui00joos.

Kasper, Robert T. 1994. Adjuncts in the Mittelfeld. In John Nerbonne, Klaus Netter & Carl J. Pollard (eds.), *German in Head-Driven Phrase Structure Grammar* (CSLI Lecture Notes 46), 39–70. Stanford, CA: CSLI Publications.

Kayne, Richard S. 1994. *The antisymmetry of syntax* (Linguistic Inquiry Monographs 25). Cambridge, MA: MIT Press.

Kiss, Tibor. 1995. *Infinite Komplementation: Neue Studien zum deutschen Verbum infinitum* (Linguistische Arbeiten 333). Tübingen: Max Niemeyer Verlag.

Kiss, Tibor. 2001. Configurational and relational scope determination in German. In Walt Detmar Meurers & Tibor Kiss (eds.), *Constraint-based approaches to Germanic syntax* (Studies in Constraint-Based Lexicalism 7), 141–175. Stanford, CA: CSLI Publications.

Kiss, Tibor. 2005. Semantic constraints on relative clause extraposition. *Natural Language and Linguistic Theory* 23(2). 281–334. DOI:10.1007/s11049-003-1838-7

Kobele, Gregory M. 2008. Across-the-board extraction in Minimalist Grammars. In *Proceedings of the Ninth International Workshop on Tree Adjoining Grammar and Related Formalisms (TAG+9)*, 113–128.

Koenig, Jean-Pierre & Karin Michelson. 2012. The (non)universality of syntactic selection and functional application. In Christopher Piñón (ed.), *Empirical issues in syntax and semantics*, vol. 9, 185–205. Paris: CNRS.

Koenig, Jean-Pierre & Frank Richter. 2019. Semantics. In Stefan Müller, Anne Abeillé, Robert D. Borsley & Jean-Pierre Koenig (eds.), *Head-Driven Phrase Structure Grammar*, i–xxxi. Berlin: Language Science Press. DOI:??

Kornai, András & Geoffrey K. Pullum. 1990. The X-bar Theory of phrase structure. *Language* 66(1). 24–50.

Koster, Jan. 1986. The relation between pro-drop, scrambling, and verb movements. *Groningen Papers in Theoretical and Applied Linguistics* 1. 1–43.

Kubota, Yusuke. 2019. HPSG and Categorial Grammar. In Stefan Müller, Anne Abeillé, Robert D. Borsley & Jean-Pierre Koenig (eds.), *Head-Driven Phrase Structure Grammar*, i–xlvi. Berlin: Language Science Press. DOI:??

Kuhn, Jonas. 2007. Interfaces in constraint-based theories of grammar. In Gillian Ramchand & Charles Reiss (eds.), *The Oxford handbook of linguistic interfaces*, 613–650. Oxford: Oxford University Press. DOI:10.1093/oxfordhb/9780199247455.013.0020

Kuthy, Kordula De. 2019. Information structure. In Stefan Müller, Anne Abeillé, Robert D. Borsley & Jean-Pierre Koenig (eds.), *Head-Driven Phrase Structure Grammar*, i–xxxi. Berlin: Language Science Press. DOI:??

Larson, Richard K. 1988. On the double object construction. *Linguistic Inquiry* 19(3). 335–391.

Larson, Richard K. 1990. Double objects revisited: Reply to Jackendoff. *Linguistic Inquiry* (21). 589–632.

Levine, Robert D. & Ivan A. Sag. 2003. Some empirical issues in the grammar of extraction. In Stefan Müller (ed.), *Proceedings of the 10th International Conference on Head-Driven Phrase Structure Grammar, Michigan State University, East Lansing*, 236–256. Stanford, CA: CSLI Publications. http://csli-publications.stanford.edu/HPSG/2003/, accessed 2018-9-25.

Li, Yen-hui Audrey. 2008. Case, 20 years later. In Marjorie K.M. Chan & Hana Kang (eds.), *Proceedings of the 20th North American Conference on Chinese Linguistics (NACCL-20)*, 41–68. Columbus, Ohio: The Ohio State University.

Lin, Dekang. 1993. Principle-based parsing without overgeneration. In *Proceedings of the 31st Annual Meeting of the Association for Computational Linguistics*, 112–120. Columbus, Ohio, USA: Association for Computational Linguistics. DOI:10.3115/981574.981590

Lin, Dekang. 2003. Dependency-based evaluation of MINIPAR. In Anne Abeillé (ed.), *Treebanks: Building and Using Parsed Corpora* (Text, Speech and Language Technology 20), 317–329. Kluwer Academic Publishers. DOI:10.1007/978-94-010-0201-1_18

Lohnstein, Horst. 2014. Artenvielfalt in freier Wildbahn: Generative Grammatik. In Jörg Hagemann & Sven Staffeldt (eds.), *Syntaxtheorien: Analysen im Vergleich* (Stauffenburg Einführungen 28), 165–185. Tübingen: Stauffenburg Verlag.

Lücking, Andy. 2019. Gesture. In Stefan Müller, Anne Abeillé, Robert D. Borsley & Jean-Pierre Koenig (eds.), *Head-Driven Phrase Structure Grammar*, i–xxxiii. Berlin: Language Science Press. DOI:??

Marslen-Wilson, William D. 1975. Sentence perception as an interactive parallel process. *Science* 189(4198). 226–228. DOI:10.1126/science.189.4198.226

Matsuyama, Tetsuya. 2004. The N *after* N Construction: A constructional idiom. *English Linguistics* 1(11). 55–84.

May, Robert. 1985. *Logical form: Its structure and derivation* (Linguistic Inquiry Monographs 12). Cambridge, MA/London: MIT Press.

McCawley, James D. 1968. Lexical insertion in a Transformational Grammar without Deep Structure. In *Fourth regional meeting of the Chicago Linguistic Society*, 71–81. University of Chicago.

McCloskey, James. 2002. Resumption, successive cyclicity and the locality of operations. In Samuel David Epstein & T. Daniel Seely (eds.), *Derivation and explanation in the Minimalist Program*, 184–226. Oxford: Blackwell Publishers Ltd. DOI:10.1002/9780470755662

McCloskey, James. 2006. Resumption. In Martin Everaert & Henk van Riemsdijk (eds.), *The blackwell companion to syntax*, 94–117. Oxford: Blackwell Publishers Ltd.

Meinunger, André. 2000. *Syntactic aspects of topic and comment* (Linguistik Aktuell/Linguistics Today 38). Amsterdam: John Benjamins Publishing Co.

Meurers, Walt Detmar. 1999. German partial-VP fronting revisited. In Gert Webelhuth, Jean-Pierre Koenig & Andreas Kathol (eds.), *Lexical and Constructional aspects of linguistic explanation* (Studies in Constraint-Based Lexicalism 1), 129–144. Stanford, CA: CSLI Publications.

Meurers, Walt Detmar. 2001. On expressing lexical generalizations in HPSG. *Nordic Journal of Linguistics* 24(2). 161–217.

Meurers, Walt Detmar & Stefan Müller. 2009. Corpora and syntax. In Anke Lüdeling & Merja Kytö (eds.), *Corpus linguistics: An international handbook*, vol. 29 (Handbücher zur Sprach- und Kommunikationswissenschaft), chap. 42, 920–933. Berlin: Mouton de Gruyter.

Michaelis, Laura A. & Knud Lambrecht. 1996. Toward a Construction-based theory of language function: The case of nominal extraposition. *Language* 72(2). 215–247.

Müller, Gereon. 1998. *Incomplete category fronting: A derivational approach to remnant movement in German* (Studies in Natural Language and Linguistic Theory 42). Dordrecht: Kluwer Academic Publishers.

Müller, Gereon. 2011. Regeln oder Konstruktionen? Von verblosen Direktiven zur sequentiellen Nominalreduplikation. In Stefan Engelberg, Anke Holler & Kristel Proost (eds.), *Sprachliches Wissen zwischen Lexikon und Grammatik* (Institut für Deutsche Sprache, Jahrbuch 2010), 211–249. Berlin: de Gruyter.

Müller, Stefan. 1999a. An HPSG-analysis for free relative clauses in German. *Grammars* 2(1). 53–105.

Müller, Stefan. 1999b. *Deutsche Syntax deklarativ: Head-Driven Phrase Structure Grammar für das Deutsche* (Linguistische Arbeiten 394). Tübingen: Max Niemeyer Verlag.

Müller, Stefan. 2002. *Complex predicates: Verbal complexes, resultative constructions, and particle verbs in German* (Studies in Constraint-Based Lexicalism 13). Stanford, CA: CSLI Publications.

Müller, Stefan. 2003. Solving the bracketing paradox: An analysis of the morphology of German particle verbs. *Journal of Linguistics* 39(2). 275–325. DOI:10.1017/S0022226703002032

Müller, Stefan. 2004. Complex NPs, subjacency, and extraposition. *Snippets* 8. 10–11.

Müller, Stefan. 2007a. Qualitative Korpusanalyse für die Grammatiktheorie: Introspektion vs. Korpus. In Gisela Zifonun & Werner Kallmeyer (eds.), *Sprachkorpora – Datenmengen und Erkenntnisfortschritt* (Institut für Deutsche Sprache Jahrbuch 2006), 70–90. Berlin: Walter de Gruyter.

Müller, Stefan. 2007b. The Grammix CD Rom: A software collection for developing typed feature structure grammars. In Tracy Holloway King & Emily M. Bender (eds.), *Grammar Engineering across Frameworks 2007* (Studies in Computational Linguistics ONLINE). Stanford, CA: CSLI Publications. http://csli-publications.stanford.edu/GEAF/2007/, accessed 2018-2-25.

Müller, Stefan. 2009. On predication. In Stefan Müller (ed.), *Proceedings of the 16th International Conference on Head-Driven Phrase Structure Grammar, University of Göttingen, Germany*, 213–233. Stanford, CA: CSLI Publications.

Müller, Stefan. 2012. *On the copula, specificational constructions and type shifting*. Ms. Freie Universität Berlin.

Müller, Stefan. 2013. Unifying everything: Some remarks on Simpler Syntax, Construction Grammar, Minimalism and HPSG. *Language* 89(4). 920–950. DOI:10.1353/lan.2013.0061

Müller, Stefan. 2014. Elliptical constructions, multiple frontings, and surface-based syntax. In Paola Monachesi, Gerhard Jäger, Gerald Penn & Shuly Wintner (eds.), *Proceedings of Formal Grammar 2004, Nancy*, 91–109. Stanford, CA: CSLI Publications.

Müller, Stefan. 2015a. HPSG – A synopsis. In Tibor Kiss & Artemis Alexiadou (eds.), *Syntax – Theory and analysis: An international handbook* (Handbooks of Linguistics and Communication Science 42.2), 937–973. Berlin: Walter de Gruyter. DOI:10.1515/9783110363708-004

Müller, Stefan. 2015b. The CoreGram project: Theoretical linguistics, theory development and verification. *Journal of Language Modelling* 3(1). 21–86. DOI:10.15398/jlm.v3i1.91

Müller, Stefan. 2016a. *Grammatical Theory: From Transformational Grammar to Constraint-Based Approaches* (Textbooks in Language Sciences 1). Berlin: Language Science Press. DOI:10.17169/langsci.b25.167

Müller, Stefan. 2016b. Satztypen: Lexikalisch oder/und phrasal. In Rita Finkbeiner & Jörg Meibauer (eds.), *Satztypen und Konstruktionen im Deutschen* (Linguistik – Impulse & Tendenzen 65), 72–105. Berlin: de Gruyter.

Müller, Stefan. 2017. *German sentence structure: An analysis with special consideration of so-called multiple fronting* (Empirically Oriented Theoretical Morphology and Syntax). Berlin: Language Science Press. Revise and resubmit.

Müller, Stefan. 2018a. *Grammatical theory: From Transformational Grammar to constraint-based approaches*. 2nd edn. (Textbooks in Language Sciences 1). Berlin: Language Science Press. DOI:10.5281/zenodo.1193241

Müller, Stefan. 2018b. The end of lexicalism as we know it? *Language* 94(1). e54–e66. DOI:10.1353/lan.2018.0014

Müller, Stefan. 2019a. Constituent order. In Stefan Müller, Anne Abeillé, Robert D. Borsley & Jean-Pierre Koenig (eds.), *Head-Driven Phrase Structure Grammar*, i–xxxv. Berlin: Language Science Press. DOI:??

Müller, Stefan. 2019b. *Germanic syntax*. Ms. Humboldt Universität zu Berlin, to be submitted to Language Science Press. Berlin. https://hpsg.hu-berlin.de/~stefan/Pub/germanic.html, accessed 2019-6-30.

Müller, Stefan. 2019c. *Grammatical theory: From Transformational Grammar to constraint-based approaches*. 3rd edn. (Textbooks in Language Sciences 1). Berlin: Language Science Press. DOI:10.5281/zenodo.3364215

Müller, Stefan. 2019d. HPSG and Construction Grammar. In Stefan Müller, Anne Abeillé, Robert D. Borsley & Jean-Pierre Koenig (eds.), *Head-Driven Phrase Structure Grammar*, i–xxxix. Berlin: Language Science Press. DOI:??

Müller, Stefan, Felix Bildhauer & Philippa Cook. 2012. Beschränkungen für die scheinbar mehrfache Vorfeldbesetzung im Deutschen. In Colette Cortès (ed.), *Satzeröffnung: Formen, Funktionen, Strategien* (Eurogermanistik 31), 113–128. Tübingen: Stauffenburg Verlag.

Musso, Mariacristina, Andrea Moro, Volkmar Glauche, Michel Rijntjes, Jürgen Reichenbach, Christian Büchel & Cornelius Weiller. 2003. Broca's area and the language instinct. *Nature Neuroscience* 6(7). 774–781. DOI:10.1038/nn1077

Newmeyer, Frederick J. 1986. *Linguistic theory in America*. 2nd edn. New York, NY: Academic Press.

Newmeyer, Frederick J. 2005. *Possible and probable languages: A Generative perspective on linguistic typology.* Oxford: Oxford University Press.

Newmeyer, Frederick J. 2006. *A rejoinder to 'On the role of parameters in Universal Grammar: A reply to Newmeyer' by Ian Roberts and Anders Holmberg.* https://ling.auf.net/lingbuzz/000248, accessed 2018-9-25.

Newmeyer, Frederick J. 2017. Where, if anywhere, are parameters? A critical historical overview of parametric theory. In Claire Bowern, Laurence Horn & Raffaella Zanuttini (eds.), *On looking into words (and beyond): Structures, relations, analyses* (Empirically Oriented Theoretical Morphology and Syntax 3), 547–569. Language Science Press. DOI:10.5281/zenodo.495467

Ott, Dennis. 2011. A note on free relative clauses in the theory of Phases. *Linguistic Inquiry* 42(1). 183–192.

Partee, Barbara H. 1987. Noun phrase interpretation and type-shifting principles. In Jeroen A. G. Groenendijk, Dick de Jongh & Martin J. B. Stokhof (eds.), *Studies in Discourse Representation Theory and the theory of generalized quantifiers* (Groningen-Amsterdam Studies in Semantics 8), 115–143. Dordrecht: Foris Publications.

Phillips, Colin. 2003. Linear order and constituency. *Linguistic Inquiry* 34(1). 37–90. DOI:10.1162/002438903763255922

Pollard, Carl. 1997. *Lectures on the foundations of hpsg.* Ms. Ohio State University. https://www1.essex.ac.uk/linguistics/external/clmt/papers/hpsg/pollard-foundations.ps, accessed 2018-9-29.

