Advanced Review

Language acquisition and language change

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Children acquire a mature language system and sometimes this system differs from that of their parents. This is a significant part of language change and understanding acquisition is key to understanding this kind of change in people's internal grammars. I outline one approach to language acquisition, based on children finding cues expressed in the input they are exposed to. This enables us to understand historical change in grammars: change in external language sometimes triggers a new internal grammar as cues come to be expressed differently. Work on language variation, acquisition, and change converges, and these three areas are mutually dependent; empirical work in one area may enrich understanding more generally, opening the way to new kinds of empirical work. Seen this way, language is a complex system and language change can be treated productively in the context of complexity science. *WIREs Cogn Sci* 2010 1 677–684

Languages change over time. New lexical items, morphological endings, and syntactic constructions enter a language and old ones become more or less frequent or die out. For example, in older versions of English it was possible to say things corresponding to *She has could understand chapter four* or *Understands she chapter four?*, which do not occur today, while sentences with 'periphrastic' *do* such as *Does she understand chapter four?* represent a relatively new development. Languages may change under external influence from other languages or dialects or they change through internal factors, the focus in this paper. Other approaches explain language change more or less exclusively through social processes among adolescents[1] but for us this is just part of the story.

Hermann Paul[2] was the first to relate language change to acquisition by children and there have been many attempts since. Here I discuss recent work on a cue-based approach to acquisition and illustrate how it enables us to understand diachronic change in productive new ways.

The cue-based approach distinguishes external language, the mass of unanalyzed utterances that a child might hear, from the internal languages or 'grammars,' the systems that grow in children on exposure to external language. On this view, external language and internal languages are different *kinds* of objects, one a mass notion, the other a set of discrete entities, each generating an infinite set of structures. The core idea in the cue-based approach is that an internal language grows in a child in response to structures that are expressed in the ambient, external language that she hears. These structures are the *cues* designated in advance of experience, and they are *expressed* in sentences that a child hears that can only be analyzed, given everything else the child knows, if a particular cue is utilized.[3] The end of Section 'What Children Learn and What They Don't Learn' provides examples of how cues are expressed.

Cue-based learning is a variant of the principles-and-parameters approach to language variation and acquisition:[4–6] the structures or cues that may or may not occur in any particular internal language constitute the parameters of variation—other structures are invariant and occur in all internal languages. The crucial difference with other work on parameters is that children do not evaluate candidate grammars against sets of sentences; this is a major conceptual and methodological break with standard parameter-setting models. Indeed, it differs from generative work beginning with Ref 7, which views children as *evaluating* grammars against a corpus of sentences. In the cue-based approach, children are on a forced march, interpreting the external language they hear through the available inventory of structures, provided by universal grammar (UG). Children are insensitive

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to the set of sentences generated by any grammar and the approach makes strong predictions about the 'learning path,' the sequence of structures in the growing internal language. For discussion, see Ref 8.

Under this view of language acquisition, one can view historical change as taking place when external language comes to express cues differently, leading to the growth of new internal languages in children.

The paper is organized as follows: I first outline some general properties of the human language capacity (Section 'The Human Language Capacity') and then show what they entail for how we may understand language acquisition (Section 'What Children Learn and What They Don't Learn'). Section 'Language Change' discusses some changes in the history of English and Section 'Conclusion' locates this approach to language change in the wider context of complexity science.[a]

THE HUMAN LANGUAGE CAPACITY

Everybody's language capacity has general properties that are not learned but which must somehow be part of an innate endowment for language. For example, the human language capacity is represented in the brain and must be finite, but there is an infinite number of things one can say and understand. Evidence for this is that everybody's language has three recursive devices that permit sentences to go on indefinitely.

Relativization: *This is the cow that kicked the dog that chased the cat that killed the rat that caught the mouse that nibbled the cheese that lay in the house that Jack built.*

Complementation: *Ray said that Kay said that Jay thought that Fay said that Gay told me that Clay reported that there was hay on the way.*

Coordination: *Ray and Kay went home and Jay and Fay to the store, while Gay and May and Clay worked where Shay and Jack were playing, but Zach and Mack slept.*

If sentences may, in principle, go on indefinitely, then there is an indefinite number of sentences. That capacity links to something fundamental: virtually everything we say is novel. It may be quite trivial, e.g., *I think that the Ivory Coast will give Argentina a tough time tonight in Hamburg*, but we say it because we want to express that thought, not because we heard somebody else say this some time ago. In that way, the language capacity is infinitely creative and that makes humans different from other animals. This is not learned (no child hears a sentence of indefinite length; they all end) but it is built into our general human language capacity, which is fine-tuned differently in Toronto and Togo.

