Tomalin’s monograph offers an in-depth historiographical analysis of the influences of the formal sciences upon the development of Transformational Generative Grammar (TGG). The particular time span under investigation ranges from 1951–1955 (Chapter 4) and from 1955–1957 (Chapter 5). Chapters one through to three deal with the historical path that eventually lead to the rise of TGG. The first decades of the twentieth century receive special attention.

**Chapter 1: Introduction**

He then reviews existing attempts at capturing historical perspectives on TGG development. The work of Noam Chomsky built the foundation for TGG, and if one wishes to discuss TGG in any way, one has to take stock of Chomsky’s intellectual heritage. The extensive and ever-growing body of literature about the historical dimensions of Chomsky’s work focuses on certain points; it necessarily neglects others. Newmeyer (1986) is an exemplary case in point. However, Tomalin perceives a certain lacuna in the coverage of the intellectual genesis of Chomsky: he feels that all of the existing accounts fail to address a formative period at the beginning of Chomsky’s intellectual career in the 1940s. As will be shown in the reviewed monograph, Yehoshua Bar-Hillel’s influence on Chomsky was much more significant than heretofore acknowledged. The author takes care to critically distance himself from Newmeyer’s perspectives in the sense that Newmeyer’s account of linguistic history does not include “an intense investigation of the bewildering complexity of actual events” (p. 17). It can generally be stated that all the reviewed historiographical accounts are in essence missing something; they simply do not discuss the deep links extant connecting the formal sciences to linguistics, TGG in particular.
Chapter 2: The consequences of analysis

The author’s starting point for historiographical analysis is “the emergence of the calculus as an identifiable set of algorithmic procedures in the late seventeenth century” (p. 21). The calculus is generally associated with two names: Gottfried Wilhelm Leibniz (1646–1716) and Isaac Newton (1643–1727). Leibniz’s publication of ‘A new method for maxima and minima’ in 1684 was particularly influential. Interestingly, neither Leibniz nor Newton were able to construct axiomatic foundations for the calculus. This unsatisfactory state led mathematicians of the nineteenth century to develop a renewed interest in the questions concerning analysis. One of the most influential mathematicians proved to be Georg Cantor (1845–1918), who was involved in a movement called “the arithmetisation of analysis” (p. 28). It was Cantor who discovered some striking paradoxes when working on the theory of sets. One startling result was that not all infinite sets are of the same size. For instance, the set of whole numbers is infinite ({1, 2, 3, …}), and the set of even numbers is also (countably) infinite ({2, 4, 6, …}). Yet to consider these sets to be of the same size seems counterintuitive since the set of even numbers is a subset of whole numbers and should therefore be smaller. The attempted solutions to these puzzling results led to three main strands of mathematical thought. Tomalin writes: “Indeed, the difficulties resulting from transfinite arithmetic largely inspired the various proposals for securing the foundations of mathematics that coalesced into the three dominant ideologies that came to be known (rather too simplistically perhaps) as Logicism, Formalism, and Intuitionism” (p. 32).

Logicism: This strand of mathematics is intimately linked to Gottlob Frege (1848–1925). It was Frege who first suggested that logic could be instrumental in providing a secure foundation to mathematics in general. This approach somewhat culminated in the works of Alfred Whitehead (1861–1947) and Bertrand Russell (1872–1970). Their joint publication *Principia Mathematica* (1910–1913) is still the most influential attempt to reduce mathematics to logic (cf. pp. 36–37).

Formalism: David Hilbert (1862–1943) was one of the leading thinkers of this movement and his development of ‘proof theory’ engendered much later research into the foundations of mathematics. Two fundamentally important notions can be identified here: completeness and consistency. Tomalin summarizes: “The central task was to construct a metamathematical proof that would demonstrate the validity of a given axiom set. For Hilbert, the validity of such a set was always closely related to the technical notions of completeness and consistency” (p. 43).

Intuitionism: Luitzen Brouwer (1881–1966) is closely associated with this mathematico-philosophical strand. Brouwer holds that mathematical symbols and the mathematical objects that they express are not equivalent. Mathematics consists primarily of a process of mental construction of mathematical objects. In the 1920s Brouwer began to show how this could be accomplished.

