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Complexity in Language Learning and Treatment

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Abstract

Purpose—To introduce a Clinical Forum focused on the Complexity Account of Treatment Efficacy (C. K. Thompson, L. P. Shapiro, S. Kiran, & J. Sobecks, 2003), a counterintuitive but effective approach for treating language disorders. This approach espouses training complex structures to promote generalized improvement of simpler, linguistically related structures. Three articles are included, addressing complexity in treatment of phonology, lexical-semantics, and syntax.

Method—Complexity hierarchies based on models of normal language representation and processing are discussed in each language domain. In addition, each article presents single-subject controlled experimental studies examining the complexity effect. By counterbalancing treatment of complex and simple structures across participants, acquisition and generalization patterns are examined as they emerge.

Results—In all language domains, cascading generalization occurs from more to less complex structures; however, the opposite pattern is rarely seen. The results are robust, with replication within and across participants.

Conclusions—The construct of complexity appears to be a general principle that is relevant to treating a range of language disorders in both children and adults. While challenging the longstanding clinical notion that treatment should begin with simple structures, mounting evidence points toward the facilitative effects of using more complex structures as a starting point for treatment.

Keywords

treatment; complexity; generalization

This Clinical Forum focuses on complexity in treatment of language deficits and includes three articles. Each discusses complexity as it pertains to treatment of disorders in a particular language domain: phonological, lexical-semantic, and syntactic. In all domains, greater treatment gains have resulted when more complex, as compared with simpler, language material becomes the focus of treatment.

In the first article, Gierut (2007) discusses the relevance of complexity in treatment of children with functional phonological delays and summarizes several studies that have experimentally examined the effects of training complex phonological material. Results have shown that training children to produce more complex (marked) structures such as affricates results in learning of simpler but related unmarked structures (e.g., fricatives). Similarly, training clusters results in generalization to singletons, and training clusters with greater sonority (e.g., /kw/) affects learning of clusters with lesser sonority (e.g., /bl/). In all

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cases, training the simpler target sounds does not affect the more complex ones. These findings indicate that children with phonological delays, like normally developing children, are able to utilize complex input to advance their phonological systems—a general premise of language learnability theory.

The second article (Kiran, 2007) focuses on complexity in treatment of lexical-semantic impairments in individuals with aphasia and severe naming deficits. Kiran summarizes work showing that training more complex, atypical items within a semantic category (e.g., *penguin* in the category of *birds*) advances access to simpler, typical items within the category (e.g., *robin*). The opposite training paradigm does not operate as effectively—that is, training simpler items has no effect on more complex ones. These findings suggest that training items that emphasize the featural variation within a category, as well as features of the category prototype, strengthens access to all category items.

In the syntactic domain, the third article (Thompson & Shapiro, 2007) highlights the benefits of training complex, rather than simple, sentence structures in individuals with agrammatic aphasia. Thompson and Shapiro summarize a series of studies showing that training production and comprehension of complex sentences with *wh*-movement, such as object relative structures (e.g., “The man saw the artist who the thief chased”), results in generalization to simpler sentences with the same type of movement (e.g., object cleft structures and *wh*-questions, such as “It was the artist who the thief chased” and “Who did the thief chase?” respectively), as well as simple active forms. The opposite training order, however, does not facilitate generalization: Training *wh*-questions does not affect the more complex forms. Further, generalization does not result, in either case, to sentences that require movement of a different type (i.e., NP-movement) such as passive sentences (e.g., “The artist was chased by the thief ”). These findings suggest that generalization occurs across structures with similar syntactic properties and that when these properties are consistent across sentences, training the more complex forms influences production and comprehension of simpler forms.

The findings reported in all articles were derived by using single-subject controlled experimental paradigms in which some participants were trained to produce structures with greater complexity while others were trained on simpler structures, with the primary dependent variable being generalization to untrained structures. This methodology allows researchers to examine acquisition and generalization patterns as they emerge during treatment (see Thompson, 2006). In all domains, the complexity effect is robust. It has been replicated both within and across participants with similar language deficit patterns in several separate but related studies.