Another thing that is not learned, which must be built into the system, is that everybody's language is compositional, consisting of units consisting of smaller units. In an expression *I saw a man with curly hair*, the words *man with curly hair* constitute a unit but the words *man with* do not. These units undergo the computational operations of the system, as we shall see.

These are two fundamental properties of the human language capacity, a capacity that is remarkably complex, and things are even more interesting: a person's language has properties that she is not aware of and for which there was no evidence in her childhood experience. This reveals details of the genetic component of language through what is called poverty-of-stimulus arguments.[9,10] The central question is how we may come to have such a complex capacity when the stimulus, the specific language we hear in our environment, contains so little evidence of the nature of the system. The general answer within the generative framework is that humans must be genetically endowed with UG, which encompasses the fundamental properties of the capacity. Furthermore, as children we must be sensitive to certain aspects of the input to be able to acquire language-specific properties of the mature system. The nature of the human language capacity is linked inextricably with the way it is acquired, and that, in turn, links with the way that it changes over time, as we shall see.

WHAT CHILDREN LEARN AND WHAT THEY DON'T LEARN

People may say *Kim is taller* or *Kim's taller*, with *is* reduced. One can think of this as an operation *is* ⇒ *'s*. Children hear both the full and reduced forms and can learn the operation on exposure to external data. However, the poverty-of-stimulus problem is that the operation sometimes may not apply: in (1) the underlined *is* never reduces.

1. Kim's taller than Jim is.

The stimulus that children have does not convey this kind of information, usually referred to as negative evidence, data about what does not occur. Children hear things but they are not instructed in what does not occur, and therefore they do not *learn* the limitation. Helicopter parents may try to correct the occasional *goed* or *taked*, but they do not tell children that a reduced *is* does not occur in (1). That is partly because

they do not know and partly because children do not misuse the reduced forms, so there is no need for correction—a lot of ingenious experimental work has shown how rich children's language capacities are.[11]

This is no longer mysterious. Children are exposed to simple speech,[12] what linguists call 'primary linguistic data.' That is part of external language (E-language), language out there, and acts as a triggering experience. The initial genetic inheritance (UG) blossoms into a specific internalized grammar (I-language), depending on whether the children are raised in Tromsø or Tokyo (for the distinction between external and internal language, see Ref 9, echoing Ref 13, who distinguished the language of individual citizens and the language of a nation). Linguists try to tease apart internal and external factors, contributions of genetic inheritance and contributions of environmental factors. Both internal, genetic factors and external, environmental elements shape a child's internal language system, and some of what children know is intrinsic, not learned.

Let us take another poverty-of-stimulus problem. English embedded clauses may start with a sentence introducer (a complementizer), a word like *that*, as illustrated in (2). Those words may be omitted, perhaps due to an operation *that* ⇒ *0*. Again, this is learnable: children hear the full forms and the reduced forms without *that*. French and Dutch children hear no equivalent reduced forms and learn no comparable operation *(*Je crois il fait chaud*, **Ik denk het warm is* 'I think it is warm').

2. a. Peter said (that) Kay left.
b. The book (that) Kay wrote arrived.
c. It was obvious (that) Kay left.

Here is the poverty-of-stimulus problem: the operation deleting *that* does not apply to (3) and English speakers would not say the equivalent forms without *that*.

3. a. Ray said yesterday in Chicago [*(that) Kay had left].
b. The book arrived yesterday [*(that) Kay wrote].
c. Fay believes, but Kay doesn't, [*(that) Ray is smart].
d. [*(that) Kay left] was obvious to all of us.

Again, children have no direct *evidence* for this limitation in the input. They sometimes hear forms with *that*, sometimes without *that*, but they are not explicitly told that the forms of (3) without *that* do not exist. Somehow they deduce that limitation, using both learned and intrinsic knowledge of language. Deletion is subject to various constraints, and the phenomena illustrated in (2) and (3) can be said to be due to a simple principle, which may be formulated as (4); see Ref 8.