The body of literature that tried to make some of the general points and assumptions available to the wider readership is enormous. Quine’s *Mathematical Logic* (1940), Church’s *Introduction to Mathematical Logic: Part I* (1944) and Kleene’s *Introduction to Metamathematics* (1952) are three important instances. Hans Reichenbach’s *Elements of Symbolic Logic* (1947) and Paul Rosenbloom’s *Elements of Mathematical Logic* (1950) are of particular interest, since the authors attempted to apply logic to facilitate the study of language in these publications.
Chapter 3: Mathematical linguistics

One central feature of axiomatic methods is the requirement that assumptions be stated explicitly. Bloomfield writes that “the postulational method can further the study of language, because it forces us to state explicitly whatever we assume, to define our terms, and to decide what things may exist independently and what things are interdependent” (Bloomfield 1926: 153). Note that Bloomfield was always content with stating the definitions and assumptions in ordinary language. Tomalin says that he did not use mathematical symbolization in any significant way. Let me elucidate this by looking at the first three definitions and one assumption taken from Bloomfield (1926: 154–155).

1. Definition. An act of speech is an utterance.
2. Assumption 1. Within certain communities successive utterances are alike or partly alike.
3. Def. Any such community is a speech-community.
4. Def. The totality of utterances that can be made in a speech-community is the language of that speech-community.

No formal symbolic language is utilized here. It was F. W. Harwood who introduced a specific type of symbolic language; this consequently led to a reduction of the amount of ambiguity in comparison to Bloomfield. Harwood was influenced by Yehoshua Bar-Hillel, and it was Bar-Hillel who showed how recursive definitions could fruitfully be applied to the study of language. The author places particular emphasis on the fact that recursive function theory influenced the development of syntactic theory specifically in the early 1950s. It was in Bar-Hillel’s paper ‘On recursive definitions in empirical science’ (1953) where the potential benefits of the adoption of recursive mechanisms were discussed. According to Tomalin, Bar-Hillel’s influence upon Noam Chomsky was significant in the early 1950s—a fact expounded on in a later chapter.

Tomalin’s larger perspective on the sociocultural background of the then dominant strands of scientific thinking also considers the influence of the so-called Vienna Circle. Tomalin may belong to only a few historiographers of linguistics who have outlined its importance and influence on linguistic thinking in North America. Carnapian positivism was a prevalent approach among philosophico-scientific circles, but only through the mediation by the writings of Willard van Orman Quine and Nelson Goodman did it have any lasting effect on Chomsky’s development of TGG. The two sub-chapters dealing with this are labelled ‘Constructional system theory’ and ‘Constructive nominalism.’ For Goodman, notions such as simplicity and economy were crucial in any systematic logical ‘construction’ of the world in a positivistic Carnapian sense. In the late 1940s Chomsky started to study philosophy—taught by Goodman. The first direct contact is established between the founder of TGG and a formal philosophical theory—again an incident to be dealt with in a later chapter. Tomalin then assesses the dual intellectual developments of Quine and Goodman; suffice it here to quote that “Quine’s assault upon, and Goodman’s defence of, logical empiricism…all stimulated Chomsky while he was in the process of developing TGG, and it is crucial to recognise that these developments were largely provoked by the constructive nominalist research programme that Goodman and Quine had propounded in the 1940s” (p. 88).
Chapter 4: Systems of syntax: 1951–1955

This chapter introduces the early work of Noam Chomsky. It explicitly seeks to outline Goodman’s and Quine’s influence on the earliest developmental stages of TGG. The chapter claims to show that Chomsky was deeply inspired by the ideas of Goodman, Quine, and also Zellig Harris.

Tomalin argues that Goodman’s thinking can be identified in Chomsky’s thesis *The Morphophonemics of Modern Hebrew* (1951). At that time, Goodman was working on simplicity measures for the bases of constructional systems. These being for the most part philosophical and epistemological questions (How do we construct a coherent representation of the world from some data acquired through our sensory system?), Chomsky early on starts to adapt methodological guidelines such as simplicity, economy, and compactness, utilizing them in syntactic descriptions and analyses. Apparently, prior to his 1951 publication, Chomsky had already become familiar with Goodman’s (1943) ‘On the simplicity of ideas.’

Zellig Harris aimed at describing natural language in such a way as to be of pedagogical utility—such a goal has never interested Chomsky. If linguistic description does not serve such special pedagogical purposes, then the leading principles governing the construction of a grammar must be those of general simplicity and elegance (cf. p. 114). This point is made most forcefully in his 1975[1955] publication *The Logical Structure of Linguistic Theory* (LSLT) (I leave aside here the publication history, 1955 is the key year). One major aspect of this pivotal work is the focus on so-called evaluation procedures. Put crudely, an evaluation procedure helps us decide which grammar of a given set of possible grammars is more adequate, that is, which corresponds best to a given linguistic corpus. The formerly used notion of discovery procedure was rejected chiefly for reasons of being too strong a condition on the way a grammar is unearthed and formulated. Throughout LSLT, Chomsky adduces arguments as to why one cannot mechanically ‘discover’ the grammar of a given language from a representative sample of that language (i.e. a corpus). As a linguist, the only thing one can do is to compare already existing grammars that would generate this language and find criteria why one grammar should be favoured over the other.