The crux of this work lies in how complexity is conceptualized. This requires careful consideration of complexity hierarchies in the language domain of interest. The articles in this issue highlight how complexity can be considered within the phonological, semantic, and syntactic domains. Gierut emphasizes that in the area of phonology, a description of the system, the hierarchical organization of elements within the system, and the lawful relationship among elements required or allowed by the system must be considered. Kiran suggests that when determining semantic complexity within a category, the variation of semantic features, featural overlap of items, and the distance between category examples and the prototype within a category be considered. Each category can be conceptualized within multidimensional space, with typical (simple) examples in the center of semantic space and atypical (complex) examples furthest away from the prototype. Finally, Thompson and Shapiro consider complexity with regard to the syntactic properties of sentences, including the order in which elements appear in sentences (i.e., canonical vs. noncanonical word order), the types of phrasal movement involved in generating the surface form, and the distance between crucial elements in the sentence. The number of propositions in a sentence as well as embeddings also affects sentence complexity. In all domains, there is one overarching principle: The complexity effect emerges when items selected for training encompass information relevant to untreated ones, that is, a subset relationship exists between trained and untrained material. This theory of treatment, the Complexity Account of Treatment Efficacy, is stated as follows:

> Training complex structures results in generalization to less complex structures when untreated structures encompass processes relevant to (i.e., are in a subset relation to) treated ones. (Thompson, Shapiro, Kiran, & Sobecks, 2003, p. 602)

Thus, targets selected for training and generalization must be linguistically related to one another and set up in a hierarchical fashion, whether one is considering phonological, semantic, or syntactic structures. If the phonological, semantic, or syntactic property Y is encompassed within property X, then training X should result in generalization to Y. But, because this is a unidirectional relationship, training Y should have no effect on X.

Collectively these articles provide compelling evidence supporting the notion that greater language learning results when more complex, rather than simpler, language material is entered into treatment. In addition, the complexity account is buttressed by evidence from other sources. Complexity training effects have been found in individuals with acquired apraxia of speech, with sound acquisition and generalization patterns similar to those shown by Gierut in children with phonological delays (Maas, Barlow, Robin, & Shapiro, 2002). Children with specific language impairment show acquisition and generalization of *wh*-movement structure in a manner much like that noted by Thompson and Shapiro for adults with aphasia (Ebbles & van der Lely, 2002; Levy & Friedmann, in press). Similarly, Eckman and colleagues have found that teaching complex relative clauses to second language learners of English results in generalization to untrained simpler sentence structures (i.e., actives and subject relatives; Eckman, Bell, & Nelson, 1988). Finally, individuals with moderate-to-severe aphasia provided with whole-task training of complex tasks demonstrate improvement in task components (Hinckley & Carr, 2005).

Support for the complexity effect also comes from computational modeling work. Computer simulations of language learning (using a pseudogrammar) have shown a clear advantage for starting with a full grammar (Rohde & Plaut, 1999), contrary to claims that “starting small” enhances language learning (Elman, 1991). In addition, Plaut (1996) showed in a computer-simulated lexical-semantic network that when the system was impaired, greater reacquisition effects were forthcoming when complex (i.e., atypical) rather than simple (i.e., typical) constructs were retrained—an effect identical to that found by Kiran and Thompson (2003) in humans.

Findings substantiating the complexity hypothesis also come from domains outside of language, such as in cognitive development (Kuhn, 1972), math learning (Yao, 1989), and motor skill acquisition (Schmidt & Lee, 1999). These findings suggest that the complexity of input is relevant to the way in which the mind processes and acquires new information. While this approach is counterintuitive and challenges the long-standing clinical notion that treatment must begin with the easiest or simplest tasks and move to the more difficult or complex ones, mounting evidence points toward the facilitative effects of training more complex items in order to obtain generalization to simpler structures. The construct of complexity appears to be a general principle that is relevant to treating a range of language disorders, regardless of the language domain that is impaired.

Without question, there are other variables that affect treatment outcome, including the type of treatment used to improve language and the frequency of treatment delivery. In addition, participant variables such as severity of the deficit and presence of concomitant problems, such as attention and memory impairments, also affect recovery. The articles in this issue do not completely address these and other relevant factors. Rather, their focus is on the complexity of selected treatment targets. At the present time, the extent to which these factors interact with complexity is unknown and awaits additional research.