Pollard, Carl J. 1996. *The nature of constraint-based grammar.* http://lingo.stanford.edu/sag/L221a/pollard-96.txt, accessed 2018-2-25. Paper presented at the Pacific Asia Conference on Language, Information, and Computation, Kyung Hee University, Seoul, Korea.

Pollard, Carl J. 1999. Strong generative capacity in HPSG. In Gert Webelhuth, Jean-Pierre Koenig & Andreas Kathol (eds.), *Lexical and Constructional aspects of linguistic explanation* (Studies in Constraint-Based Lexicalism 1), 281–298. Stanford, CA: CSLI Publications.

Pollard, Carl J. & Ivan A. Sag. 1987. *Information-based syntax and semantics* (CSLI Lecture Notes 13). Stanford, CA: CSLI Publications.

Pollard, Carl J. & Ivan A. Sag. 1992. Anaphors in English and the scope of Binding Theory. *Linguistic Inquiry* 23(2). 261–303.

Pollard, Carl J. & Ivan A. Sag. 1994. *Head-Driven Phrase Structure Grammar* (Studies in Contemporary Linguistics). Chicago: The University of Chicago Press.

Pollock, Jean-Yves. 1989. Verb movement, Universal Grammar and the structure of IP. *Linguistic Inquiry* 20(3). 365–424.

Postal, Paul M. 1970. On the surface verb 'remind'. *Linguistic Inquiry* 1(1). 37–120.

Postal, Paul M. 2003. (Virtually) conceptually necessary. *Journal of Linguistics* 39(3). 599–620.   DOI:10.1017/S0022226703002111

Postal, Paul M. 2004. *Skeptical linguistic essays*. Oxford: Oxford University Press.

Postal, Paul M. 2010. *Edge-based clausal syntax: A study of (mostly) English object structure*. Cambridge, MA: MIT Press.

Pullum, Geoffrey K. 1989. Formal linguistics meets the Boojum. *Natural Language and Linguistic Theory* 7(1). 137–143.   DOI:10.1007/BF00141350

Pullum, Geoffrey K. & Barbara C. Scholz. 2001. On the distinction between generative-enumerative and model-theoretic syntactic frameworks. In Philippe de Groote, Glyn Morrill & Christian Retor (eds.), *Logical Aspects of Computational Linguistics: 4th International Conference* (Lecture Notes in Computer Science 2099), 17–43. Berlin: Springer Verlag.

Radford, Andrew. 1993. Head-hunting: On the trail of the nominal Janus. In Greville G. Corbett, Norman M. Fraser & Scott McGlashan (eds.), *Heads in grammatical theory*, 73–113. Cambridge University Press. DOI:10.1017/CBO9780511659454.005

Radford, Andrew. 1997. *Syntactic theory and the structure of English: A Minimalist approach* (Cambridge Textbooks in Linguistics). Cambridge, UK: Cambridge University Press.

Ramchand, Gillian. 2005. Post-Davidsonianism. *Theoretical Linguistics* 31(3). 359–373.   DOI:10.1515/thli.2005.31.3.359

Reape, Mike. 1994. Domain union and word order variation in German. In John Nerbonne, Klaus Netter & Carl J. Pollard (eds.), *German in Head-Driven Phrase Structure Grammar* (CSLI Lecture Notes 46), 151–198. Stanford, CA: CSLI Publications.

Richards, Marc. 2015. Minimalism. In Tibor Kiss & Artemis Alexiadou (eds.), *Syntax – theory and analysis: An international handbook*, vol. 42.3 (Handbooks of Linguistics and Communication Science), 803–839. Berlin: Mouton de Gruyter. DOI:10.1515/9783110363685

Richter, Frank. 2019. Formal Background. In Stefan Müller, Anne Abeillé, Robert D. Borsley & Jean-Pierre Koenig (eds.), *Head-Driven Phrase Structure Grammar*, i–ii. Berlin: Language Science Press.   DOI:??

Richter, Frank & Manfred Sailer. 1999. Underspecified semantics in HPSG. In Harry Bunt & Reinhard Muskens (eds.), *Computing meaning*, vol. 1, 95–112. Dordrecht: Springer Netherlands.   DOI:10.1007/978-94-011-4231-1_5

Rizzi, Luigi. 1982. Violations of the *wh* island constraint and the Subjacency Condition. In Luigi Rizzi (ed.), *Issues in Italian syntax* (Studies in Generative Grammar 11), 49–76. Dordrecht: Foris Publications.

Rizzi, Luigi. 1997. The fine structure of the left periphery. In Liliane Haegeman (ed.), *Elements of grammar*, 281–337. Dordrecht: Kluwer Academic Publishers.

Rizzi, Luigi. 2014. Syntactic Cartography and the Syntacticisation of Scope-Discourse Semantics. In Anne Reboul (ed.), *Mind, Values, and Metaphysics: Philosophical Essays in Honor of Kevin Mulligan*, vol. 2, 517–533. Cham: Springer International Publishing. DOI:10.1007/978-3-319-05146-8_30

Roberts, Ian. 2005. *Principles and Parameters in a VSO language: A case study in Welsh*. Oxford: Oxford University Press.

Roberts, Ian F. & Anders Holmberg. 2005. On the role of parameters in Universal Grammar: A reply to Newmeyer. In Hans Broekhuis, N. Corver, Riny Huybregts, Ursula Kleinhenz & Jan Koster (eds.), *Organizing grammar: Linguistic studies in honor of Henk van Riemsdijk* (Studies in Generative Grammar 86), 538–553. Berlin: Mouton de Gruyter. DOI:10.1515/9783110892994.538

Ross, John R. 1967a. *Constraints on variables in syntax*. MIT, Cambridge, Massachusetts. [Published in 1986 as *Infinite Syntax!* Norwood, NJ: Ablex Publishing] Ph.D. Dissertation.

Ross, John Robert. 1967b. *Constraints on variables in syntax*. MIT dissertation. http://files.eric.ed.gov/fulltext/ED016965.pdf, accessed 2018-2-25. Reproduced by the Indiana University Linguistics Club and later published as **Ross86a-u**.

Rouveret, Alain. 1994. *Syntaxe du gallois: principes généraux et typologie*. Paris: Editions du CNRS.

Sadler, Louisa. 1988. *Welsh syntax: a government binding approach*. London: Croom Helm.

Sag, Ivan A. 1983. On parasitic gaps. *Linguistics and Philosophy* 6(1). 35–45. DOI:10.1007/BF00868089

Sag, Ivan A. 1997. English relative clause constructions. *Journal of Linguistics* 33(2). 431–484.

Sag, Ivan A. 2003. Coordination and underspecification. In Jongbok Kim & Stephen Mark Wechsler (eds.), *The proceedings of the 9th International Conference on Head-Driven Phrase Structure Grammar*, 267–291. Stanford, CA: CSLI Publications. http://csli-publications.stanford.edu/HPSG/3/, accessed 2018-9-25.

Sag, Ivan A. 2010. English filler-gap constructions. *Language* 86(3). 486–545.

Sag, Ivan A. 2012. Sign-Based Construction Grammar: An informal synopsis. In Hans C. Boas & Ivan A. Sag (eds.), *Sign-Based Construction Grammar* (CSLI Lecture Notes 193), 69–202. Stanford, CA: CSLI Publications.

Sag, Ivan A. & Janet Dean Fodor. 1994. Extraction without traces. In Raul Aranovich, William Byrne, Susanne Preuss & Martha Senturia (eds.), *Proceedings of the Thirteenth West Coast Conference on Formal Linguistics*, 365–384. Stanford, CA: CSLI Publications/SLA. http://lingo.stanford.edu/sag/papers/sag-fodor-wccfl.pdf, accessed 2018-2-25.

Sag, Ivan A. & Thomas Wasow. 2011. Performance-compatible competence grammar. In Robert D. Borsley & Kersti Börjars (eds.), *Non-transformational syntax: Formal and explicit models of grammar: A guide to current models*, 359–377. Oxford, UK/Cambridge, MA: Blackwell Publishers Ltd.

Sag, Ivan A. & Thomas Wasow. 2015. Flexible processing and the design of grammar. *Journal of Psycholinguistic Research* 44(1). 47–63.

Salkoff, Morris. 1988. Analysis by fusion. *Lingvisticæ Investigationes* 12(1). 49–84. DOI:10.1075/li.12.1.03sal

Sauerland, Uli & Paul Elbourne. 2002. Total reconstruction, PF movement, and derivational order. *Linguistic Inquiry* 33(2). 283–319.

Schütze, Carson T. 2016. *The empirical base of linguistics: Grammaticality judgments and linguistic methodology.* 2nd edn. (Classics in Linguistics 2). Berlin: Language Science Press. DOI:10.17169/langsci.b89.100

Shiraishi, Aoi & Anne Abeillé. 2016. Peripheral ellipsis and verb mismatch. In Doug Arnold, Miriam Butt, Berthold Crysmann, Tracy Holloway-King & Stefan Müller (eds.), *Proceedings of the joint 2016 conference on Head-driven Phrase Structure Grammar and Lexical Functional Grammar*, 662–680. Stanford, CA: CSLI Publications. http : / / cslipublications . stanford . edu / HPSG / 2016 / headlex2016-shiraishi-abeille.pdf.

Sorace, Antonella & Frank Keller. 2005. Gradience in linguistic data. *Lingua* 115(11). 1497–1524. DOI:10.1016/j.lingua.2004.07.002

Sproat, Richard. 1985. Welsh syntax and VSO structure. *Natural Language and Linguistic Theory* 3(2). 173–216.

Sproat, Richard & Shalom Lappin. 2005. *A challenge to the Minimalist community.* http://linguistlist.org/issues/16/16-1156.html, accessed 2018-3-21.

Stabler, Edward P. 2001. Minimalist Grammars and recognition. In Christian Rohrer, Antje Rossdeutscher & Hans Kamp (eds.), *Linguistic form and its computation* (Studies in Computational Linguistics 1), 327–352. Stanford, CA: CSLI Publications.

Starke, Michael. 2014. Towards elegant parameters: Language variation reduces to the size of lexically-stored trees. In M. Carme Picallo (ed.), *Linguistic variation in the Minimalist framework*, 140–152. Oxford: Oxford University Press.

Steedman, Mark J. 1991. Structure and intonation. *Language* 67(2). 260–296.

Steedman, Mark J. 2000. *The syntactic process* (Language, Speech, and Communication). Cambridge, MA: MIT Press.

Sternefeld, Wolfgang. 2006. *Syntax: Eine morphologisch motivierte generative Beschreibung des Deutschen* (Stauffenburg Linguistik 31). Tübingen: Stauffenburg Verlag.

Sternefeld, Wolfgang & Frank Richter. 2012. Wo stehen wir in der Grammatiktheorie? — Bemerkungen anläßlich eines Buchs von Stefan Müller. *Zeitschrift für Sprachwissenschaft* 31(2). 263–291. DOI:10.1515/zfs-2012-0010

Taghvaipour, Mehran A. 2010. *Persian relative clauses in HPSG: An Analysis of Persian relative clause constructions in Head-Driven Phrase Structure Grammar*. Saarbrücken: LAMBERT Academic Publishing.

Tanenhaus, Michael K., Michael J. Spivey-Knowlton, Kathleen M. Eberhard & Julie C. Sedivy. 1995. Integration of visual and linguistic information in spoken language comprehension. *Science* 268(5217). 1632–1634. DOI:10.1126/science.7777863

Tanenhaus, Michael K., Michael J. Spivey-Knowlton, Kathleen M. Eberhard & Julie C. Sedivy. 1996. Using eye movements to study spoken language comprehension: Evidence for visually mediated incremental interpretation. In Toshio Inui & James L. McClelland (eds.), *Information integration in perception and communication* (Attention and Performance XVI), 457–478. Cambridge, MA: MIT Press.

Torr, John & Edward P. Stabler. 2016. Coordination in Minimalist Grammars: Excorporation and across the board (head) movement. In.

Torr, John, Milos Stanojevic, Mark Steedman & Shay B. Cohen. 2019. Widecoverage neural A* parsing for Minimalist Grammars. In Anna Korhonen, David Traum & Lluís Màrquez (eds.), *Proceedings of the 57th annual meeting of the association for computational linguistics*, 2486–2505. Florence, Italy: Association for Computational Linguistics. DOI:10.18653/v1/P19-1238

Vaillette, Nathan. 2001. Irish gaps and resumptive pronouns in HPSG. In Frank Van Eynde, Lars Hellan & Dorothee Beermann (eds.), *Proceedings of the HPSG-2001 Conference, Norwegian University of Science and Technology, Trondheim*, 284–299. Stanford, CA: CSLI Publications. http://csli-publications.stanford.edu/HPSG/2001/, accessed 2015-12-23.

Van Eynde, Frank. 2015. *Predicative constructions: From the Fregean to a Montagovian treatment* (Studies in Constraint-Based Lexicalism). Stanford, CA: CSLI Publications.

Van Koppen, Marjo. 2005. *One probe–two goals: Aspects of agreement in Dutch dialects.* Vol. 105 (LOT Dissertation Series). Utrecht Institute of Linguistics: Netherlands Graduate School of Linguistics.

Wasow, Tom. 2019. Processing. In Stefan Müller, Anne Abeillé, Robert D. Borsley & Jean-Pierre Koenig (eds.), *Head-Driven Phrase Structure Grammar*, i–xvi. Berlin: Language Science Press. DOI:??

Williams, Edwin. 1989. The anaphoric nature of θ-roles. *Linguistic Inquiry* 20(3). 425–456.

Willis, David. 2011. The limits of resumption in Welsh *wh*-dependencies. In Alain Rouveret (ed.), *Resumptive pronouns at the interfaces*, 189–222. Amsterdam: John Benjamins Publishing Co.

Wurmbrand, Susanne. 2003. *Long passive (corpus search results).* Ms. University of Connecticut.

Chapter 33

HPSG and Categorial Grammar

Yusuke Kubota

National Institute for Japanese Language and Linguistics

This chapter aims to offer an up-to-date comparison of HPSG and categorial grammar (CG). Since the CG research itself consists of two major types of approaches with overlapping but distinct goals and research strategies, I start by giving an overview of these two variants of CG (section 2). This is followed by a comparison of HPSG and CG at a broad level, in terms of the general architecture of the theory (section 3), and then, by a more focused comparison of specific linguistic analyses of some selected phenomena (section 4). The chapter ends by briefly touching on issues related to computational implementation and human sentence processing (section 5). Thoughtout the discussion, I attempt to highlight both the similarities and differences between HPSG and CG research, in the hope of stimulating further research in the two research communities on their respective open questions, and so that the two communities can continue to learn from each other.

1 Introduction

The goal of this chapter is to provide a comparison between HPSG and CATEGORIAL GRAMMAR (CG). The two theories share certain important insights, mostly due to the fact that they are among the so-called 'lexicalist', 'non-transformational' theories of syntax that were proposed as major alternatives to the mainstream transformational syntax in the 1980s (see Borsley & Börjars (2011) for an overview of these theories). However, due to the differences in the main research goals in the respective communities in which these approaches have been developed, there are certain nontrivial differences between them as well. The present chapter assumes researchers working in HPSG or other non-CG theories of syntax as its main audience, and aims to inform them of key aspects of CG which

make it distinct from other theories of syntax. While computational implementation and investigations of the formal properties of grammatical theory have been important in both HPSG and CG research, I will primarily focus on the linguistic aspects in the ensuing discussion, with pointers (where relevant) to literature on mathematical and computational issues. Throughout the discussion, I presuppose basic familiarity with HPSG (with pointers to relevant chapters in the handbook). The present handbook contains chapters that compare HPSG with other grammatical theories, including the present one. I encourage the reader to take a look at the other theory comparison chapters too (as well as other chapters dealing with specific aspects of HPSG in greater detail), in order to obtain a fuller picture of the theoretical landscape in current (non-transformational) generative syntax research.