4. Something can be deleted if it is (in) the complement of an adjacent, overt word.

In the simple forms of (2), the clause introduced by *that* completes the meaning of *said*, *book* and *was obvious*. *That* is adjacent to those words, is in the complement, and may therefore be deleted. However, the bracketed clauses of (3) do not complete the meaning of the adjacent *Chicago*, *yesterday* or *doesn't*. And in (3d) there is nothing preceding it. Therefore, in these cases *that* may not be deleted. That simple principle of our language capacity solves this poverty-of-stimulus problem and accounts for a lot of other things, as we will see.

Now consider another learned operation, whereby the second of two identical verbs may be deleted: *Gap V*. There may be an understood, empty verb in the second clause, indicated as $_V$e in (5c) and (6c). So alongside (5a) we find (5b), perfectly normal, comprehensible speech, which has a representation with an empty verb (5c).

5. a. Jay introduced Kay to Ray and Jim introduced Kim to Tim.
b. Jay introduced Kay to Ray and Jim Kim to Tim.
c. Jay introduced Kay to Ray and Jim $_V$e Kim to Tim

Example (6a) is another example of gapping. But we do not gap a verb *and* delete the sentence introducer *that* (6b), which would have the representation (6c). Again our principle has the explanation: *that* may not delete at the front of its clause (hence boldface), if it is not (in) the complement of an adjacent, overt verb. Here the verb is not overt.

6. a. Fay said Ray left and Tim that Jim stayed.
b. *Fay said Ray left and Tim Jim stayed.
c. Fay said Ray left and Tim $_V$e [**that** Jim stayed]

English speakers form questions by displacing the interrogative word to the front of its clause, deleting the original element in the position where it is understood; there is an operation *Copy wh-*. The simple expression *Who did Jay see?* has a representation in which *who* is copied to the front of the clause and the original *who* is deleted: Who did Jay see ~~who~~? It is the complement of *see* and the deletion conforms to our principle. However, we do not find sentences like (7a), which would have the structure (7b), where the boldface *who* may not delete, because there is no adjacent overt verb.

7. a. *Who did Jay introduce to Ray and who (did) Jim to Tim?

b. Who did Jay introduce ~~who~~ to Ray and who (did) Jim $_{V}$e **who** to Tim

We now return to our first example and see that the same deletion principle accounts for the distinctions noted. A reduced *is* is absorbed into the preceding word and becomes an integral part of it (a clitic). It is pronounced differently, depending on the last segment of the word it attaches to, as a voiceless 's' in *Pat's*, as a voiced 'z' in *Doug's*, and as an extra syllable in *Alice's* (8).

8. Pat's happy, Doug's happy, and Alice's here.

Now we can see why we do not reduce *is* in certain contexts. Example (9a) has a representation (9b), where *tall* is deleted, adjacent to the verb *is*, of which it is the complement. However, (9c) does not exist: the representation would be (9d), where the reduced *is* has been absorbed into *Tim* and therefore is no longer a separate word that may license the deletion of *tall*.

9. a. Kim is taller than Tim is.

b. Kim is taller [than Tim is ~~tall~~]

c. *Kim is taller than Tim's.

d. Kim is taller [than Tim's **tall**]

Similarly one finds (10a), which has the representation (10b), where *what* deletes, licensed by the adjacent verb whose meaning it completes. On the other hand, we do not have (10c), which would have the representation (10d), where the reduced *is* has been absorbed into *that* and cannot license the deletion of *what*.

10. a. I wonder what that is up there.

b. I wonder [what that is ~~what~~ up there]

c. *I wonder what that's up there.

d. I wonder [what that's **what** up there]

Things are getting complex, but nothing complex is learned by children in this regard (for details, see Ref 8). One's language is a complex system but the complexity can be understood in terms of an *interaction* between a simple principle at the genetic level and simple generalizations that are triggered in children on exposure to the speech around them.

In short, we have sketched four operations, each learnable by children on exposure to the relevant sentence type:

that ⇒ 0	*Peter said Kay left*
copy *wh-*	*Who did Jay see?*
gap V	*Jay saw Ray and Jim Kim*
is ⇒'s	*Kim's happy*

And we have one simple principle of the human language capacity, governing how elements are deleted. That principle (4) is the source of many distinctions. The interaction between intrinsic and learned elements captures the immense complexity of a person's language capacity, revealing distinctions that most people are unaware of.