Simplicity is one of those criteria. Goodman and Quine are mentioned in connection with this (cf. LSLT: 114, Fn. 2).

Now, how is the simplicity of competing grammars measured, or made measurable? One way is to simply measure the length of a given grammar via counting the symbols one needs to represent it. Only the length of ‘consolidated’ grammars can be measured. As Tomalin does not really explicate this notion of ‘consolidation,’ I here refer to Chomsky’s own use of the term: “To evaluate a grammar of conversions…in terms of its simplicity, we construct notations which permit the consolidation of similar statements and we then measure ‘degree of generalization’ (which we have tentatively taken as the measure of simplicity) as length of the consolidated grammar” (*LSLT*: 119). Having introduced rules of conversion and bracketing, Chomsky writes:

We can now convert a consolidated grammar into a unique sequence of conversions. The notational devices we have introduced permit certain selected features of similarity among statements of the grammar…to effect a decrease in length, so that grammars whose rules have these features are more highly valued. Thus these constructions can be
understood as offering an analysis for certain aspects of simplicity. Whether they provide a correct or sufficient account can only be determined by investigating the effects of using them in actual grammatical work. \(\text{LSLT}: 123–124\)

It should become clear that the notion of ‘consolidation’ remains mysterious; this point is not highlighted by Tomalin.

Tomalin then traces back some of the key elements of Chomsky’s thinking to a paper published in 1953 called ‘Systems of syntactic analysis.’ He, Tomalin, outlines the centrality of this paper to the genesis of TGG (cf. p. 125). Chomsky’s assessment of then prevalent semantic analyses is recounted and his critical views towards those approaches are outlined. Since Tomalin does not provide any examples but only refers to them, here is one: “If another example is needed, consider \textit{The man is tall and thin}, from which we can infer \textit{The man is tall}, as opposed to the ‘syntactically identical’ \textit{The flag is black and white}, from which we cannot infer \textit{The flag is black}; no one would say that a newspaper page is black. Such examples can easily be multiplied” (Chomsky 1955: 40). Some significant parts of these strands of Chomsky’s thinking were certainly influenced by analytic philosophy, as claimed by Tomalin (cf. p. 136). However, Chomsky’s general critical stance towards logical semantics, interpreted as a model of natural language, has never been dogmatic. Applying logic to the construction of a linguistic theory is something very different than expecting logic to be a model of actual linguistic behaviour.

**Chapter 5: Transforming generative grammar: 1955–1957**

During the 1950s, various stochastic models were common, most notably the well-known Markov model. The core of this model is a set of conditional probabilities that determine the transitional likelihood of one element or symbol following another. In 1956, Chomsky showed that no such model was adequate as a grammar of the English language (cf. pp. 148–149). More generally, grammaticality and frequency are not related. This can easily be perceived via Chomsky’s famous sentences \textit{Colorless green ideas sleep furiously} and \textit{Furiously sleep ideas green colorless}. Both sentences can be said to appear equally infrequently in the English language, yet the first is considered grammatical, the second is not.

When discussing chapter four, I already mentioned the swing from discovery to evaluation procedures, especially with regard to \textit{LSLT}. In the introduction to \textit{LSLT}, formulated in 1973 and published in 1975, Chomsky says:

> By 1953, I had abandoned any hope of formulating taxonomic “discovery procedures” and turned my attention entirely to the problems of generative grammar, in theory and in application…

I was particularly impressed by Nelson Goodman’s work on constructional systems (see his \textit{Structure of Appearance}, Harvard University Press, 1951)….But Goodman’s ongoing critique of induction seemed to point in a rather different direction, suggesting the inadequacy in principle of inductive approaches….Quine’s critique of logical empiricism also gave some reason to believe that this line of inquiry might be a plausible one. Quine argued that the principles of scientific theory are confronted with experience as a
systematic complex, with adjustments possible at various points, governed by such factors as general simplicity. Perhaps, then, analogous considerations hold for “the fundamental problem of linguistic theory” (LSLT: 33).

In Tomalin’s view, it was mainly Goodman and Quine who drove Chomsky towards a more rationalist, non-empiricist stance (cf. p. 154).

