



Reply to comment

Linguistic complex networks: Rationale, application, interpretation, and directions

Reply to comments on “Approaching human language with complex networks”

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Amid the enthusiasm for real-world networks of the new millennium, the enquiry into linguistic networks is flourishing not only as a productive branch of the new networks science but also as a promising approach to linguistic research. Although the complex network approach constitutes a potential opportunity to make linguistics a science, the world of linguistics seems unprepared to embrace it. For one thing, linguistics has been largely unaffected by quantitative methods. Those who are accustomed to qualitative linguistic methods may find it hard to appreciate the application of quantitative properties of language such as frequency and length, not to mention quantitative properties of language modeled as networks. With this in mind, in our review [1] we restrict ourselves to the basics of complex networks and the new insights into human language with the application of complex networks. For another, while breaking new grounds and posing new challenges for linguistics, the complex network approach to human language as a new tradition of linguistic research is faced with challenges and unsolved issues of its own. It is no surprise that the comments on our review, especially their skepticism and suggestions, focus on various different aspects of the complex network approach to human language. We are grateful to all the insightful and penetrating comments, which, together with our review, mark a significant impetus to linguistic research from the complex network approach. In this reply, we would like to address four major issues of the complex network approach to human language, namely, a) its theoretical rationale, b) its application in linguistic research, c) interpretation of the results, and d) directions of future research.

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a) Theoretical rationale. We argue that the models and measures of complex networks provide a necessary and operational methodology for system thinking in linguistics. A representative of the system perspective on human language, as mentioned in our review [1], is the Saussurean conception of language as a system. It is noteworthy that some theories along this line emphasize that language is a network [2,3]. In his comment, Hudson [4] shows that lexicon, together with the relations between words at various levels of analysis, is a network. With traditional linguistic methods, language as a system (or network) can hardly be examined in empirical terms. According to Ferrer-i-Cancho [5], statistics does not play a central role in the work of Saussure and many of his successors. The application of complex networks helps to change this situation and makes it possible to examine the quantitative properties of language at the system-level.

In his comment, Cech [6] doubts whether (dynamic) linguistic networks, which are based on observable language use (*parole* in Saussure's term), can model the language system (*langue* in Saussure's term), which is defined by Saussure as the ideal and abstract system of linguistic units and their relations. We would like to point out that the dichotomy between *langue* and *parole* is itself ideal. Even if *langue* as what is ideal and abstract really exists, it cannot be immediately observed and instead must be inferred on the basis of *parole* as the observable use of language. Moreover, even though we accept the distinction between the ideal language system and actual language use, there is perhaps no good reason to believe that the two are totally unconnected. Otherwise, we might need complicated mechanisms to bridge linguistic knowledge and on-line language use, which would not help to save the effort involved in language processing and acquisition. The usage-based approach [7,8], for instance, assumes that the units of actual language use are units of the mental storage of language. Linguistic networks based on actual language use, therefore, can at least shed light on the ideal and abstract language system even though they may not be ideal models of the latter.

In addition to the Saussurean conception of language system, other lines of system thinking also deserve considerable attention in linguistics. The comment of Ferrer-i-Cancho [5], for instance, calls for recognition of the work of Zipf [9] both as a pioneer of the view of language as a complex system and as the founder of modern quantitative linguistics. A fundamental consideration underlying Zipf's understanding of the organization of language (e.g., lexicon) as a complex system is the balance between the need for effort saving of the hearer and that of the speaker. Although Zipf's work is not mentioned in the introduction part of our review, his idea of the hearer–speaker balance has been used for the interpretation of scale-free degree distribution of linguistic networks investigated in line 1 of our review [1].

b) Application of complex networks in linguistic research. As shown by Yu and Xu [10], a major advantage of complex networks in linguistic research is the capability to capture the holistic (or global) properties of language, which are indicated by the topological measures of linguistic network models. As we argue in our review [1], the topological properties of linguistic networks characterize the macro structure of language. This macro structure generally pertains to language as a system, for which the whole is greater than the sum of parts. In other words, this global characterization of language with the complex network approach cannot be achieved with traditional linguistic methods, which generally focus on microscopic linguistic features. In her comment, Chen [11] claims that the complex network approach has enabled researchers to analyze linguistic features beyond the sentence level. With models and measures beyond detailed linguistic features, the complex network approach can be used for system-level characterization of human language and applied as potential methodology for linguistic branches such as typology and first language acquisition, whereby a global characterization of language may play a role. Also as noticed by Chen [11], the topological properties of linguistic networks may integrate information concerning linguistic features at different language levels. For instance, Liu and Xu [12] have shown that the topological properties of syntactic dependency networks with word forms as vertices reflect both syntactic and morphological features emergent at the system-level. In typological comparison of languages, for instance, it is possible to use the same set of topological properties of linguistic networks to reveal the overall similarities and differences of languages at different language levels.

Complex networks constitute a new means of quantification of linguistic properties, with different models and measures from those often used in the existing body of linguistic research. In his comment, Köhler [13] compares how language data are dealt with in linguistic networks research and traditional quantitative linguistics. The complex network approach to human language focuses on “networked” texts, instead of the texts as commonly dealt with in traditional quantitative linguistics. Köhler [13] also rightly views the difference between the measures of complex networks and those in traditional quantitative linguistics as the distinction between *relational data* and *attribute data* [14]. By focusing on networked texts, the complex network approach employ measures concerning the relations

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