Technically, corresponding to the 'operations' above, we say that children identify structural 'cues,' such as $_{C}$[0], indicating an empty sentence introducer or complementizer in sentences such as *Peter said Kay left*. Other examples of cues are $_{SpecCP}$[*wh-*], indicating a clause-initial *wh*-phrase (in the Specifier of the clausal phrase), $_{V}$[e], a gapped verb, or [NP+'s], indicating a cliticized verb. These cues are abstract pieces of structure in the child's I-language and they are *expressed* by sentences such as those above. That is, *Peter said Kay left*, meaning what it means (for example, with *[Kay left]* as the complement of *said*), can only be analyzed with the $_{C}$[0] cue in the child's internalized grammar; similarly *Jay saw Ray and Jim Kim* requires an analysis with an empty verbal position, i.e., the $_{V}$[e] cue.

LANGUAGE CHANGE

This view of the language capacity and its development in children obliges us to think about change in a certain way, which turns out to illuminate mysteries about how particular languages have evolved over time. Children acquire their grammar under the influence of their biology and their environment, as we have seen. The environment means language out there, the kinds

of things that children hear. Sometimes the ambient speech may shift a little, yielding new primary data so that some children hear different things, and then there may be new internal languages. That is when we have bumpy changes, phase transitions, and new I-language systems emerge. Small changes in E-language sometimes trigger new I-languages, with more far-reaching consequences.

We noted earlier that people's speech is individual and unique; people may have slightly different systems and furthermore they use their systems differently. For example, people differ in how they use tag questions like *It is raining, isn't it?* or in how they use the topic constructions favored by sports commentators: *Taylor, he throws the ball down the middle*. People's use of their system varies, sometimes randomly and sometimes there are statistical tendencies that can be identified, with certain construction types coming to be used more frequently.

Because of varying use, all children have different experiences even in relatively homogeneous language communities and hear different things around them with somewhat different frequencies. It is those experiences of external language, language out there, that trigger the development of a child's internal language. Because no two children have exactly the same experiences, there is always the possibility of new grammars emerging. Once that happens and some children have new I-languages, E-language changes further, because the new I-language entails that people speak differently. As a result, the new I-language may propagate through the population rather quickly.

In the next sections I consider two well-understood examples from the history of English (drawn from Ref 14), structural shifts that have made Shakespeare sometimes difficult for modern Londoners to understand, Chaucer still harder without special training, and *Beowulf* as incomprehensible as German.

Introduction of an Inflection Category

UG provides the structures available for people's grammars. Sometimes we see changes in these structures and thereby learn about the structures themselves and about what triggers them in children.

Speakers of present-day English use lexical verbs in the perfect aspect (11a) but not modal auxiliaries (11b). Sentences such as (11b) do not occur, although it is clear what it might mean: he has been able to understand chapter 4 but now cannot. Not only is it clear what it would mean, but equivalent forms occur in many languages closely related to English, which have not undergone the equivalent change.

11. a. He has understood chapter 4.
b. *He **has could** understand chapter 4.

Lexical verbs also occur in an infinitival *to* form (12a) but not auxiliaries (12b). Likewise, a lexical verb may occur with a modal (13a), but not a second modal (13b).

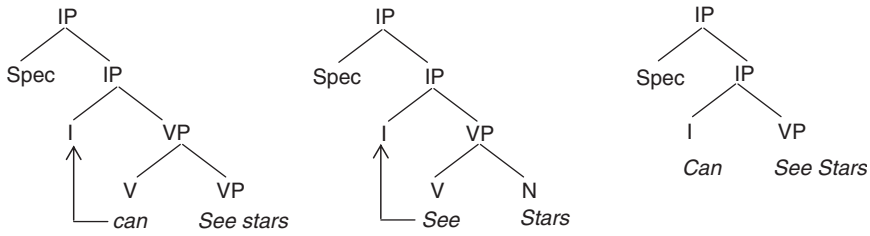
12. a. He wanted to understand.
b. *He wanted **to can** understand.
13. a. He will try to understand.
b. *He **will can** understand.