The author further on discusses the role of four key concepts constitutive of TGG: (1) **linguistic (and/or constructional) levels** (pp. 156–159), (2) **transformation** (pp. 159–168), (3) **recursivity (recursive rules)** (pp. 168–174), and (4) **formal syntax** (pp. 174–182). Each notion is a complex topic in itself, and Marcus Tomalin acknowledges this correctly. In the construction of linguistic levels, he shows how Chomsky has probably been influenced by Goodman’s and Quine’s notions of constructional system theory. In *LSLT*, Chomsky explicitly refers to Goodman and Quine when it comes to the construction of so-called L-markers (cf. *LSLT*: 107, Fn. 4). The notion of transformation was certainly entertained by Zellig Harris, especially to analyse structures longer than a sentence. Now, when Chomsky uses the term ‘transformation’ he intends to mean something rather different. Tomalin concludes that for Chomsky, transformations cause a change in the order of elements in existing sentences (cf. p. 168). These sentences have been formed by the application of, for example, phrase structure rules. Linguistic levels and transformations constitute a pivotal part of *LSLT* (chapters III, IX, and X). Recursivity is discussed in chapter seven of *LSLT*. It is suggested that recursive rules have their roots in recursive function theory. Two key figures should be named here: Emil Post and the above mentioned Yehoshua Bar-Hillel. Finally, formal syntax refers to syntax dealing exclusively with the shape and arrangement of symbols as opposed to the meaning of those symbols. From the outset, Chomsky has issued a cautionary note on the program of formalization.

A formalized theory, then, is one that is formulated in accordance with certain clear canons of rigor and precision; definitions are given explicitly in such a way that defined terms are always eliminable, and the axioms and methods of proof are precisely stated. We can thus have a formalized theory purporting to be about form or about meaning. A formalized theory is, of course, not necessarily an acceptable or enlightening theory….What concerns us here is the possibility of a formalized theory of linguistic form, and the problems involved in constructing such a theory. (*LSLT*: 83)

As formulated this way, formalization can never be an end in itself; on page 58 (not 59, as indicated by Tomalin), Chomsky says that “formalization can play a very productive role in the process of discovery itself.” A general, abstract, and formal theory of linguistic structure becomes fruitful and of explanatory power if a specific grammar of a particular language is derivable from this formal theory. Formalization is only interesting if the outcome may engender a particular grammar or grammars.

**Chapter 6: Conclusion**

According to Tomalin, Hilbert’s influence inspired Bloomfield to be an early proponent of the axiomatic-deductive method in linguistics. In the following developmental stages of Chomsky’s TGG, Bar-Hillel acquires central importance, a point illustrated at length throughout the
monograph under review. Goodman’s and Quine’s notions of simplicity criteria subsequently found their way into early papers published by Chomsky and, of course, *LSLT*. The following quote may stand uncommented:

> With its focus on syntax as opposed to semantics, with its use of a logic-based notational system, with its identification of the analogy between a proof and the generation of a grammatical sentence, and with its use of such procedures as recursive definitions and axiomatic deduction, TGG unambiguously reveals its associations with the formal sciences. (p. 186)

Tomalin then goes on to outline ground yet to be covered by the historiography of linguistics. In particular, Chomsky’s interactions with Eric Lenneberg (1921–1975) may be of significant import here. More recent transformations and developments of the pivotal notion of recursion are then discussed, especially with regard to its use in *The Minimalist Program* (1995) and subsequent publications. Also linked to more recent models are the notions of simplicity and economy. Tomalin argues that the motivation for the retention of those notions has remained constant throughout the decade-long development of TGG (and later Minimalism). How exactly the terms simplicity and economy have survived (and partly been reinterpreted) as a kind of constant in Chomsky’s thinking is yet to be shown.

**Assessment**

The reviewed monograph is not for the ‘interested layman.’ It is not even for the interested ‘undergraduate student.’ Is it for those who have dedicated considerable time to the reading of Chomsky’s texts? Well, partly yes—partly no. It is at least debatable whether chapter two (‘The consequences of analysis’) could not have been dispensed with. Very elaborately done and intriguing were the discussions of the powerful intellectual influences Goodman and Quine exerted on Chomsky’s thinking. This was particularly lucid in the discussions of Chomsky’s early 1950s publications—in *LSLT* especially. Since Chomsky mentions Goodman and Quine several times in *LSLT* footnotes, Tomalin provides highly valuable context that aids the reader in understanding the crucial links between Chomsky’s theory and his intellectual predecessors’ work. Maybe the monograph would have benefited from shortening the second chapter and compensating this loss in bulk with an even more extensive discussion of Goodman and Quine. Also, an example or two, actually deserving the name, would not have been detrimental to the overall clear and quite revealing exposition of the relation of the formal sciences to TGG.

**Notes**

1 I am told by a mathematician that the term ‘calculus’ is never to be used with a definite article. However, I here adhere to Tomalin’s use.

**References**