The clinical relevance of the complexity account, however, cannot be understated. This approach results in improvement in complex language targets, and a cascading effect to untrained structures occurs as well. In addition, in all language domains, systemwide improvement has been noted. Gierut reports enhanced phonological systems in children following treatment. Kiran has shown improvements in lexical-semantic abilities on posttreatment testing in individuals with naming deficits, and Thompson and colleagues have noted improvement in the structure and content of spontaneous language in individuals with agrammatic output patterns as a result of treatment. Such generalization is at the heart of efficacious treatment. It is the ultimate goal, indeed, the gold standard for impairment-based treatment of communication disorders—without it, the benefits of treatment are open to question. In addition, there is some evidence that training more complex structures results in more rapid learning than training simpler structures. This finding is particularly relevant in the current health care climate in which clinicians are hard-pressed to deliver effective treatment in the least amount of time possible. While the complexity approach to treatment is challenging to implement because identifying relevant hierarchical relationships and principles within language domains is a difficult process, the articles in this series provide clinicians with a starting point for using this approach. Further research will help to clarify these hierarchies within and across language domains, making this operating principle more clinically accessible such that it can be used successfully in the treatment of language disorders.

References

Ebbles, S.; van der Lely, H. Meta-syntactic therapy using visual coding: Teaching grammatical structures to children with severe, persistent SLI. Paper presented at the Treatment Efficacy Conference; London. 2002 September.

Eckman FR, Bell L, Nelson D. On the generalization of relative clause instruction in the acquisition of English as a second language. Applied Linguistics. 1988; 9:1–20.

Elman JL. Distributed representations, simple recurrent networks, and grammatical structure. Machine Learning. 1991; 7:195–224.

Gierut JA. Phonological complexity and language learnability. American Journal of Speech-Language Pathology. 2007; 16:6–17. [PubMed: 17329671]

Hinckley JJ, Carr TH. Comparing the outcomes of intensive and non-intensive context-based aphasia treatment. Aphasiology. 2005; 19:965–974.

Kiran S. Complexity in the treatment of naming deficits. American Journal of Speech-Language Pathology. 2007; 16:18–29. [PubMed: 17329672]

Kiran S, Thompson CK. The role of semantic complexity in treatment of naming deficits: Training semantic categories in fluent aphasia by controlling exemplar typicality. Journal of Speech, Language, and Hearing Research. 2003; 46:608–622.

Kuhn D. Mechanisms of change in the development of cognitive structures. Child Development. 1972; 43:833–844.

Levy H, Friedmann N. Treatment of syntactic movement in syntactic SLI: A case study. First Language. in press.

Maas E, Barlow J, Robin D, Shapiro LP. Treatment of phonological errors in aphasia and apraxia of speech: Effects of phonological complexity. Aphasiology. 2002; 16:609–622.

Plaut DC. Retraining after damage in connectionists networks: Toward a theory of rehabilitation. Brain and Language. 1996; 52:25–82. [PubMed: 8741976]

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Rohde DLT, Plaut DC. Language acquisition in the absence of explicit negative evidence: How important is starting small? Cognition. 1999; 72:67–109. [PubMed: 10520565]

Schmidt, RA.; Lee, TD. Motor control and learning: A behavioural emphasis. Champaign, IL: Human Kinetics; 1999.

Thompson CK. Single subject controlled experiments in aphasia: The science and the state of the science. Journal of Communication Disorder. 2006; 39:266–291.

Thompson CK, Shapiro LP. Complexity in treatment of syntactic deficits. American Journal of Speech-Language Pathology. 2007; 16:30–42. [PubMed: 17329673]

Thompson CK, Shapiro LP, Kiran S, Sobecks J. The role of syntactic complexity in treatment of sentence deficits in agrammatic aphasia: The complexity account of treatment efficacy (CATE). Journal of Speech, Language, and Hearing Research. 2003; 46:591–607.

Yao, K. Unpublished doctoral dissertation. Indiana University; Bloomington: 1989. Acquisition of mathematical skills in a learning hierarchy by high and low ability students when instruction is omitted on coordinate and subordinate skills.