This is true of modern English but not of English up to the early sixteenth century. The (b) forms appear in historical texts, where we find combinations of modal auxiliaries as in (14a). Sir Thomas More was one of the last writers to use a modal auxiliary in a *to* infinitive (14b) and modal auxiliaries in the perfect aspect (14c).

14. a. I fear that the emperor will depart thence, before my letters **shall may** come unto your grace's hands (1532, Cranmer, *Letters*)
b. That appered at the fyrste **to mow** stande the realm in grete stede (1533, More, *Works* 885 C1), 'appeared at first to be able to stand the realm in good stead.'
c. If wee **had mought** convenient come togyther, ye woulde rather haue chosin to haue harde my minde of mine owne mouthe (1528, More, *Works* 107 H6), 'if we had been able to come together conveniently, ...'

These changes took place quickly, at the same time, and served to make Early Modern English (EME) different from Middle English (ME). It was a single change structurally. In ME all verbs could move to a higher Inflection position, as illustrated by the first two trees in (15), but by the early sixteenth century all speakers of English had classified words like *can*, *must*, and *may* no longer as verbs but as a new Inflectional category. Children had developed a new grammar and, from that single fact about people's grammars, it follows that each of the (11-13b) forms did not exist any more.

15.



We can also identify a plausible reason for this shift, and we see that language change shows domino effects. The change in category membership was due to prior morphological changes that had the effect of singling out the new modal auxiliary verbs from other verbs. ME saw a massive simplification of morphology. In Old English (OE), verbs had different forms depending on tense and agreement (person and number). So with a first person subject, *I*, a verb might be *fremme*, but a second or third person singular subject would require the forms *fremst* or *fremþ*, and third person plural would be *fremmaþ* (meaning 'do'). For speakers of modern German, some of these endings are familiar. Another verb in OE was *rīde*, *rītst*, *rītt*, *rīdaþ* ('ride'), and the past tense forms were *rād*, *ride*, *rād*, *ridon*. This is just a fraction of the complexity; there were strong verbs, weak verbs, and verbs of many classes. Most of this disappeared under the influence of intermarriage with Scandinavians.[14–16] Specifically, the bewildering range of endings on different classes of verbs reduced to just one ending in the present tense, *−s* in the third person singular. The major simplification of the morphology entailed that new syntactic structures emerged.

The verbs *can*, *may*, *must*, etc., the verbs whose behavior changed, belonged to a particular inflectional class in early English, the so-called preterit-presents. What was distinctive about that class was that, unlike all other classes of verb, there was no *−eth* or *−s* ending for the third person singular present tense forms. Verbs like *can*, *may*, and *must* never had the *−s* ending. When there were many kinds of inflectional classes, this was just one fact among hundreds. However, once the morphological system had eroded, the presence of an *−s* ending for the third person singular became the single, defining property of English verbal morphology, and these verbs lacked it. As a result, verbs with no *−s* ending became distinctive, and evidence shows that they were assigned to a new category. The evidence is the changes just described.

The new behavior of modal auxiliaries is one feature of EME, one way in which Shakespeare's language differed from that of Chaucer. And Shakespeare's language also differed from Jane Austen's because of other structural shifts, bumps in the history of English that gave rise to yet newer forms. This is what we turn to next.

Loss of V-to-I Movement

A little later English lost expressions that had been common and whose equivalents are normal in most modern European languages (16). Instead, there were new forms with a dummy, meaningless verb *do*, as illustrated in (17a, b).

16. **a.** ***Understands Kim** chapter four?
    b. *Kim **understands not** chapter four.
    c. *Kim **reads always** the newspapers.
17. **a. Does Kim** understand chapter four?
    b. Kim **does not** understand chapter four.
    c. Kim **always reads** newspapers.

The single structural shift here is that children ceased to acquire the operation that moved verbs to a higher Inflection position, illustrated in (15). That operation had yielded the three now-obsolete forms (16). Children had previously identified a cue $_{I}$[V], i.e., a verb occurring in the Inflection position. While English-speaking children ceased to identify this cue in the eighteenth century, children speaking other European languages continue to find it expressed sufficiently robustly in the input to play a role in their grammars.