2 Two varieties of CG

CG is actually not a monolithic theory, but is a family of related approaches (or, perhaps more accurately, it is much *less of* a monolithic theory than either HPSG or LFG is). For this reason, I will start my discussion by sketching some important features of two major varieties of CG, Combinatory Categorial Grammar (CCG) (Steedman 2000; Steedman 2012) and Type-Logical Categorial Grammar (TLCG; or 'Type-Logical Grammar') (Morrill 1994; Moortgat 2011; Kubota & Levine 2020).[1] After presenting the 'core' component of CG that is shared between the two approaches—which is commonly referred to as the 'AB grammar'—I introduce aspects of the respective approaches in which they diverge from each other.

2.1 Notation and presentation

Before getting started, some comments are in order as to the notation and the mode of presentation adopted. Two choices are made for the notation. First, CCG and TLCG traditionally adopt different notations of the slash. I stick to the TLCG notation throughout this chapter for notational consistency. Second, I present all the fragments below in the so-called LABELLED DEDUCTION notation of (Prawitz-style) natural deduction. In particular, I follow Oehrle (1994) and Morrill (1994) in the use of 'term labels' in labelled deduction to encode prosodic and semantic information of linguistic expressions. This involves writing linguistic expressions

---

[1]For more detailed introductions to these different variants of CG, see Steedman & Baldridge (2011) (on CCG) and Oehrle (2011) (on TLCG), both included in Borsley & Börjars (2011).

as *tripartite signs*, formally, tuples of prosodic form, semantic interpretation and syntactic category (or syntactic type). Researchers familiar with HPSG should find this notation easy to read and intuitive; the idea is essentially the same as how linguistic signs are conceived of in HPSG. In the CG literature, this notation has its roots in the conception of 'multidimensional' linguistic signs in earlier work by Dick Oehrle (Oehrle 1988). But the reader should be aware that this is *not* the standard notation in which either CCG or TLCG is typically presented. Also, logically savvy readers may find this notation somewhat confusing since it (unfortunately) obscures certain aspects of CG pertaining to its logical properties. In any event, it is important to keep in mind that different notations co-exist in the CG literature (and the logic literature behind it), and that, just as in mathematics in general, different notations can be adopted for the same formal system to highlight different aspects of it in different contexts. As noted in the introduction, for the mode of presentation, the emphasis is consistently on linguistic (rather than computational or logical) aspects. Moreover, I have taken the liberty to gloss over certain minor differences among different variants of CG for the sake of presentation. The reader is therefore encouraged to consult primary sources as well, especially when details matter.

2.2 The AB grammar

I start with a simple fragment of CG called the AB GRAMMAR, consisting of just two syntactic rules in (1):

(1)   a.   FORWARD SLASH ELIMINATION   b.   BACKWARD SLASH ELIMINATION

$$\frac{a;\ A/B \quad b;\ B}{a \circ b;\ A}\ /\mathrm{E} \qquad\qquad \frac{b;\ B \quad a;\ B\backslash A}{b \circ a;\ A}\ \backslash\mathrm{E}$$

With the somewhat minimal lexicon in (2), we can license the sentence *John loves Mary* as in (3). The two slashes / and \ are used to form 'complex' syntactic categories (more on this below) indicating valence information: the transitive verb *loves* is assigned the category (NP\S)/NP since it first combines with an NP to its right (i.e. the direct object) and then another NP to its right (i.e. the subject).

(2)   a.   john;   NP

      b.   mary;   NP

      c.   ran;   NP\S

      d.   loves;   (NP\S)/NP

(3)

$$\frac{\text{john; NP} \quad \dfrac{\text{mary; NP} \quad \text{loves; (NP\backslash S)/NP}}{\text{loves} \circ \text{mary; NP\backslash S}} \text{/E}}{\text{john} \circ \text{loves} \circ \text{mary; S}} \text{\textbackslash E}$$

At this point, this is just like the familiar PSG analysis of the following form, except that the symbol VP is replaced by NP\S:

(4)

```
              S
            /   \
          NP     VP
          |     /  \
        John   V    NP
               |    |
             loves Mary
```

Things will start looking more interesting as we make the fragment more complex (and also by adding the semantics), but before doing so I first introduce some basic assumptions, first on syntactic categories (below) and then on semantics (next section).

SYNTACTIC CATEGORIES (or SYNTACTIC TYPES) are defined recursively in CG. This can be concisely written using the so-called 'BNC notation' as follows:[2, 3]

(5)   a. BaseType := { N, NP, PP, S }
      b. Type := BaseType | Type\Type | Type/Type

In words, anything that is a BaseType is a Type, and any complex expression of form A\ B or A/B where A and B are both Types is a Type. To give some examples, the following expressions are syntactic types according to the definition in (5):[4]

(6)   a. S\S

---

[2] See section 3.3 below for the treatment of syntactic features (such as those used for agreement). I ignore this aspect for the fragment developed below for the sake of exposition. The treatment of syntactic features (or its analog) is a relatively underdeveloped aspect of CG syntax literature, as compared to HPSG research (where the whole linguistic theory is built on the basis of a theory/formalism of complex feature structures).

[3] Recognizing PP as a basic type is somewhat non-standard, although there does not seem to be any consensus on what should be regarded as a (reasonably complete) set of basic syntactic types for natural language syntax.

[4] I omit parentheses for a sequence of the same type of slash, for which disambiguation is obvious—for example, A\A\A is an abbreviation for (A\(A\A)).

    b. (NP\S)/NP/NP

    c. (S/(NP\S))\(S/NP)

    d. ((NP\S)\(NP\S))\((NP\S)\(NP\S))

One important feature of CG is that, like HPSG, it lexicalizes the valence (or subcategorization) properties of linguistic expressions. Unlike HPSG, where this is done by a list (or set) valued syntactic feature, in CG, complex syntactic categories directly represent the combinatoric (i.e. valence) properties of lexical items. For example, lexical entries for intransitive and transitive verbs in English will look like the following (semantics is omitted here but will be supplied later):

(7)   a. ran; NP\S

        b. read; (NP\S)/NP

        c. introduces; (NP\S)/PP/NP

(7a) says that the verb *ran* combines with its argument NP *to its left* to become an S. Likewise, (7c) says that *read* first combines with an NP *to its right* and then another NP to its left to become an S.

One point to keep in mind (though it may not seem to make much difference at this point) is that in CG, syntactic rules are thought of as logical rules and the derivations of sentences like (3) as *proofs* of the well-formedness of particular strings as sentences. From this 'logical' point of view, the two slashes should really be thought of as directional variants of implication (that is, both A/B and $B\backslash A$ essentially mean '*if* there is a B, *then* there is an A'), and the two rules of Slash Elimination introduced in (1) should be thought of as directional variants of MODUS PONENS $(B \rightarrow A, B \vdash A)$. This analogy between natural language syntax and logic is emphasized in particular in the TLCG research.

2.3 Syntax-semantics interface in CG

One attractive property of CG as a theory of natural language syntax is its straightforward syntax-semantics interface. In particular, there is a functional mapping from syntactic categories to semantic types.[5] For the sake of exposition, I assume an extensional fragment of Montagovian model-theoretic semantics in what follows, but it should be noted that the CG syntax is mostly neutral to the choice

---

[5]Technically, this is ensured in TLCG by the homomorphism from the syntactic type logic to the semantic type logic (the latter of which is often implicit) and the so-called Curry-Howard correspondence between proofs and terms (van Benthem 1988).

of the specific variant of semantic theory to go with it.[6]

Assuming the standard recursive definition of semantic types as in (8) (with basic types *e* (individuals) and *t* (truth values)), we can define the function Sem that returns, for each syntactic category given as input, its semantic type, as in (9) and (10).

(8) a. BaseSemType := { *e*, *t* }

  b. SemType := BaseSemType | SemType → SemType

(9) (Base Case)

  a. Sem(NP) = Sem(PP) = *e*

  b. Sem(N) = *e* → *t*

  c. Sem(S) = *t*

(10) (Recursive Clause)

  For any complex syntactic category of the form A/B (or $B\backslash A$),

  Sem(A/B) (= Sem($B\backslash A$)) = Sem(B) → Sem(A)

For example, we have Sem(S/(NP\S)) = $(e \rightarrow t) \rightarrow t$ (for subject position quantifier in CCG).

Syntactic rules with semantics can then be written as in (11) (where the semantic effect of these rules is FUNCTION APPLICATION) and a sample derivation with semantic annotation is given in (12).

(11) a. FORWARD SLASH ELIMINATION b. BACKWARD SLASH ELIMINATION

$$\frac{a; \mathcal{F}; A/B \quad b; \mathcal{G}; B}{a \circ b; \mathcal{F(G)}; A} /E \qquad \frac{b; \mathcal{G}; B \quad a; \mathcal{F}; B\backslash A}{b \circ a; \mathcal{F(G)}; A} \backslash E$$

(12)

$$\frac{john; \mathbf{j}; NP \quad \dfrac{loves; \mathbf{love}; (NP\backslash S)/NP \quad mary; \mathbf{m}; NP}{loves \circ mary; \mathbf{love(m)}; NP\backslash S} /E}{john \circ loves \circ mary; \mathbf{love(m)(j)}; S} \backslash E$$

A system of CG with only the Slash Elimination rules like the fragment above is called the AB GRAMMAR, so called because it corresponds to the earliest form of CG formulated by Ajdukiewicz (1935) and Bar-Hillel (1953).

---

[6]See for example Martin (2013) and Bekki & Mineshima (2017) for recent proposals on adopting compositional variants of (hyper)intensional dynamic semantics and proof theoretic semantics, respectively, for the semantic component of CG-based theories of natural language.

2.4 Combinatory Categorial Grammar

2.4.1 An 'ABC' fragment: AB grammar with order-preserving 'combinatory' rules

To do some interesting linguistic analysis, we need some more machinery. I now extend the AB fragment above by adding two types of rules: Type-Raising and (Harmonic) Function Composition. These are a subset of rules typically entertained in CCG. I call the resultant system ABC Grammar (AB + Function Composition).[7] Though it is an impoverished version of CCG, the ABC fragment already enables an interesting and elegant analysis of nonconstituent coordination (NCC), originally due to Steedman (1985) and Dowty (1988), which is essentially identical to the analysis of NCC in the current versions of both CCG and TLCG. I will then discuss the rest of the rules constituting CCG in the next section. The reason for drawing a distinction between the 'ABC' fragment and (proper) CCG is just for the sake of exposition. The rules introduced in the present section have the property that they are all derivable as *theorems* in the (associative) Lambek calculus, the calculus that underlies most variants of TLCG. For this reason, separating the two sets of rules helps clarify the similarities and differences between CCG and TLCG.

The Type Raising and Function Composition rules are defined as in (13) and (14), respectively.

(13) a. Forward Function Composition

$$\frac{a; \mathcal{F}; A/B \quad b; \mathcal{G}; B/C}{a \circ b; \lambda x.\mathcal{F}(\mathcal{G}(x)); A/C} \text{ FC}$$

  b. Backward Function Composition

$$\frac{b; \mathcal{G}; C\backslash B \quad a; \mathcal{F}; B\backslash A}{b \circ a; \lambda x.\mathcal{F}(\mathcal{G}(x)); C\backslash A} \text{ FC}$$

(14) a. Forward Type Raising

$$\frac{a; \mathcal{F}; A}{a; \lambda v.v(\mathcal{F}); B/(A\backslash B)} \text{ TR}$$

  b. Backward Type Raising

$$\frac{a; \mathcal{F}; A}{a; \lambda v.v(\mathcal{F}); (B/A)\backslash B} \text{ TR}$$

The Type-Raising rules are essentially rules of 'type lifting' familiar in the formal semantics literature, except that they specify the 'syntactic effect' of type lifting explicitly (such that the function-argument relation is reversed). Similarly Function Composition rules can be understand as function composition in the usual sense (as in mathematics and functional programming), except, again, that the syntactic effect is explicitly specified.

---

[7]This is not a standard terminology, but giving a name to this fragment is convenient for the purpose of the discussion below.

As noted by Steedman (1985), with Type Raising and Function Composition, we can analyze a string of words such as *John loves* as a constituent of type S/NP, that is, an expression that is looking for an NP to its right to become an S:

(15)

$$\frac{\dfrac{\text{john; } \mathbf{j}; \text{NP}}{\text{john; } \lambda f.f(\mathbf{j}); \text{S}/(\text{NP}\backslash\text{S})}\ \text{TR} \quad \text{loves; } \mathbf{love}; (\text{NP}\backslash\text{S})/\text{NP}}{\text{john} \circ \text{loves; } \lambda x.\mathbf{love}(x)(\mathbf{j}); \text{S}/\text{NP}}\ \text{FC}$$

Assuming generalized conjunction (with the standard definition for the generalized conjunction operator ⊓ *a la* Partee & Rooth (1983) and the polymorphic syntactic category $(X\backslash X)/X$ for *and*), the analysis for a RIGHT-NODE RAISING (RNR) sentence such as (16) is straightforward, as in (17).

(16) John loves, and Bill hates, Mary.

(17)

$$\frac{\begin{array}{cc}\vdots & \dfrac{\begin{array}{cc}\text{and;} & \text{bill}\circ\text{hates;}\\ \sqcap; (X\backslash X)/X & \lambda x.\mathbf{hate}(x)(\mathbf{b}); \text{S}/\text{NP}\end{array}}{\begin{array}{c}\text{and}\circ\text{bill}\circ\text{hates;}\\ \sqcap(\lambda x.\mathbf{hate}(x)(\mathbf{b})); (\text{S}/\text{NP})\backslash(\text{S}/\text{NP})\end{array}}\ \text{FA}\\ \begin{array}{c}\text{john}\circ\text{loves;}\\ \lambda x.\mathbf{love}(x)(\mathbf{j}); \text{S}/\text{NP}\end{array} \end{array}}{\begin{array}{c}\text{john}\circ\text{loves}\circ\text{and}\circ\text{bill}\circ\text{hates; } (\lambda x.\mathbf{love}(x)(\mathbf{j}))\sqcap(\lambda x.\mathbf{hate}(x)(\mathbf{b})); \text{S}/\text{NP}\end{array}}\ \text{FA} \quad \frac{\text{mary;}}{\mathbf{m}; \text{NP}}$$
$$\frac{}{\text{john}\circ\text{loves}\circ\text{and}\circ\text{bill}\circ\text{hates}\circ\text{mary; } \mathbf{love}(\mathbf{m})(\mathbf{j})\wedge\mathbf{hate}(\mathbf{m})(\mathbf{b}); \text{S}}\ \text{FA}$$

Dowty (1988) showed that this analysis extends straightforwardly to the (slightly) more complex case of ARGUMENT CLUSTER COORDINATION (ACC), such as (18), as in (19) (here, VP, TV and DTV are abbreviations of NP\S, (NP\S)/NP, and (NP\S)/NP/NP, respectively).

(18) Mary gave Bill the book and John the record.

