Modeling morphological development using Network Analysis

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The dynamic nature of language development entails growing complexity of networks between forms and functions, as well as between functions and between forms. Network Analysis in linguistics has been used to explain dynamic relations especially in the realm of semantic networks, analyzing their structure and development. The present paper proposes a novel methodology to account for emerging patterns of use by analyzing morphological form-form relations as networks. We account for the relations between the Semitic constructs of roots and verb patterns (*binyanim* 'buildings'), the morphological building blocks of Hebrew verbs. We analyze new Hebrew corpora of input to young children, and children's own output, in dyadic and peer interactions: Child speech in interaction with caregivers between the ages of 1;8 to 2;2 years, child peer talk of six age groups (2;0–2;6, 2;6–3;0, 3;0–4;0, 4;0–5;0, 5;0–6;0, 7;0–8;0), adults' speech to infants (3 months, 6 months, 9 months, 12 months), and to toddlers (1;8–2;2), and storybooks for young children. Using network analyses of the relations between roots and patterns in each corpus, we reveal emerging patterns of links, manifested as root-based and pattern-based derivational families. We show that the morphological development of the Hebrew verb category can be modeled by the measures of (i) network hubs (based on degree centrality), as representing patterns' linkage, (ii) changes in node centrality, as representing importance within networks, (iii) network density, as representing growth potential, and (iv) network modularity and community structure, as representing emergent morphological categories. Our findings indicate that in both child speech and child directed speech networks linkage increases with age, nodes change centrality within the network, density values decline with age, networks become less modular, and larger, more coherent communities emerge. These findings add another facet to the quantification of language development, specifically modeling the emergence of morphological categories and system-level productivity.