This shift was due to two prior changes and we see another domino effect. The first was the recategorization of modal verbs that we just discussed, and the second was the emergence, first in the Westcountry (see Ref 17 but now MacWhorter argues that the change may reflect the influence of Cornish[18]), of 'periphrastic' *do* forms as an alternative option for expressing past tense: *John did leave*, *John did not leave*, instead of *John left* and *John left not*. As a result, the Inflection position was occupied by modal auxiliaries and by *do* and was not available as a target for verb movement in those instances. Thus, lexical verbs did not occur in that position as often as

before the days of periphrastic *do* and before modal auxiliaries were no longer verbs. As a result, there were fewer instances of the $_I$[V] cue and children seem to have failed to identify it; the evidence for the failure to identify the cue is the loss of the forms of (16) (for interesting work on children's attention to low-frequency forms, see Refs 19,20).

We have considered two structural shifts in the history of English, each of them yielding new forms or eliminating older forms, and changing the language. We have indicated how these changes can be analyzed and understood, given what the human language capacity is and how mature systems are acquired. They unify disparate phenomena that co-occurred, in that they provide a single structural change at a certain level of abstraction that unifies a range of phenomena. Second, in each case, we point to prior changes in external language, the things that children heard, such that we can link those changes to the postulated change in grammars. That is, if language out there changes in certain ways, it may trigger new grammars in children. External language and internal grammars are different kinds of objects, but they interact: there can be no new I-language without new E-language. Put differently, children will not develop new I-languages unless they have different experiences. We have seen domino effects: by virtue of the human language capacity, if one thing changes, other changes follow, and new languages entail other new languages. Once some children have a new I-language, that entails different E-language for others, because they speak differently, not using (11-13b, 14, 16); that facilitates the spread of the new I-language through the population. The details of the analyses will change as linguistic theory develops, but in this sense the structural shifts constitute the right *kind* of explanation, given the way we have construed the problem.

The central empirical question is what is the nature of the cues that children find, the building blocks of the grammar they acquire; this is illuminated by work on acquisition and change. Ref 3, building on earlier work reported in Ref 21, argues that some cues need to be formulated on a smaller scale, just as other work has argued for micro-parameters.[22,23]

CONCLUSION

I have portrayed language as a complex system and it can usefully be viewed in the context of complexity science, a perspective emerging from work in physics and the biological and other sciences. Defining complexity science is difficult but catastrophe and chaos theories were its antecedents, focusing on nonrepeating behavior with sensitive dependence on initial conditions. We have seen that changes in external language, morphological changes for example, may entail new categories in I-language and therefore different syntactic patterns.

Complex systems change in ways that often manifest 'emergent phenomena' and tipping points, which are hallmarks of language acquisition and change. We have seen that properties emerge in young children that go beyond what they experience and our poverty-of-stimulus arguments are based on such discrepancies. Furthermore, if external language shifts a little so that children hear different things, periphrastic *do*, for example, there can be a single shift in emergent I-languages such that many phenomena change at the same time, a tipping point or 'phase transition.'

We have the opportunity to study language change in the context of the dynamics of complex systems quite generally, in domains from weather patterns to protein folding to the collapse of economic markets, part of a much larger enterprise. We can learn from colleagues in other sciences but linguists have succeeded in developing productive theories of language acquisition that yield explanations for structural shifts in language over time, including major phase transitions. Complexity science is about change, flux, dissolving and re-created order; it is concerned with contingent accidents of history.[24–27] Diachronic linguists have much to contribute to this new, unified science.

Perhaps this is not surprising, since linguistics began as a historical discipline in the nineteenth century, concerned to understand the relationship between languages and how they change across generations. These successes enabled linguists to play a central role in the late nineteenth century, when biologists sought to understand the relationship between species and their history and early political scientists sought to understand change in political systems. Evolutionary biologists like Darwin and political scientists like Marx read the linguists of their day and perhaps that will happen again as many sciences pursue the common themes of complexity science.

Now linguists have successful theories of aspects of language change embedded in analyses of language acquisition and these theories have some explanatory depth, as I hope to have shown here.

NOTES

[a]The first part of the paper is similar to the first part of Ref 3 but then takes a different turn, toward complexity science.