(19)

$$\frac{\begin{array}{c}\text{mary;}\\ \mathbf{m};\\ \text{NP}\end{array}\quad \dfrac{\begin{array}{c}\text{gave;}\\ \mathbf{give};\\ \text{DTV}\end{array}\quad \dfrac{\dfrac{\dfrac{\begin{array}{cc}\begin{array}{c}\text{bill;}\\ \mathbf{b}; \text{NP}\end{array} & \\ \hline \begin{array}{c}\text{bill;}\\ \lambda P.P(\mathbf{b});\\ \text{DTV}\backslash\text{TV}\end{array}\end{array}\text{TR}\quad \begin{array}{c}\text{the}\circ\text{book;}\\ \hline \iota(\mathbf{bk}); \text{NP}\\ \hline \begin{array}{c}\text{the}\circ\text{book;}\\ \lambda Q.Q(\iota(\mathbf{bk}));\\ \text{TV}\backslash\text{VP}\end{array}\end{array}\text{TR}}{\begin{array}{c}\text{bill}\circ\text{the}\circ\text{book;}\\ \lambda R.R(\mathbf{b})(\iota(\mathbf{bk})); \text{DTV}\backslash\text{VP}\end{array}}\text{FC}\quad \dfrac{\begin{array}{cc}\text{and;} & \begin{array}{c}\text{john}\circ\text{the}\circ\text{record;}\\ \lambda R.R(\mathbf{j})(\iota(\mathbf{rc}));\\ \text{DTV}\backslash\text{VP}\end{array}\\ \sqcap; & \\ (X\backslash X)/X & \end{array}}{\begin{array}{c}\text{and}\circ\text{john}\circ\text{the}\circ\text{record;}\\ \sqcap(\lambda R.R(\mathbf{j})(\iota(\mathbf{rc})));\\ (\text{DTV}\backslash\text{VP})\backslash(\text{DTV}\backslash\text{VP})\end{array}}}{\begin{array}{c}\text{bill}\circ\text{the}\circ\text{book}\circ\text{and}\circ\text{john}\circ\text{the}\circ\text{record;}\\ \lambda R.R(\mathbf{j})(\iota(\mathbf{rc}))\sqcap\lambda R.R(\mathbf{b})(\iota(\mathbf{bk})); \text{DTV}\backslash\text{VP}\end{array}}}{\begin{array}{c}\text{gave}\circ\text{bill}\circ\text{the}\circ\text{book}\circ\text{and}\circ\text{john}\circ\text{the}\circ\text{record;}\\ \mathbf{give}(\mathbf{j})(\iota(\mathbf{rc}))\sqcap\mathbf{give}(\mathbf{b})(\iota(\mathbf{bk})); \text{VP}\end{array}}}{\begin{array}{c}\text{mary}\circ\text{gave}\circ\text{bill}\circ\text{the}\circ\text{book}\circ\text{and}\circ\text{john}\circ\text{the}\circ\text{record;}\\ \mathbf{give}(\mathbf{j})(\iota(\mathbf{rc}))(\mathbf{m})\wedge\mathbf{give}(\mathbf{b})(\iota(\mathbf{bk}))(\mathbf{m}); \text{S}\end{array}}$$

Here, by Type Raising, the indirect and direct objects become functions that can be combined via Function Composition, to form a non-standard constituent that can then be coordinated. After two such expressions are conjoined, the verb is fed as an argument to return a VP. Intuitively, the idea behind this analysis is that *Bill the book* is of type DTV\VP since if it were to combine with an actual ditransitive verb (such as *gave*), we would obtain a VP (*gave Bill a book*). Note that in both the RNR and ACC examples above, the right semantic interpretation for the whole sentence is assigned compositionally via the rules given above in (13) and (14).

2.4.2 From ABC to CCG

CCG is a version of CG developed by Mark Steedman since the 1980s with extensive linguistic application. The best sources for CCG are the three books by Steedman (Steedman 1997; 2000; Steedman 2012), which present treatments of major linguistic phenomena in CCG, and gives pointers to earlier literature. CCG is essentially a rule-based extension of the AB grammar. We have already seen in the previous section the two key components that constitute this extension: Type Raising and (Harmonic) Function Composition.[8] There are aspects of natural language syntax that cannot be handled adequately in this simple system, and in such situations, CCG makes (restricted) use of additional rules. This point can be illustrated nicely with two issues that arise in connection with the analysis of long-distance dependencies.

The basic idea behind the CCG analysis of long-distance dependencies, due originally to Ades & Steedman (1982), is very simple and is similar in spirit to the HPSG analysis in terms of SLASH feature percolation (see Chapter 14 for the treatment of long-distance dependencies in HPSG). Specifically, CCG analyzes extraction dependencies via a chain of function composition, as illustrated by the derivation for (20) in (21).

(20)   This is the book that John thought that Mary read __.

---

[8]There is actually a subtle point about Type Raising rules. Recent versions of CCG (Steedman 2012) do not take them to be syntactic rules but rather assume that Type Raising is an operation in the lexicon. This choice seems to be motivated by parsing considerations (so as to eliminate as many unary rules as possible from the syntax). It is also worth noting in this connection that the CCG-based syntactic fragment that Jacobson (1999; 2000) assumes for her Variable-Free Semantics is actually a quite different system from Steedman's version of CCG in that it crucially assumes Geach rules, another type of unary rules likely to have similar computational consequences as Type-Raising rules, in the syntactic component.

(21)

$$
\begin{array}{c}
\text{that} \circ \text{john} \circ \text{thought} \circ \text{that} \circ \text{mary} \circ \text{read}; \\
\lambda Q \lambda x. Q(x) \wedge \mathbf{think}(\mathbf{read}(x)(\mathbf{m}))(\mathbf{j}); \text{N} \backslash \text{N}
\end{array}
$$

Derivation tree for (21):

- mary; $\mathbf{m}$; NP — TR
- mary; $\lambda P.P(\mathbf{m})$; S/(NP\S)
- read; $\mathbf{read}$; (NP\S)/NP
- mary ∘ read; $\lambda x.\mathbf{read}(x)(\mathbf{m})$; S/NP — FC
- that; $\lambda p.p$; S′/S
- that ∘ mary ∘ read; $\lambda x.\mathbf{read}(x)(\mathbf{m})$; S′/S — FC
- john; $\mathbf{j}$; NP — TR
- john; $\lambda P.P(\mathbf{j})$; S/(NP\S)
- thought; $\mathbf{think}$; (NP\S)/S′
- thought ∘ that ∘ mary ∘ read; $\lambda x.\mathbf{think}(\mathbf{read}(x)(\mathbf{m}))$; (NP\S)/NP — FC
- john ∘ thought ∘ that ∘ mary ∘ read; $\lambda x.\mathbf{think}(\mathbf{read}(x)(\mathbf{m}))(\mathbf{j})$; S/NP — FC
- that; $\lambda P \lambda Q \lambda x. Q(x) \wedge P(x)$; (N\N)/(S/NP)
- that ∘ john ∘ thought ∘ that ∘ mary ∘ read; $\lambda Q \lambda x. Q(x) \wedge \mathbf{think}(\mathbf{read}(x)(\mathbf{m}))(\mathbf{j})$; N\N — FA

Like (many versions of) HPSG, CCG does not assume any empty expression at the gap site. Instead, the information that the subexpressions (constituting extraction pathway) such as *Mary read* and *thought that Mary read* are missing an NP on the right edge is encoded in the syntactic category of the linguistic expression. *Mary read* is assigned the type S/NP since it is a sentence missing an NP on its right edge. *thought that Mary read* is of type VP/NP since it is a VP missing an NP on its right edge, etc. Expressions that are not originally functions (such as the subject NPs in the higher and lower clauses inside the relative clause in (20)) are first type-raised. Then, function composition effectively 'delays' the saturation of the object NP argument of the embedded verb, until the whole relative clause meets the relative pronoun, which itself is a higher-order function that takes a sentence missing an NP (of type S/NP) as an argument.

The successive passing of the /NP specification to larger structures is essentially analogous to the treatment of extraction via the SLASH feature in HPSG. However, unlike HPSG, which has a dedicated feature that handles this information passing, CCG achieves the effect via the ordinary slash that is also used for local syntactic composition.[9]

This difference immediately raises some issues for the CCG analysis of extraction. First, in (20), the NP gap happens to be on the right edge of the sentence, but this is not always the case. Harmonic function composition alone cannot handle non-peripheral extraction of the sort found in examples such as the following:

---

[9]There are several complications that arise in the CCG analysis because of this architectural difference, which I discuss immediately below. But one interesting consequence of the CCG approach is that the quite complex set of specifications of SLASH feature percolation (including the *termination* of percolation) are all unnecessary in CCG.

(22)   This is the book that John thought that [Mary read __ at school].

Assuming that *at school* is a VP modifier of type (NP\S)\(NP\S), what is needed here is a mechanism that assigns the type VP/NP to the string *read __ at school*, despite the fact that the missing NP is not on the right edge. CCG employs a special rule of 'crossed' function composition for this purpose, defined as follows:

(23)   Crossed Function Composition

$$\frac{a;\, \boldsymbol{G};\, A/B \qquad b;\, \mathcal{F};\, A\backslash C}{a \circ b;\, \lambda x.\mathcal{F}(\boldsymbol{G}(x));\, C/B}\ \text{xFC}$$

Unlike its harmonic counterpart (in which a has the type $B\backslash A$), in (23) the directionality of the slash is different in the two premises, and the resultant category inherits the slash originally associated with the inherited argument (i.e. $/B$).

Once this non-order-preserving version of function composition is introduced in the grammar, the derivation for (22) is straightforward, as in (24):

(24)

$$\frac{\dfrac{\text{mary};\, \mathbf{m};\, \text{NP}}{\begin{array}{c}\text{mary};\\ \lambda P.P(\mathbf{m});\\ \text{S}/(\text{NP}\backslash\text{S})\end{array}}\ \text{TR} \qquad \dfrac{\text{read};\ \dfrac{}{\mathbf{read};\, (\text{NP}\backslash\text{S})/\text{NP}} \qquad \dfrac{\text{at} \circ \text{school};}{\mathbf{at\text{-}school};\, (\text{NP}\backslash\text{S})\backslash(\text{NP}\backslash\text{S})}}{\text{read} \circ \text{at} \circ \text{school};\, \lambda x.\mathbf{at\text{-}school}(\mathbf{read}(x));\, (\text{NP}\backslash\text{S})/\text{NP}}\ \text{xFC}}{\text{mary} \circ \text{read} \circ \text{at} \circ \text{school};\, \lambda x.\mathbf{at\text{-}school}(\mathbf{read}(x))(\mathbf{m});\, \text{S}/\text{NP}}\ \text{FC}$$

Unless appropriately constrained, the addition of the crossed composition rule leads to potential overgeneration, since non-extracted expressions cannot change word order so freely in English. For example, without additional restrictions, the simple CCG fragment above overgenerates examples such as the following:

(25)   *Mary read at school it.

Here, I will not go into the technical details of how this issue is addressed in the CCG literature.[10] In contemporary versions of CCG, the application of special rules such as crossed composition in (23) is regulated by the notion of 'structural control' borrowed into CCG from the 'multi-modal' variant of TLCG (see Baldridge (2002) and Steedman & Baldridge (2011)).

Another issue that arises in connection to extraction is how to treat multiple gaps corresponding to a single filler. The simple fragment developed above cannot license examples involving PARASITIC GAPS such as the following:[11]

---

[10]The word order in (25) is of course fine in examples instantiating Heavy NP Shift.

[11]Multiple gaps in coordination (i.e. ATB extraction) is not an issue, since these cases can be handled straightforwardly via the polymorphic definition of generalized conjunction in CCG, in just the same way that unsaturated shared arguments in each conjunct are identified with one another.

(26)   a. This is the article that I filed __ without reading __.

        b. Peter is a guy who even the best friends of __ think __ should be closely watched.

Since neither type raising nor function composition changes the number of 'gaps' passed on to a larger expression, we need a new mechanism here. Steedman (1987) proposes the following rule to deal with this issue:

(27)   Substitution

$$\frac{a; \mathcal{G}; A/B \qquad b; \mathcal{F}; (A\backslash C)/B}{a \circ b; \lambda x.\mathcal{F}(x)(\mathcal{G}(x)); C/B} \text{ S}$$

This rule has the effect of 'collapsing' the arguments of the two inputs into one, to be saturated by a single filler. The derivation for the adjunct parasitic gap example in (26a) then goes as follows (where VP is an abbreviation for NP\S):

(28)

$$\frac{\text{filed};\ \mathbf{file}; VP/NP \qquad \dfrac{\dfrac{\text{without};\ \mathbf{wo}; (VP\backslash VP)/VP \qquad \text{reading};\ \mathbf{read}; VP/NP}{\text{without} \circ \text{reading};\ \lambda x.\mathbf{wo}(\mathbf{read}(x)); (VP\backslash VP)/NP}\ \text{FC}}{}}{\text{filed} \circ \text{without} \circ \text{reading};\ \lambda x.\mathbf{wo}(\mathbf{read}(x))(\mathbf{file}(x)); VP/NP}\ \text{S}$$

Like the crossed composition rule, the availability of the substitution rule should be restricted to extraction environments. In earlier versions of CCG, this was done by a stipulation on the rule itself. Baldridge (2002) proposed an improvement of the organization of the CCG rule system in which the applicability of particular rules is governed by lexically specified 'modality' encodings. See Steedman & Baldridge (2011) for this relatively recent development in CCG.

2.5 Type-Logical Categorial Grammar

The 'rule-based' nature of CCG should be clear from the above exposition. TLCG takes a somewhat different perspective on the underlying architecture of the grammar of natural language. Specifically, in TLCG, the rule system of grammar is literally taken to be a kind of logic. Consequently, all (or almost all) grammar rules are logical inference rules reflecting the properties of (typically a small number of) logical connectives such as / and \ (which are, as noted in section 2.2, viewed as directional variants of implication). This conceptual shift can be best illustrated by first replacing the ABC grammar introduced in section 2.4.1

by the Lambek calculus, where all the rules posited as primitive rules in the former are derived as *theorems* (in the technical sense of the term) in the latter.

Before moving on, I should hasten to note that the TLCG literature is more varied than the CCG literature, consisting of several related but distinct lines of research. I choose to present one particular variant called Hybrid Type-Logical Categorial Grammar (Kubota & Levine 2020) in what follows, in line with the present chapter's linguistic emphasis (for a more in-depth discussion on the linguistic application of TLCG, see Carpenter (1998) and Kubota & Levine (2020)). A brief comparison with major alternatives is offered in section 2.5.3. Other variants of TLCG, most notably, the Categorial Type Logics (Moortgat 2011) and Displacement Calculus (Morrill 2010) emphasize the logical and computational aspects. Moot & Retoré (2012) is a good introduction to TLCG with emphasis on these latter aspects.

2.5.1 The Lambek calculus

In addition to the Slash Elimination rules (reproduced here as (29)), which are identical to the two rules in the AB grammar from section 2.2, the Lambek calculus posits the Slash Introduction rules, which can be written in the current labelled deduction format as in (30).[12]

(29)   a.   Forward Slash Elimination

$$\frac{a; \mathcal{F}; A/B \qquad b; \mathcal{G}; B}{a \circ b; \mathcal{F}(\mathcal{G}); A} \text{ /E}$$

b.   Backward Slash Elimination

$$\frac{b; \mathcal{G}; B \qquad a; \mathcal{F}; B\backslash A}{b \circ a; \mathcal{F}(\mathcal{G}); A} \text{ \textbackslash E}$$

(30)   a.   Forward Slash Introduction

$$\frac{\begin{array}{ccc} \vdots & [\varphi; x; A]^n & \vdots \\ \vdots & \vdots & \vdots \\ \hline & b \circ \varphi; \mathcal{F}; B & \end{array}}{b; \lambda x.\mathcal{F}; B/A} \text{ /I}^n$$

b.   Backward Slash Introduction

$$\frac{\begin{array}{ccc} \vdots & [\varphi; x; A]^n & \vdots \\ \vdots & \vdots & \vdots \\ \hline & \varphi \circ b; \mathcal{F}; B & \end{array}}{b; \lambda x.\mathcal{F}; A\backslash B} \text{ \textbackslash I}^n$$

I illustrate the workings of these rules in some examples first and then come back to some formal and notational issues. One consequence that immediately follows is that Type Raising and Function Composition (as well as other theorems; see, e.g., Jäger (2005: sec 2.2.5, pp. 46–)) are now derivable as theorems. As an illustration, the proofs for (14a) and (13a) are shown in (31) and (32), respectively.

---

[12]Morrill (1994) was the first to recast the Lambek calculus in this labelled deduction format.

(31)
$$\frac{\dfrac{[\varphi; v; A\backslash B]^1 \qquad a; \mathcal{F}; A}{a \circ \varphi; v(\mathcal{F}); B} \backslash \text{E}}{a; \lambda v.v(\mathcal{F}); B/(A\backslash B)} /\text{I}^1$$

(32)
$$\frac{\dfrac{a; \mathcal{F}; A/B \qquad \dfrac{[\varphi; x; C]^1 \qquad b; \mathcal{G}; B/C}{b \circ \varphi; \mathcal{G}(x); B} /\text{E}}{a \circ b \circ \varphi; \mathcal{F}(\mathcal{G}(x)); A} /\text{E}}{a \circ b; \lambda x.\mathcal{F}(\mathcal{G}(x)); A/C} /\text{I}^1$$

These are formal theorems, but they intuitively make sense. For example, what's going on in (32) is simple. We first hypothetically assume the existence of some expression of type C and combine it with B/C. This gives us a larger expression of type B, which then can be fed as an argument to A/B. At that point, we withdraw the initial hypothesis and conclude that what we really had was just something that would become an A *if* there is a C to its right, namely, an expression of type A/C. Thus, a sequence of expression of types A/B and B/C is proven to be of type A/C. This type of proof is known as HYPOTHETICAL REASONING, since it involves a step of positing a hypothesis initially and withdrawing that hypothesis at a later point.

Getting back to some notational issues, there are two crucial things to keep in mind about the notational convention adopted here (which I implicitly assumed above). First, the connective $\circ$ in the prosodic component designates string concatenation and is associative in both directions (i.e. $(\varphi_1 \circ \varphi_2) \circ \varphi_3 \equiv \varphi_1 \circ (\varphi_2 \circ \varphi_3)$). In other words, hierarchical structure is irrelevant for the prosodic representation. Thus, the applicability condition on the Forward Slash Introduction rule (30a) is simply that the prosodic variable φ of the hypothesis appear as the rightmost element of the string prosody of the input expression (i.e. $b \circ \varphi$). Since the penultimate step in (32) satisfies this condition, the rule is applicable here. Second, note in this connection that the application of the Introduction rules is conditioned on the position of the prosodic variable, and *not* on the position of the hypothesis itself in the proof tree (this latter convention is more standardly adopted when the Lambek calculus is presented in Prawitz-style natural deduction, though the two presentations are equivalent—see, e.g., Carpenter (1998) and Jäger (2005)).

Hypothetical reasoning with Slash Introduction makes it possible to recast the CCG analysis of nonconstituent coordination from section 2.4.1 within the logic of / and \. This reformulation fully retains the essential analytic ideas of the original CCG analysis but makes the underlying 'logic' of syntactic composition more transparent.

The following derivation illustrates how the 'reanalysis' of the string *Bill the book* as a derived constituent of type (VP/NP/NP)\VP (the same type as in (19)) can be obtained in the Lambek calculus:

(33)

$$\cfrac{\cfrac{[\varphi; f; \mathrm{VP/NP/NP}]^1 \quad \mathrm{bill}; \mathbf{b}; \mathrm{NP}}{\varphi \circ \mathrm{bill}; f(\mathbf{b}); \mathrm{VP/NP}} \mathrm{/E} \quad \mathrm{the} \circ \mathrm{book}; \iota(\mathbf{bk}); \mathrm{NP}}{\cfrac{\varphi \circ \mathrm{bill} \circ \mathrm{the} \circ \mathrm{book}; f(\mathbf{b})(\iota(\mathbf{bk})); \mathrm{VP}}{\mathrm{bill} \circ \mathrm{the} \circ \mathrm{book}; \lambda f.f(\mathbf{b})(\iota(\mathbf{bk})); (\mathrm{VP/NP/NP})\backslash\mathrm{VP}} \backslash \mathrm{I}^1} \mathrm{/E}$$

At this point, one may wonder what the relationship is between the analysis of nonconstituent coordination via Type Raising and Function Composition in the ABC grammar in section 2.4.1 and the hypothetical reasoning-based analysis in the Lambek calculus just presented. Intuitively, they seem to achieve the same effect in slightly different ways. The logic-based perspective of TLCG allows us to obtain a deeper understanding of the relationship between them. To facilitate comparison, I first recast the Type Raising + Function Composition analysis from section 2.4.1 in the Lambek calculus. The relevant part is the part that derives the 'noncanonical constituent' *Bill the book*:

(34)

$$\cfrac{\cfrac{[\varphi_3; R; \mathrm{DTV}]^3 \quad \cfrac{\cfrac{[\varphi_2; P; \mathrm{DTV}]^2 \quad \mathrm{bill}; \mathbf{b}; \mathrm{NP}}{\varphi_2 \circ \mathrm{bill}; P(\mathbf{b}); \mathrm{TV}} \mathrm{/E}}{\mathrm{bill}; \lambda P.P(\mathbf{b}); \mathrm{DTV}\backslash\mathrm{TV}} \backslash \mathrm{I}^2}{\varphi_3 \circ \mathrm{bill}; R(\mathbf{b}); \mathrm{TV}} \backslash \mathrm{E} \quad \cfrac{\cfrac{[\varphi_1; Q; \mathrm{TV}]^1 \quad \mathrm{the} \circ \mathrm{book}; \iota(\mathbf{bk}); \mathrm{NP}}{\varphi_1 \circ \mathrm{the} \circ \mathrm{book}; Q(\iota(\mathbf{bk})); \mathrm{VP}} \mathrm{/E}}{\mathrm{the} \circ \mathrm{book}; \lambda Q.Q(\iota(\mathbf{bk})); \mathrm{TV}\backslash\mathrm{VP}} \backslash \mathrm{I}^1}{\cfrac{\varphi_3 \circ \mathrm{bill} \circ \mathrm{the} \circ \mathrm{book}; R(\mathbf{b})(\iota(\mathbf{bk})); \mathrm{VP}}{\mathrm{bill} \circ \mathrm{the} \circ \mathrm{book}; \lambda R.R(\mathbf{b})(\iota(\mathbf{bk})); \mathrm{DTV}\backslash\mathrm{VP}} \backslash \mathrm{I}^3} \backslash \mathrm{E}$$

By comparing (34) and (33), we see that (34) contains some redundant steps. First, hypothesis 2 is introduced only to be replaced by hypothesis 3. This is completely redundant since we could have obtained exactly the same result by directly combining hypothesis 3 with the NP *Bill*. Similarly, hypothesis 1 can be eliminated by replacing it with the TV $\varphi_3 \circ \mathrm{book}$ on the left-hand side of the third line from the bottom. By making these two simplifications, we obtain the derivation in (33).

The relationship between the more complex proof in (34) and the simpler one in (33) is parallel to the relationship between an unreduced lambda term (such as $\lambda R[\lambda Q[Q(\iota(\mathbf{bk}))](\lambda P[P(\mathbf{b})](R))])$) and its β-normal form (i.e. $\lambda R.R(\mathbf{b})(\iota(\mathbf{bk}))$). In fact, there is a formally precise one-to-one relationship between linear logic (of which the Lambek calculus is known to be a straightforward extension) and the typed lambda calculus known as the Curry-Howard Isomorphism (Howard 1969), according to which the lambda term that represents the proof (34) β-reduces to the term that represents the proof (33).[13] Technically, this is known as PROOF

---

[13]There is a close relationship between these lambda terms representing proofs and the lambda terms that we write to notate semantic translations, especially if we write the latter at each step of derivation *without* performing β-reduction. But it is important to keep in mind that

NORMALIZATION (Jäger (2005) contains a particularly useful discussion on this notion).

Thus, the logic-based architecture of the Lambek calculus (and various versions of TLCG, which are all extensions of the Lambek calculus) enables us to say, in a technically precise way, how (34) and (33) are the 'same' (or, more precisely, equivalent), by building on independently established results in mathematical logic and computer science. This is one big advantage of taking seriously the view, advocated by the TLCG research, that 'language *is* logic'.

2.5.2 Extending the Lambek calculus

Hypothetical reasoning is a very powerful (yet systematic) tool, but with forward and backward slashes, it is only good for analyzing expressions missing some material at the (right or left) periphery. This is problematic in the analyses of many linguistic phenomena, such as *wh*-extraction (where the 'gap' can be in a sentence-medial position—recall the discussion about crossed composition rules in CCG in section 2.4.2) and quantifier scope (where the quantifier needs to 'covertly' move from a sentence-medial position), as well as various kinds of discontinuous constituency phenomena (see for example Morrill et al. (2011), which contains analyses of various types of discontinuous constituency phenomena in a recent version of TLCG known as 'Displacement Calculus'). In what follows, I sketch one particular, relatively recent approach to this problem, known as HYBRID TYPE-LOGICAL CATEGORIAL GRAMMAR (Hybrid TLCG; Kubota 2010; 2015; Kubota & Levine 2015; 2020). This approach combines the Lambek calculus with Oehrle's (1994) term-labelled calculus, which deals with discontinuity by employing λ-binding in the prosodic component.

Hybrid TLCG extends the Lambek calculus with the Elimination and Introduction rules for the VERTICAL SLASH:

(35)   a. VERTICAL SLASH INTRODUCTION

$$\frac{\begin{array}{ccc} \vdots & \underline{[\varphi; x; A]^n} & \vdots \\ \vdots & \vdots & \vdots \\ & b; \mathcal{F}; B & \end{array}}{\lambda\varphi.b; \lambda x.\mathcal{F}; B{\upharpoonright}A} {\upharpoonright}I^n$$

b. VERTICAL SLASH ELIMINATION

$$\frac{a; \mathcal{F}; A{\upharpoonright}B \quad b; \mathcal{G}; B}{a(b); \mathcal{F}(\mathcal{G}); A} {\upharpoonright}E$$

These rules allow us to model what (roughly) corresponds to syntactic movement

---

lambda terms representing syntactic proofs and lambda terms notating semantic translations are distinct things.

operations in derivational frameworks. This is illustrated in (36) for the $\forall > \exists$ reading for the sentence *Someone talked to everyone today*:

(36)

$$
\cfrac{
\cfrac{
\cfrac{
\cfrac{
\cfrac{
\cfrac{
\begin{array}{c}
\text{talked} \circ \text{to;} \\
\textbf{talked-to;} \\
\text{(NP\textbackslash S)/NP}
\end{array}
\quad
\left[
\begin{array}{c}
\varphi_1; \\
x_1; \\
\text{NP}
\end{array}
\right]^1
}{
\begin{array}{c}
\text{talked} \circ \text{to} \circ \varphi_1; \\
\textbf{talked-to}(x_1); \text{NP\textbackslash S}
\end{array}
}\, {}_{/\text{E}}
}{}
}{}
}{}
}{}
}{}
$$

someone $\circ$ talked $\circ$ to $\circ$ everyone $\circ$ today;
$\mathbf{V}_{\text{person}}(\lambda x_1.\mathbf{\exists}_{\text{person}}(\lambda x_2.\textbf{tdy}(\textbf{talked-to}(x_1)(x_2)))); \text{S}$

$$\frac{\begin{array}{c}\text{talked}\circ\text{to};\\\textbf{talked-to};\\(\text{NP}\backslash\text{S})/\text{NP}\end{array}\quad\left[\begin{array}{c}\varphi_1;\\x_1;\\\text{NP}\end{array}\right]^1}{\begin{array}{c}\text{talked}\circ\text{to}\circ\varphi_1;\\\textbf{talked-to}(x_1);\text{NP}\backslash\text{S}\end{array}}\,_{/\text{E}}$$

with $\left[\begin{array}{c}\varphi_2;\\x_2;\\\text{NP}\end{array}\right]^2$:

$$\frac{\begin{array}{c}\varphi_2\circ\text{talked}\circ\text{to}\circ\varphi_1;\\\textbf{talked-to}(x_1)(x_2);\text{S}\end{array}\quad\begin{array}{c}\text{today};\\\textbf{tdy};\\\text{S}\backslash\text{S}\end{array}}{\begin{array}{c}\varphi_2\circ\text{talked}\circ\text{to}\circ\varphi_1\circ\text{today};\\\textbf{tdy}(\textbf{talked-to}(x_1)(x_2));\text{S}\end{array}}\,_{\backslash\text{E}}$$

① $\quad \dfrac{}{\begin{array}{c}\lambda\varphi_2.\varphi_2\circ\text{talked}\circ\text{to}\circ\varphi_1\circ\text{today};\\\lambda x_2.\textbf{tdy}(\textbf{talked-to}(x_1)(x_2));\text{S}\!\upharpoonright\!\text{NP}\end{array}}\,_{\upharpoonright\text{I}^2}$

② with $\begin{array}{c}\lambda\sigma.\sigma(\text{someone});\\\mathbf{\exists}_{\text{person}};\\\text{S}\!\upharpoonright\!(\text{S}\!\upharpoonright\!\text{NP})\end{array}$:

$$\dfrac{\begin{array}{c}\text{someone}\circ\text{talked}\circ\text{to}\circ\varphi_1\circ\text{today};\\\mathbf{\exists}_{\text{person}}(\lambda x_2.\textbf{tdy}(\textbf{talked-to}(x_1)(x_2)));\text{S}\end{array}}{\begin{array}{c}\lambda\varphi_1.\text{Someone}\circ\text{talked}\circ\text{to}\circ\varphi_1\circ\text{today};\\\lambda x_1.\mathbf{\exists}_{\text{person}}(\lambda x_2.\textbf{tdy}(\textbf{talked-to}(x_1)(x_2)));\text{S}\!\upharpoonright\!\text{NP}\end{array}}\,_{\upharpoonright\text{I}^1}$$

with $\begin{array}{c}\lambda\sigma.\sigma(\text{everyone});\\\mathbf{V}_{\text{person}};\\\text{S}\!\upharpoonright\!(\text{S}\!\upharpoonright\!\text{NP})\end{array}$, by $_{\upharpoonright\text{E}}$:

someone $\circ$ talked $\circ$ to $\circ$ everyone $\circ$ today;
$\mathbf{V}_{\text{person}}(\lambda x_1.\mathbf{\exists}_{\text{person}}(\lambda x_2.\textbf{tdy}(\textbf{talked-to}(x_1)(x_2))));\text{S}$

A quantifier has the ordinary GQ meaning ($\mathbf{\exists}_{\text{person}}$ and $\mathbf{V}_{\text{person}}$ abbreviate the terms $\lambda P.\exists x[\textbf{person}(x) \wedge P(x)]$ and $\lambda P.\forall x[\textbf{person}(x) \rightarrow P(x)]$, respectively), but its phonology is a function of type $(\textbf{st} \rightarrow \textbf{st}) \rightarrow \textbf{st}$ (where $\textbf{st}$ is the type of strings). By abstracting over the position in which the quantifier 'lowers into' in an S via the Vertical Slash Introduction rule (35a), we can obtain an expression of type $\text{S}\!\upharpoonright\!\text{NP}$ (phonologically $\textbf{st} \rightarrow \textbf{st}$) (①), which can be given as an argument to the quantifier. Then, by function application via $\upharpoonright$E (②), the subject quantifier *someone* semantically scopes over the sentence and lowers its phonology to the 'gap' position kept track of by λ-binding in phonology (note that this result obtains by function application and beta-reduction of the prosodic term). The same process takes place for the object quantifier *everyone* to complete the derivation. The scopal relation between multiple quantifiers depends on the order of application of this hypothetical reasoning. The surface scope reading is obtained by switching the order of the hypothetical reasoning for the two quantifiers (which results in the same string of words, but with the opposite scope relation).