REFERENCES

1. Jesperson O. *Language: Its Nature, Development, and Origin*. London: Allen & Unwin; 1922, Croft, W. Explaining language change: An evolutionary approach. Harlow, Essex: Longman; 2000.
2. Paul H. *Prinzipien der Sprachgeschichte*. Tübingen: Niemeyer; 1880.
3. Lightfoot DW, Westergaard MR. Language acquisition and language change: inter-relationships. *Lang and Ling Compass* 2007, 1:396–416.
4. Haegeman L. *Introduction to Government and Binding Theory*. Oxford: Blackwell; 1994.
5. Hornstein NR, Nunes, J, Grohmann, KK. *Understanding Minimalism*. Cambridge: Cambridge University Press; 2005.
6. Lasnik, H, Lohndal, T. Government-binding/Principles and parameters. *WIRES*. This volume.
7. Chomsky N. *Syntactic Structures*. The Hague: Mouton; 1957.
8. Lightfoot DW. Minimizing government: deletion as cliticization. *The Ling Rev* 2006, 23:97–126.
9. Chomsky N. *Knowledge of Language: Its Nature, Origin and Use*. New York: Praeger; 1986.
10. Lightfoot DW. Plato's problem, UG and the language organ. In McGilvray, James, ed. *The Cambridge Companion to Chomsky*. Cambridge: Cambridge University Press; 2005, 42–59.
11. Crain S, Thornton R. *Investigations in Universal Grammar: A Guide to Experiments on the Acquisition of Syntax and Semantics*. Cambridge, MA: MIT Press; 1998.
12. Lightfoot DW. The child's trigger experience: degree-0 learnability. *Behav Brain Sci* 1989, 12:321–334.
13. von Humboldt W. 1836. *Über die Verschiedenheit des menschlichen Sprachbaues und ihren Einfluss auf die geistige Entwicklung des Menschengeschlechts*. Royal Academy of Sciences of Berlin [Linguistic variability and intellectual development, transl. Buck, GC, Raven, FA. 1971. University of Pennsylvania Press, Philadelphia].
14. Lightfoot DW. *How New Languages Emerge*. Cambridge: Cambridge University Press; 2006.
15. O'Neil W. The evolution of the Germanic inflectional systems: a study in the causes of language change. *Orbis* 1978, 27:248–285.
16. Kroch A, Taylor A. The syntax of verb movement in Middle English: Dialect variation and language contact. In van Kemenade A, Vincent N, eds. *Parameters of Morphosyntactic Change*. Cambridge: Cambridge University Press; 1997.
17. Garrett A. On the origin of auxiliary *do*. *Engl Lang Linguist* 1998, 2:283–330.
18. McWhorter J. What else happened to English? A brief for the Celtic hypothesis. To appear in *English Language and Linguistics*. (In press).
19. Singleton JL, Newport EL. When learners surpass their models: the acquisition of American Sign Language from inconsistent input. *Cogn Psychol* 2004, 49:370–407.
20. Hudson Kam C, Newport EL. Regularizing unpredictable variation: the roles of adult and child learners in language formation and change. *Lang Learn Dev* 2005, 1:151–195.
21. Westergaard MR. Microvariation as diachrony: a view from acquisition. *Journal of Comp Germ Ling* 2009, 12:49–79.
22. Kayne R. *Movement and Silence*. Oxford: Oxford University Press; 2005.
23. Vangsnes ØA. Microparameters for Norwegian *wh*-grammars. *Ling Vari Yearbook* 2005, 5:187–226.
24. Waldrop M. 1992, *Complexity: The Emerging Science at the Edge of Order and Chaos*. New York: Simon & Schuster.
25. Ball P. *The Self-made Tapestry: Pattern Formation in Nature*. Oxford: Oxford University Press; 2001.
26. Epstein JM. *Generative Social Science: Studies in Agent-based Computational Modeling*. Princeton: Princeton University Press; 2007.
27. Miller, JH, Page, SE. *Complex Adaptive Systems: An Introduction to Computational Models of Social Life*. Princeton: Princeton University Press; 2007.

FURTHER READING

Lightfoot DW. *The Development of Language: Acquisition, Change and Evolution*. Oxford: Blackwell; 1999.
Roberts IG. *Diachronic Syntax*. Oxford: Oxford University Press; 2007
Camazine S, Deneubourg J-L, Franks NR, Sneyd J, Theraula G, Bonbeau E. *Self-organization in biological systems*. Princeton: Princeton University Press; 2001.