This formalization of quantifying-in by Oehrle (1994) has later been extended by Barker (2007) for more complex types of scope-taking phenomena known as parasitic scope in the analysis of symmetrical predicates (such as *same* and

different).[14] Empirical application of parasitic scope include 'respective' readings (Kubota & Levine 2016b), 'split scope' of negative quantifiers (Kubota & Levine 2016a) and modified numerals such as *exactly N* (Pollard 2014).

Hypothetical reasoning with prosodic λ-binding enables a simple analysis of *wh* extraction too, as originally noted by Muskens (2003). The key idea is that sentences with medial gaps can be analyzed as expressions of type $S{\upharpoonright}NP$, as in the derivation for (37) in (38).

(37) Bagels$_i$, Kim gave t_i to Chris.

(38)

Here, after deriving an $S{\upharpoonright}NP$, which keeps track of the gap position via the λ-bound variable φ, the topicalization operator fills in the gap with an empty string and concatenates the topicalized NP to the left of the string thus obtained. This way, the difference between 'overt' and 'covert' movement reduces to a lexical difference in the prosodic specifications of the operators that induce them. A covert movement operator throws in some material in the gap position, whereas an overt movement operator 'closes off' the gap with an empty string.

As illustrated above, hypothetical reasoning for the Lambek slashes / and \ and for the vertical slash $\upharpoonright$ have important empirical motivations, but the real strength of a 'hybrid' system like Hybrid TLCG which recognizes both types of slashes is that it extends automatically to cases in which 'directional' and 'non-directional' phenomena interact. A case in point comes from the interaction of nonconstituent coordination and quantifier scope. Examples such as those in

---

[14]'Parasitic scope' is a notion coined by Barker (2007) where, in transformational terms, some expression takes scope at LF by parasitizing on the scope created by a different scopal operator's LF movement. In versions of (TL)CG of the sort discussed here, this corresponds to double lambda-abstraction via the order-insensitive slash.

(39) allow for at least a reading in which the shared quantifier outscopes conjunction.[15]

(39) a. I gave a couple of books to Pat on Monday and to Sandy on Tuesday.

  b. Terry said nothing to Robin on Thursday or to Leslie on Friday.

I now illustrate how this wide scope reading for the quantifier in NCC sentences like (39) is immediately predicted to be available in the fragment developed so far (Hybrid TLCG actually predicts both scopal relations for all NCC sentences; see Kubota & Levine (2015) for how the distributive scope is licensed). The derivation for (39b) is given in (40).

(40)
$$\cfrac{\cfrac{\cfrac{\cfrac{[\varphi_1; P; \text{VP/PP/NP}]^1 \quad [\varphi_2; x; \text{NP}]^2}{\varphi_1 \circ \varphi_2; P(x); \text{VP/PP}} /\text{E} \quad \begin{array}{c}\text{to} \circ \text{robin};\\ \mathbf{r}; \text{PP}\end{array}}{\varphi_1 \circ \varphi_2 \circ \text{to} \circ \text{robin}; P(x)(\mathbf{r}); \text{VP}} /\text{E} \quad \begin{array}{c}\text{on} \circ \text{thursday};\\ \mathbf{onTh}; \text{VP}\backslash\text{VP}\end{array}}{\varphi_1 \circ \varphi_2 \circ \text{to} \circ \text{robin} \circ \text{on} \circ \text{thursday}; \mathbf{onTh}(P(x)(\mathbf{r})); \text{VP}} \backslash\text{E}}{\varphi_2 \circ \text{to} \circ \text{robin} \circ \text{on} \circ \text{thursday}; \lambda P.\mathbf{onTh}(P(x)(\mathbf{r})); (\text{VP/PP/NP})\backslash\text{VP}} \backslash\text{I}^1}{\text{to} \circ \text{robin} \circ \text{on} \circ \text{thursday}; \lambda x\lambda P.\mathbf{onTh}(P(x)(\mathbf{r})); \text{NP}\backslash(\text{VP/PP/NP})\backslash\text{VP}} \backslash\text{I}^2$$

$$\cfrac{\begin{array}{cc} \begin{array}{c}\vdots\\[4pt]\text{to} \circ \text{robin} \circ \text{on} \circ \text{thursday};\\ \lambda x\lambda P.\mathbf{onTh}(P(x)(\mathbf{r}));\\ \text{NP}\backslash(\text{VP/PP/NP})\backslash\text{VP}\end{array} & \cfrac{\begin{array}{c}\text{or};\\ \lambda\mathcal{V}\lambda\mathcal{W}.\mathcal{W} \sqcup \mathcal{V};\\ (X\backslash X)/X\end{array} \quad \begin{array}{c}\vdots\\[4pt]\text{to} \circ \text{leslie} \circ \text{on} \circ \text{friday};\\ \lambda x\lambda P.\mathbf{onFr}(P(x)(\mathbf{l}));\\ \text{NP}\backslash(\text{VP/PP/NP})\backslash\text{VP}\end{array}}{\begin{array}{c}\text{or} \circ \text{to} \circ \text{leslie} \circ \text{on} \circ \text{friday};\\ \lambda\mathcal{W}.\mathcal{W} \sqcup [\lambda x\lambda P.\mathbf{onFr}(P(x)(\mathbf{l}))];\\ (\text{NP}\backslash(\text{VP/PP/NP})\backslash\text{VP})\backslash(\text{NP}\backslash(\text{VP/PP/NP})\backslash\text{VP})\end{array}} /\text{E} \end{array}}{\begin{array}{c}\text{to} \circ \text{robin} \circ \text{on} \circ \text{thursday} \circ \text{or} \circ \text{to} \circ \text{leslie} \circ \text{on} \circ \text{friday};\\ \lambda x\lambda P\lambda z.\mathbf{onTh}(P(x)(\mathbf{r}))(z) \vee \mathbf{onFr}(P(x)(\mathbf{l}))(z); \text{NP}\backslash(\text{VP/PP/NP})\backslash\text{VP}\end{array}} \backslash\text{E}$$

---

[15]Whether the other scopal relation (one in which the quantifier meaning is 'distributed' to each conjunct, as in the paraphrase 'I gave a couple of books to Pat on Monday and I gave a couple of books to Sandy on Tuesday' for (39)) is possible seems to depend on various factors. With downward-entailing quantifiers such as (39b), this reading seems difficult to obtain without heavy contextualization and appropriate intonational cues. See Kubota & Levine (2015) for some discussion.

$$\vdots$$

$$\text{to} \circ \text{robin} \circ \text{on} \circ \text{thursday} \circ$$
$$\text{or} \circ \text{to} \circ \text{leslie} \circ \text{on} \circ \text{friday};$$
$$\lambda x \lambda P \lambda z.\mathbf{onTh}(P(x)(\mathbf{r}))(z) \vee$$
$$\begin{bmatrix} \varphi_3; \\ x; \mathrm{NP} \end{bmatrix}^3 \qquad \mathbf{onFr}(P(x)(\mathbf{l}))(z);$$
$$\mathrm{NP} \backslash (\mathrm{VP}/\mathrm{PP}/\mathrm{NP}) \backslash \mathrm{VP}$$

$$\frac{}{} \backslash \mathrm{E}$$

$$\varphi_3 \circ \text{to} \circ \text{robin} \circ \text{on} \circ \text{thursday} \circ$$
$$\text{or} \circ \text{to} \circ \text{leslie} \circ \text{on} \circ \text{friday};$$
said; $\qquad \lambda P \lambda z.\mathbf{onTh}(P(x)(\mathbf{r}))(z) \vee$
said; $\qquad \mathbf{onFr}(P(x)(\mathbf{l}))(z);$
VP/NP/PP $\qquad (\mathrm{VP}/\mathrm{PP}/\mathrm{NP}) \backslash \mathrm{VP}$

$$\backslash \mathrm{E}$$

said $\circ \varphi_3 \circ$ to $\circ$ robin $\circ$ on $\circ$ thursday $\circ$
or $\circ$ to $\circ$ leslie $\circ$ on $\circ$ friday;
terry; $\qquad \lambda z.\mathbf{onTh}(\mathbf{said}(x)(\mathbf{r}))(z) \vee \mathbf{onFr}(\mathbf{said}(x)(\mathbf{l}))(z); \mathrm{VP}$
t; NP

$$\backslash \mathrm{E}$$

terry $\circ$ said $\circ \varphi_3 \circ$ to $\circ$ robin $\circ$ on $\circ$ thursday $\circ$
or $\circ$ to $\circ$ leslie $\circ$ on $\circ$ friday;
$\mathbf{onTh}(\mathbf{said}(x)(\mathbf{r}))(\mathbf{t})\mathbf{onFr}(\mathbf{said}(x)(\mathbf{l}))(\mathbf{t}); \mathrm{S}$

$$\uparrow \mathrm{I}^3$$

$\lambda \sigma.\sigma(\mathbf{nothing});$ $\qquad \lambda \varphi_3.\text{terry} \circ$ said $\circ \varphi_3 \circ$ to $\circ$ robin $\circ$ on $\circ$ thursday $\circ$
$\neg \exists_{\mathbf{thing}};$ $\qquad$ or $\circ$ to $\circ$ leslie $\circ$ on $\circ$ friday;
$\mathrm{S} \uparrow (\mathrm{S} \uparrow \mathrm{NP})$ $\qquad \lambda x.\mathbf{onTh}(\mathbf{said}(x)(\mathbf{r}))(\mathbf{t}) \vee \mathbf{onFr}(\mathbf{said}(x)(\mathbf{l}))(\mathbf{t}); \mathrm{S} \uparrow \mathrm{NP}$

$$\uparrow \mathrm{E}$$

terry $\circ$ said $\circ$ nothing $\circ$ to $\circ$ robin $\circ$ on $\circ$ thursday $\circ$ or $\circ$ to $\circ$ leslie $\circ$ on $\circ$ friday;
$\neg \exists_{\mathbf{thing}}(\lambda x.\mathbf{onTh}(\mathbf{said}(x)(\mathbf{r}))(\mathbf{t}) \vee \mathbf{onFr}(\mathbf{said}(x)(\mathbf{l}))(\mathbf{t})); \mathrm{S}$

The key point in this derivation is that, via hypothetical reasoning, the string *to Robin on Thursday or to Leslie on Friday* forms a syntactic constituent with a full-fledged meaning assigned to it in the usual way. Then the quantifier takes scope above this whole coordinate structure, yielding the non-distributive, quantifier wide-scope reading.

Licensing the correct scopal relation between the quantifier and conjunction in the analysis of NCC remains a challenging problem in the HPSG literature. See section 4.2.1 for some discussion.

2.5.3 Notes on other variants of TLCG

2.5.3.1 Displacement Calculus and NL$_\lambda$ Among different variant of TLCG, Morrill's Displacement Calculus (Morrill et al. 2011; Morrill 2010) and Barker and Shan's continuation-based calculus NL$_\lambda$ (Barker & Shan 2015) are most closely related to Hybrid TLCG. Roughly speaking, Hybrid TLCG's vertical slash $\uparrow$ plays more or less the same role as the discontinuity connectives $\uparrow$ and $\downarrow$ in Displacement Calculus and the 'continuation' slashes $//$ and $\backslash\backslash$ in NL$_\lambda$. Many empirical analyses of linguistic phenomena formulated in one of these variants of TLCG translate to the other two more or less straightforwardly (for example, the analyses of Gapping and symmetrical predicates in Kubota & Levine (2016a) and Kub-

ota & Levine (2016b) build on Morrill's and Barker's analyses of the respective phenomena), though there are some important differences (some of which I point out below).

One major difference between the Displacement Calculus and Hybrid TLCG on the one hand and NL_λ on the other is that the latter takes **NL**, namely, the *Non*-associative Lambek Calculus, as the underlying calculus for the directional slashes / and \. Barker & Shan (2015) briefly comment on this property of their system, alluding to the possibility of controlling flexibility of constituency via the notion of 'structural control' (see section 2.5.3.2 below) in Multi-Modal Categorial Type Logics. This certainly is a viable view, but no explicit extension of NL_λ along these lines currently exists. Morrill's approach differs from Kubota & Levine's in certain important ways in the treatment of specific linguistic phenomena. The most substantial disagreement pertains to the treatment of island constraints. Unlike Kubota & Levine, who take (most) island constraints to arise from factors pertaining to on-line language processing, Morrill consistently holds the view that major island constraints are to be treated within the narrow syntax (Morrill 1994; Morrill 2010; 2017). See also a brief discussion about determiner gapping in section 4.2.2 for another point of disagreement.

2.5.3.2 Multi-Modal Categorial Type Logics   There is a line of work in the TLCG literature most actively investigated back in the 90s and whose core architecture provides the theoretical underpinnings to Barker and Shan's NL_λ, called Multi-Modal Categorial Type Logics (MMCTL) (Moortgat & Oehrle 1994; Moortgat 2011; Bernardi 2002; Vermaat 2005) (but it should be kept in mind that NL_λ and MMCTL from the 90s differ from each other considerably in terms of empirical scope and orientation). One crucial difference between Hybrid TLCG and the Displacement Calculus on the one hand and MMCTL on the other is that, instead of recognizing a separate level of prosodic representation, MMCTL deals with various (somewhat heterogeneous) phenomena ranging from morphosyntactic properties of verb clusters in Dutch cross-serial dependencies (Moortgat & Oehrle 1994) to technical difficulties with the Lambek Calculus in dealing with medial extraction (Bernardi 2002; Moortgat 2011) (see the discussion in sections 2.4.2 and 2.5.2 above) via the abstract notion of 'structural control', building on the technique of mixing different kinds of logic within a single deductive system originally developed in the literature of substructural logic (Restall 2000).

To see this point, it is instructive to take a look at the analysis of medial extraction in MMCTL, illustrated by the following derivation (adapted from Bernardi (2002)):

(41)

$$\cfrac{ \cfrac{(N\backslash N)/(S/_aNP) \vdash}{(N\backslash N)/(S/_aNP)} \qquad \cfrac{ NP \vdash \atop NP \qquad \cfrac{ \cfrac{ \cfrac{(NP\backslash S)/_aNP \vdash}{(NP\backslash S)/_aNP} \quad [\,NP \vdash NP\,]^1}{(NP\backslash S)/_aNP \circ_a NP \vdash NP\backslash S} {}_{/aE} \quad \cfrac{(NP\backslash S)\backslash(NP\backslash S) \vdash}{(NP\backslash S)\backslash(NP\backslash S)}}{(((NP\backslash S)/_aNP \circ_a NP) \circ (NP\backslash S)\backslash(NP\backslash S) \vdash NP\backslash S} {}_{\backslash E}}{ \cfrac{ \cfrac{ \cfrac{ \cfrac{NP \circ (((NP\backslash S)/_aNP \circ_a NP) \circ (NP\backslash S)\backslash(NP\backslash S)) \vdash S}{NP \circ (((NP\backslash S)/_aNP \circ (NP\backslash S)\backslash(NP\backslash S)) \circ_a NP) \vdash S} {}_{\text{Diss}}}{(NP \circ ((NP\backslash S)/_aNP \circ (NP\backslash S)\backslash(NP\backslash S))) \circ_a NP \vdash S} {}_{\text{MixAssoc}}}{NP \circ ((NP\backslash S)/_aNP \circ (NP\backslash S)\backslash(NP\backslash S)) \vdash S/_aNP} {}_{/aI^1}}{} } {}_{\backslash E}}{(N\backslash N)/(S/_aNP) \circ (NP \circ ((NP\backslash S)/_aNP \circ (NP\backslash S)\backslash(NP\backslash S))) \circ_a NP) \vdash N\backslash N} {}_{/E}$$

Here, the derivation is written in the sequent style natural deduction (see Chapter 2). A sequent is a construct of the form $\Gamma \vdash A$ where the consequent A is a syntactic type and the antecedent Γ is a structured object consisting of possibly multiple syntactic types that are combined with one another via binary connectives (of several sorts). On the leaves of the trees, we find axioms of the form $A \vdash A$ and the sequent on the final line of the proof tree is obtained by applying the rules of logic (such as the Elimination and Introduction rules similar to the ones we have posited above) and 'structural rules', which manipulate the forms of the antecedents of the sequents that are derived.

Intuitively, what is going on in the above derivation is that an object NP that is hypothesized on the right of a transitive verb is 'moved' to the right edge via the structural rule of Mixed Associativity in the structured antecedent on the third line from the bottom. This licenses the $/_aI$ rule, withdrawing the hypothesis to create the $S/_aNP$ category that is suitable as an argument to the relative pronoun. After lexical substitution, the derivation in (41) embodies, for example, a formal proof for the fact that the string 'which Sara wrote __ there' is a well-formed relative clause in English containing a medial gap.

There are a couple of important points of difference between MMCTL and other variants of TLCG that should already be clear from this rather cursory exposition. First, the analysis of extraction via structure rewriting operations in the abstract substructural component of the type logic is very different from the prosodic λ abstraction analysis presented above, due originally to Muskens (2003) and incorporated in many contemporary variants of TLCG (such as Hybrid TLCG and Pollard's Linear Categorial Grammar (Mihaliček & Pollard 2012; Pollard 2013)). Second, the exact ontological status of this 'multi-modal' substructural component is somewhat unclear. As noted above, the structure-changing operations have been put to use not only for extraction in English but also for dealing with complex morpho-syntactic phenomena such as verb clustering in Dutch cross-serial dependencies (Moortgat & Oehrle 1994) and clitic pronouns in

French (Kraak 1998). All this is done, not in a separate prosodic component, but inside a complex logic of syntactic types, where these syntactic types are taken as primitives that enter into binary composition operations of various sorts having different combinatorial possibilities. The different ontological assumptions in different variants of contemporary TLCG may have to do with the different research goals and research practices. When the emphasis is on linguistic application, a clear separation of ontologically distinct components is an important requirement, but when the emphasis is on studying the meta-logical properties of the formal calculus, building directly on the rich literature of substructural logic and formalizing the type logic for natural language syntax literally *as* a substructural logic may be a natural choice.

2.5.3.3 Linear Categorial Grammar   There is a family of related approaches in the TLCG tradition (Oehrle 1994; de Groote 2001; Muskens 2003; Mihaliček & Pollard 2012; Pollard 2013) that are distinctly different from the variants of TLCG discussed above in *not* recognizing the directional slashes of the Lambek calculus as primitive logical connectives. I call this family of approaches Linear Categorial Grammar (LCG) in what follows.[16]

LCG is essentially a subsystem of Hybrid TLCG without the rules for the directional slashes. The original conceptual motivation for this architecture is similar to the motivation for linearization-based HPSG—the idea, originally due to Curry (1961), that separating the combinatoric component of grammar and surface word order realization leads to a cleaner theoretical architecture. To get a flavor of LCG, an analysis of extraction from section 2.5.2 can be reformulated in an LCG fragment as follows:

---

[16] Among these variants, Abstract Categorial Grammar (ACG) has mostly been studied in the formal grammar literature as a meta-framework for embedding different types of linguistic theories (rather than as a linguistic theory by itself), despite the fact that de Groote (2001), the very first paper that advocates it, motivated it by pointing out some empirical issues with standard variants of TLCG. For a highly readable and interesting recent work on using ACG as a meta-framework for embedding Tree Adjoining Grammar, see Pogodalla (2017).

(42)

$$\lambda\varphi_1\lambda\varphi_2\lambda\varphi_3.$$
$$\varphi_3 \circ \mathrm{gave} \circ \varphi_1 \circ \varphi_2;$$
$$\mathbf{gave};$$
$$S{\upharpoonleft}NP{\upharpoonleft}PP{\upharpoonleft}NP \qquad \begin{bmatrix} \varphi; \\ x; \\ NP \end{bmatrix}^1$$

$$\dfrac{}{\lambda\varphi_2\lambda\varphi_3.\varphi_3 \circ \mathrm{gave} \circ \varphi \circ \varphi_2;}\ {\upharpoonleft}E$$
$$\mathbf{gave}(x); S{\upharpoonleft}NP{\upharpoonleft}PP \qquad \mathrm{to} \circ \mathrm{chris}; \ \mathbf{c}; PP$$

kim; **k**; NP

$$\lambda\sigma\lambda\varphi.$$
$$\varphi \circ \sigma(\epsilon);$$
$$\lambda\mathcal{F}.\mathcal{F};$$
$$(S{\upharpoonleft}X){\upharpoonleft}(S{\upharpoonleft}X)$$

bagels; **b**; NP

$$\dfrac{\lambda\varphi_3.\varphi_3 \circ \mathrm{gave} \circ \varphi \circ \mathrm{to} \circ \mathrm{chris}; \mathbf{gave}(x)(\mathbf{c}); S{\upharpoonleft}NP}{}\ {\upharpoonleft}E$$

$$\dfrac{\mathrm{kim} \circ \mathrm{gave} \circ \varphi \circ \mathrm{to} \circ \mathrm{chris}; \mathbf{gave}(x)(\mathbf{c})(\mathbf{k}); S}{}\ {\backslash}E$$

$$\dfrac{\lambda\varphi.\mathrm{kim} \circ \mathrm{gave} \circ \varphi \circ \mathrm{to} \circ \mathrm{chris}; \lambda x.\mathbf{gave}(x)(\mathbf{c})(\mathbf{k}); S{\upharpoonleft}NP}{}\ {\upharpoonleft}I^1$$

$$\dfrac{\lambda\varphi.\varphi \circ \mathrm{kim} \circ \mathrm{gave} \circ \mathrm{to} \circ \mathrm{chris}; \lambda x.\mathbf{gave}(x)(\mathbf{c})(\mathbf{k}); S{\upharpoonleft}NP}{\mathrm{bagels} \circ \mathrm{kim} \circ \mathrm{gave} \circ \mathrm{to} \circ \mathrm{chris}; \mathbf{gave}(\mathbf{b})(\mathbf{c})(\mathbf{k}); S}\ {\upharpoonleft}E$$

The key difference from the Hybrid TLCG derivation above in (38) is that here the syntactic categories of linguistic expressions do not specify word order. Note in particular that the ditransitive verb *gave* is syntactically of type $S{\upharpoonleft}NP{\upharpoonleft}PP{\upharpoonleft}NP$, and specifies the order of the arguments relative to the verb itself in the prosodic representation, which is formally a function of type $\mathbf{st}{\rightarrow}\mathbf{st}{\rightarrow}\mathbf{st}{\rightarrow}\mathbf{st}$.

While the clear separation of the underlying combinatorics and surface word order is certainly appealing, the conceptual elegance comes at some nontrivial empirical cost. Specifically, the simple analysis of NCC as constituent coordination discussed in section 2.4.1, which is the hallmark of many variants of CG, does not straightforwardly carry over to this setup. This issue was already anticipated by Muskens (2001), and is discussed in detail in Kubota & Levine (2015). To see what's at issue, note that the distinction between S/NP and NP\S, which is crucial for distinguishing well-formed RNR sentence and ungrammatical strings in the CCG/Lambek calculus analysis of RNR is lost in LCG, since the two will be collapsed into the same type $S{\upharpoonleft}NP$. But then, neither the syntactic type nor the prosodic type (which is uniformly $\mathbf{st}{\rightarrow}\mathbf{st}$) of the conjuncts provides enough information to determine conjoinability.

Worth (2016) presents the most comprehensive treatment of coordination in LCG addressing this problem (see also Kanazawa (2015)). The core idea of his proposal is to encode word order information via fine-grained subtypes of the prosodic types of linguistic expressions. Whether this extension of LCG offers the same (or better) empirical coverage as more traditional variants of TLCG (including Hybrid TLCG) is currently an open question.

3 Architectural similarities and differences

3.1 Broad architecture

One important property common to HPSG and CG is that they are both 'lexicalist' theories of syntax in the broader sense.[17] This is partly due to an explicit choice made at an early stage of the development of HPSG to encode valence information in the syntactic categories of linguistic expressions, following CG (see Chapters 2 and 4).[18] The two theories share many similarities in the analyses of specific linguistic phenomena due to this basic architectural similarity. For example, many phenomena that are treated by means of A movement operations (or via empty categories) in mainstream syntax, such as passivization, raising/control in English and 'complex predicate' phenomena in a typologically broad range of languages are generally treated by the sharing of valence information in the lexicon in these theories. For HPSG analyses of these phenomena, see Chapters 9, 12 and 13. Steedman & Baldridge (2011) contains a good summary of CG analyses of local dependencies (passivization, raising/control). Kubota (2014) contains a comparison of HPSG and CG analyses of complex predicates. The heavy reliance on 'lexicalist' analyses of local dependencies is perhaps the most important property that is shared in common in HPSG and various versions of CG.

the chapter label seems currently missing from the Lexicon chapter

But emphasizing this commonality too much may be a bit misleading, since the valence features of HPSG and the slash connectives in CG have very different ontological statuses in the respective theories. The valence features in HPSG are primarily specifications, closely tied to the specific phrase structure rules, that dictate the ways in which hierarchical representations are built. To be sure, the lexical specifications of the valence information play a key role in the movement-free analyses of local dependencies along the lines noted above, but still, there is

---

[17]I say 'broader sense' here since not all variants of either HPSG or CG subscribe to the so-called 'lexical integrity hypothesis' (see Chapter 4), which says that syntax and morphology are distinct components of grammar. For example, the treatments of verb clustering in Dutch by Moortgat & Oehrle (1994) and in Japanese by Kubota (2014) seem to go against the tenet of the lexical integrity hypothesis. See also Chapter 4 for some discussion on lexicalism.

[18]This point is explicitly noted by the original founders of HPSG in the following passage in Pollard & Sag (1987: 11):

> A third principle of universal grammar posited by HPSG, the Subcategorization Principle, is essentially a generalization of the 'argument cancellation' employed in categorial grammar

a rather tight connection between these valence specifications originating in the lexicon and the ways in which they are 'cancelled' in specific phrase structure rules.

Things are quite different in CG, especially in TLCG. As discussed in section 2, TLCG views the grammar of natural language *not* as a structure-building system, but as a logical deductive system. The two slashes / and \ are thus not 'features' that encode the subcategorization properties of words in the lexicon, but have a much more general and fundamental role within the basic architecture of grammar in TLCG. These connectives are literally implicational connectives within a logical calculus. Thus, in TLCG, 'derived' rules such as type-raising and function composition are *theorems*, in just the same way that the transitivity inference is a theorem in classical propositional logic. Note that this is not just a matter of high-level conceptual organization of the theory, since, as discussed in section 2, the ability to assign 'constituent' statuses to non-canonical constituents in the CG analyses of NCC directly exploits this property of the underlying calculus. The straightforward mapping from syntax to semantics discussed in section 2.3 is also a direct consequence of adopting this 'derivation as proof' perspective on syntax, building on the results of Curry-Howard correspondence (Howard 1969) in setting up the syntax-semantics interface.[19]

Another notable difference between (especially a recent variant of) HPSG and CG is that CG currently lacks a detailed theory of 'constructions', that is, patterns and (sub)regularities that are exhibited by linguistic expressions that cannot (at least according to the proponents of 'constructionist' approaches) be lexicalized easily. As discussed in Chapter 36, recent Sign-Based Construction Grammar (SBCG) variants of HPSG (Sag et al. 2012) incorporate ideas from Construction Grammar (Goldberg 1995) and capture such generalizations via a set of constructional templates (or schemata), which are essentially a family of related phrase structure rules that are organized in a type inheritance hierarchy.

Such an architecture seems nearly impossible to implement literally in CG, except via empty operators or lexical operations corresponding to each such constructional schema. In particular, in TLCG, syntactic rules are logical inference rules, so, if we strictly adhere to its slogan 'language is logic', there is no option to freely add syntactic rules in the deductive system. However, the crucial tenet of Construction Grammar in its strongest form, namely, the claim that the

---

[19]Although CCG does not embody the idea of 'derivation as proof' as explicitly as TLCG does, it remains true to a large extent that the role of the slash connective within the overall theory is different from that of the valence features in HPSG, given that CCG and TLCG share many key ideas in the analyses of actual empirical phenomena.

grammar of natural language robustly exhibits patterns that cannot be perspicuously captured within the lexicon, seems still highly controversial even within the HPSG literature. Thus, if the relevant generalizations can all be lexicalized, along the lines suggested by Müller & Wechsler (2014) (see also Chapter 36 and Steedman & Baldridge (2011), the latter of which briefly discusses ways in which some of the empirical generalizations that Goldberg (1995) adduces to the notion of constructions can be lexicalized within CCG), then it may not pose any fundamental problem for the strongly lexicalist architecture of CG. That being said, the so-called 'peripheral' phenomena is largely an uncharted territory in CG research waiting for serious attention in future research.

3.2 Syntax-semantics interface

As should be clear from the exposition in section 2, both CCG and TLCG (at least in the simplest form) adopt a very rigid, one-to-one correspondence between syntax and semantics. Steedman's work on CCG has demonstrated that this simple and systematic mapping between syntax and semantics enables attractive analyses of a number of empirical phenomena at the syntax-semantics interface, including some notorious problems such as the scope parallelism issue in right-node raising known as the Geach paradigm (*Every boy loves, and every girl detests, some saxophonist*; Geach (1970)). Other important work on issues at the syntax-semantics interface includes Jacobson's (1999; 2000) work on pronominal anaphora in Variable-Free Semantics (covering a wide range of phenomena including the paycheck/Bach-Peters paradigms and binding parallelism in right-node raising), Barker & Shan's (2015) work on 'continuation-based' semantics (weak crossover, superiority effects and 'parasitic scope' treatments of symmetrical predicates and sluicing) and Kubota and Levine's (2015; 2017; 2020) Hybrid TLCG, dealing with interactions between coordination, ellipsis and scopal phenomena.

As discussed in Chapter 23, recent HPSG work on complex empirical phenomena at the syntax-semantics interface makes heavy use of underspecification. For example, major analyses of nonconstituent coordination in recent HPSG use some version of underspecification framework to deal with complex interactions between coordination and scopal operators. (Yatabe 2001; Beavers & Sag 2004; Park et al. 2019; Yatabe & Tam 2019). In a sense, HPSG retains a rigid phrase structure-based syntax (modulo the flexibility entertained with the use of the linearization-based architecture) and deals with the complex mapping to semantics via the use of underspecification languages in the semantic component (such as Minimal Recursion Semantics (Copestake et al. 2005) and Lexical Resources Se-

mantics (Richter & Sailer 2004)). CG, on the other hand, sticks to a tight mapping from syntax to semantics, but makes the syntactic component itself flexible.[20]

3.3 Morpho-syntax and word order

While there is relatively less detailed work on morphology and morpho-syntax interface in CG as compared to HPSG, there are several ideas that have been entertained in the CG literature that have either influenced some HPSG work or which are closely related to a certain line of work in in the HPSG literature. I review some of these in this section.

3.3.1 Linearization-based HPSG and the phenogrammar/tectogrammar distinction in CG

The idea of separating surface word order and the underlying combinatorics, embodied in the so-called LINEARIZATION-BASED version of HPSG (Reape 1994; Kathol 2000; cf. Chapter 10), has its origin in the work by the logician Haskell Curry (Curry 1961), in which he proposed the distinction between PHENOGRAM-MAR (the component pertaining to surface word order) and TECTOGRAMMAR (underlying combinatorics). This same idea has influenced a certain line of work in the CG literature too (the most recent incarnation of which is the family of approaches identified as 'Linear Categorial Grammar' in section 2.5.3.3). Important early work was done by Dowty (1982a; 1996b) in a variant of CG which is essentially an AB grammar with 'syncategoremmatic' rules that directly manipulate string representations, of the sort utilized in Montague Grammar, for dealing with various sorts of discontinuous constituency.[21]

Dowty's early work has influenced two separate lines of work in the later development of CG. First, a more formally sophisticated implementation of an enriched theory of phenogrammatical component of the sort sketched in Dowty (1996b) was developed in the Multi-Modal CTL work in the 90s, by exploiting the notion of 'modal control' (see section 2.5.3.2 above; as already noted, this

---

[20]But note that in principle this architecture does not preclude the use of underspecification. Steedman's (2012) recent approach to quantification crucially employs a limited use of underspecification for the treatment of indefinites. Similarly, Bekki and Mineshima's Dependent Type Semantics (Bekki 2014; Bekki & Mineshima 2017), a version of compositional proof theoretic semantics that has a straightforward interface to CG syntax, makes use of underspecification for the treatment of anaphora.

[21]See also Chapter 2, section 1.2 for a discussion of the influence that early forms of CG (Bach 1979; 1980; Dowty 1982a,b) had on Head Grammar (Pollard 1984), a precursor of HPSG.

technique was later incorporated into CCG by Baldridge (2002)). Some empirical work in this line of research includes Moortgat & Oehrle (1994) (on Dutch cross-serial dependencies; see also Dowty (1996a) for an accessible exposition of this analysis), Kraak (1998) (French clitic climbing), Whitman (2009) ('right-node wrapping' in English) and Kubota (2010; 2014) (complex predicates in Japanese). Second, as already noted in section 2.5.3.3, the Curry/Dowty idea of pheno/tecto distinction has also been the core motivation for the underlying architecture of LCG—in fact, among different variants of CG, LCG can be thought of as an extremism approach in relegating word order completely from the combinatorics, by doing away with the distinction between the Lambek forward and backward slashes.

One issue that arises for approaches that distinguish between the levels of phenogrammar and tectogrammar, across the HPSG/CG divide, is how closely these two components interact with one another. Kubota (2014) discusses some data in the morpho-syntax of complex predicates in Japanese which (according to him) would call for an architecture of grammar in which the pheno and tecto components interact with one another closely, and which would thus be problematic for the simpler LCG-type architecture. It would be interesting to see whether/to what extent this same criticism would carry over to linearization-based HPSG, which is similar (at least in its simplest form) to LCG in maintaining a clear separation of the pheno/tecto components.[22]

3.3.2 Syntactic features and feature neutralization

As compared to HPSG, the status of syntactic features in CG is somewhat unclear, despite the fact that such 'features' are often used in linguistic analyses in the CG literature. One reason that a full-blown theory of syntactic features has not been developed in CG research to date seems to be that as compared to HPSG, syntactic features play a far less major role in linguistic analysis in CG. Another possible reason is that empirical work on complex linguistic phenomena (especially on languages other than English) are still very few in number in CG.

It is certainly conceivable to develop a theory of syntactic features and feature underspecification within CG by borrowing ideas from HPSG, for which there is already a rich tradition of foundational work on this issue. In fact, the work on

---

[22]But note also in this connection that linearization-based HPSG is by no means monolithic; for example, Yatabe & Tam (2019) (discussed below in section 4.2.1) propose a somewhat radical extension of the linearization-based approach in which semantic composition is done at the level of word order domains.

Unification-based Categorial Grammar (Calder et al. 1988) explored at the end of the 80s seems to have had precisely such a goal. Unfortunately, this approach remains largely isolated from other developments in the literature (of either CG or other grammatical theories/formalisms). Another possibility would be to pursue a more logic-based approach. For some ideas, see Bayer & Johnson (1995); Bayer (1996) and Morrill (1994). Morrill (1994) in particular briefly explores the idea of implementing syntactic features via the notion of DEPENDENT TYPES. There is some renewed interest in linguistic application of ideas from Dependent Type Theory (Martin-Löf 1984) in the recent literature of CG and formal semantics (see, for example, Chatzikyriakidis & Luo (2017)), so, pursuing this latter type of approach in connection with this new line of work may lead to some interesting developments.

One issue that is worth noting in connection to syntactic features is the treatment of case syncretism and feature neutralization (cf. Chapter 7, Section 2). The work by Morrill (1994); Bayer (1996); Bayer & Johnson (1995) mentioned above proposed an approach to feature neutralization by positing meet and join connectives (which are like conjunction and disjunction in propositional logic) in CG. The key idea of this approach was recast in HPSG by means of inheritance hierarchies by Levy (2001), Levy & Pollard (2002) and Daniels (2002). See Chapter 7, Section 2 for an exposition of this HPSG work on feature neutralization.

3.3.3 Morphological theory in HPSG and CG

Recent work by Olivier Bonami and Berthold Crysmann (see Chapter 22) on developing a morphological theory building on Greg Stump's PARADIGM FUNCTION MORPHOLOGY (PFM; Stump (2001)), with extensive use of inheritance hierarchies in HPSG, has enriched the morphological component of HPSG substantially. CG research currently lacks a comparably well developed theory of morphology. But given the similarity between HPSG and CG as lexicalist theories, adopting PFM or its extension (perhaps along the lines of Bonami and Crysmann) seems relatively straightforward. In fact, early work on morphology in CG such as Hoeksema (1984), Moortgat (1984), Hoeksema & Janda (1988) and Raffelsiefen (1992) view morphological processes not as structure-building processes but as functional mapping from one form to another, and in this sense, can be thought of as prefiguring the core ideas of PFM.

A somewhat different (and arguably more controversial) question is whether/to what extent the CG architecture is compatible with the view on morphology that is more in line with the Chomskian tradition, represented by DISTRIBUTED MORPHOLOGY (DM; Halle & Marantz (1993)). Given the 'surface-oriented' nature of

CCG, trying to combine CCG with DM is perhaps not a very fruitful idea to pursue, but things are arguably different with TLCG. Aside from the general lexicalist setup (as reflected, for example, in the explicit encoding of valance information in syntactic categories), TLCG is, in a sense, more similar to the mainstream syntax than to either CCG or HPSG. This should be clear from the analogy between hypothetical reasoning and syntactic movement in the exposition of (Hybrid) TLCG in section 2.5. Recent research in TLCG in other domains (primarily, syntax-semantics interface) has in fact shown that the logic-based setup of TLCG enables synthesis of ideas from both lexicalist and derivational approaches to syntax (Kubota 2014; Kubota & Levine 2016a,b; 2019). It remains to be seen whether a similar insight on the relationship between configurational and lexicalist approaches to morphology can be obtained by recasting both in the logic-based combinatorics of TLCG.

4 Specific empirical phenomena

Part II of the present handbook contains an excellent introduction to recent developments of HPSG research on major linguistic phenomena. I will therefore presuppose familiarity with such recent analyses, and my discussion below aims to highlight the differences between HPSG and CG in the analyses of a selected empirical phenomena. In order to make the ensuing discussion maximally informative, I focus on phenomena over which there is some ongoing major cross-theoretical debate, and those for which I believe one or the other theory would benefit from recent developments/rich research tradition in the other.

4.1 Long-distance dependencies

As noted in section 2.4, CCG treats long-distance dependencies via a sequence of function composition, which is similar to the SLASH percolation analysis in HPSG. CCG offers a treatment of major aspects of long-distance dependencies, including island effects (Steedman 2000) and parasitic gaps (Steedman 1987). Earlier versions of CCG involved a somewhat ad-hoc stipulation on the use of crossed composition rules (Steedman 1997). This was overcome in the more recent, 'multi-modal' variant of CCG (Baldridge 2002), which controls the application of such non-order-preserving rules via a fine-grained system of 'lexicalized modality'. The modality specifications in this new version of CCG enables one to relocate language-specific idiosyncrasies to the lexicon, in line with the general spirit of lexicalist theories of grammar.

The situation is somewhat different in TLCG. TLCG typically makes use of a movement-like operation for the treatment of extraction phenomena (via hypothetical reasoning), but the specific implementations differ considerably in different variants of TLCG. Major alternatives include the approach in terms of 'structural control' in Multi-Modal CTL (along the lines sketched in section 2.5.3.2, cf. Bernardi (2002); Moortgat (2011); see also Morrill (1994)), and the one involving prosodic λ-binding in LCG and related approaches (see section 2.5.2). In either approach, extraction phenomena are treated by means of some form of hypothetical reasoning, and this raises a major technical issue in the treatment of multiple gap phenomena. The underlying calculus of TLCG is a version of linear logic, and this means that the implication connective is resource sensitive. This is problematic in situations in which a single filler corresponds to multiple gaps, as in parasitic gaps and related phenomena. These cases of extraction require some sort of extension of the underlying logic or some special operator that is responsible for resource duplication. Currently, the most detailed treatment of extraction phenomena in the TLCG literature is Morrill (2017), which lays out in detail an analysis of long-distance dependencies capturing both major island constraints and parasitic gaps within the most recent version of Morrill's Displacement Calculus.

There are several complex issues that arise in relation to the linguistic analysis of extraction phenomena. One major open question is whether island constraints should be accounted for within narrow grammar. Both Steedman and Morrill follow the standard practice in generative grammar research in taking island effects to be syntactic, but this consensus has been challenged by a new body of research in the recent literature proposing various alternative explanations on different types of island constraints (see Chapter 16, Levine (2017) and Newmeyer (2016) for an overview of this line of work and pointers to the relevant literature). Recent syntactic analyses of long-distance dependencies in the HPSG literature explicitly avoid directly encoding major island constraints within the grammar (Sag 2010; Chaves 2012b). Unlike CCG and Displacement Calculus, Kubota & Levine's Hybrid TLCG opts for this latter type of view (that is, the one that is generally in line with recent HPSG work).

Another major empirical problem related to the analysis of long-distance dependencies is the so-called EXTRACTION PATHWAY MARKING phenomenon (McCloskey 1979; Zaenen 1983). While this issue has received considerable attention in the HPSG literature, through a series of work by Levine and Hukari (see Levine & Hukari 2006), there is currently no explicit treatment of this phenomenon in the CG literature. CCG can probably incorporate the HPSG analysis

relatively easily, given the close similarity between the SLASH percolation mechanism and the step-by-step inheritance of the /NP specification in the function composition-based approach in CCG. Extraction pathway marking poses a much trickier challenge to TLCG, in which extraction is typically handled by a single-chain movement-like process by means of hypothetical reasoning (but see Kubota & Levine (2020: Chapter 7) for a sketch of a possible approach which mimics successive cyclic movement in the type-logical setup).

4.2 Coordination and ellipsis

Coordination and ellipsis are both major issues in contemporary syntactic theory. There are moreover some phenomena, such as Gapping and Stripping, which seem to lie at the boundary of the two empirical domains (see for example the recent overview by Johnson (2019)). There are some important similarities and differences between analytic ideas entertained in the HPSG and CG literature for problems in these empirical domains.

4.2.1 Analyses of nonconstituent coordination

CG is perhaps best known in the linguistics literature for its analysis of nonconstituent coordination. Steedman's work on CCG (Steedman 1997; 2000; Steedman 2012) in particular has shown how this analysis of coordination interacts smoothly with analyses of other major linguistic phenomena (such as long-distance dependencies, control and raising and quantification) to achieve a surface-oriented grammar that has wide empirical coverage and at the same time has attractive computational properties. Kubota & Levine (2015; 2020) offer an up-to-date TLCG analysis of coordination, and compare it with major alternatives in both the CCG and HPSG literature.

As compared to long-distance dependencies, coordination (in particular NCC) has received considerably less attention in the (H)PSG literature initially (Sag et al. (1985) is an important exception in the early literature). Things started to change somewhat around 2000, with a series of related proposals appearing one after another, including Yatabe (2001), Beavers & Sag (2004), Chaves (2007) and Crysmann (2008) (see Chapters 17 and 20). Here, I take up Beavers & Sag (2004) and Yatabe (2001) (updated in Yatabe & Tam (2019)) as two representative proposals in this line of work. The two proposals share some common assumptions and ideas, but they also differ in important respects.

Both Beavers & Sag and Yatabe (2001) adopt linearization-based HPSG, together with (a version of) Minimal Recursion Semantics for semantics. Of the

two, Beavers & Sag's analysis is more in line with standard assumptions in HPSG. The basic idea of Beavers & Sag's analysis is indeed very simple: by exploiting the flexible mapping between the combinatoric component and the surface word order realization in linearization-based HPSG, they essentially propose a surface deletion-based analysis of NCC according to which NCC examples are analyzed as follows:

(43) [s Terry gave no man a book on Friday] or [s ~~Terry gave no man~~ a record on Saturday].

where the material in strike-out is underlyingly present but undergoes deletion in the prosodic representation.

In its simplest form, this analysis gets the scopal relation between the quantifier and coordination wrong in examples like (43) (a well-known problem for the conjunction reduction analysis from the 70s; cf. Partee (1970)). Beavers & Sag address this issue by introducing a condition called 'Optional Quantifier Merger':

(44) **Optional Quantifier Merger**: For any elided phrase denoting a generalized quantifier in the domain of either conjunct, the semantics of that phrase may optionally be identified with the semantics of its non-elided counterpart.

As noted by Levine (2011) and Kubota & Levine (2015), this condition does not follow from any general principle and is merely stipulated in Beavers & Sag's account.

Yatabe (2001) and Yatabe & Tam (2019) (the latter of which contains a much more accessible exposition of essentially the same proposal as the former) propose a somewhat different analysis. Unlike Beavers & Sag, who assume that semantic composition is carried out on the basis of the meanings of *signs* on each node (which is the standard assumption about semantic composition in HPSG), Yatabe shifts the locus of semantic composition to the list of domain objects, that is, the component that directly gets affected by the deletion operation that yields the surface string.

This crucially changes the default meaning predicted for examples such as (43). Specifically, on Yatabe's analysis, the surface string for (43) is obtained by the 'compaction' operation on word order domains that collapses two quantifiers originally contained in the two conjuncts into one. The semantics of the whole sentence is computed on the basis of this resultant word order domain representation, which contains only *one* instance of a domain object corresponding to