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## Increasing the Odds: Applying Emergentist Theory in Language Intervention

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### Abstract

**Purpose**—This review introduces a leading theory of language development, emergentism, the view that language ability is the product of interactions between the language environment and the learning capabilities of the child. It suggests ways in which emergentism provides a theoretical rationale for interventions designed to address developmental language delays in young children.

**Method**—A review of selected literature on emergentist theory and research is presented, with a focus on the acquisition of early morphology and syntax. A significant method for developing and testing emergentist theory, connectionist modeling, is described. Key themes from both connectionist and behavioral studies are summarized and applied with specific examples to language intervention techniques. A case study is presented to integrate elements of emergentism with language intervention.

**Conclusions**—Evaluating the theoretical foundation for language interventions is an important step in evidence-based practice. This article introduces three themes in the emergentist literature that have implications for language intervention: sufficiency of language input, active engagement of the child with the input, and the introduction of factors that increase the odds for correctly mapping language form to meaning. Evidence supporting the importance of these factors in effective language intervention is presented, along with limitations in that evidence.

In selecting an intervention approach for children with language disorders, clinicians can benefit from considering the theory behind the intervention. First, a sound theory is a component of the evidence base for the intervention (Justice & Fey, 2004; McCauley & Fey, 2006). Furthermore, a working knowledge of the theory allows clinicians to be more flexible in how they implement interventions, knowing that a variety of approaches and materials may contribute the essential elements of language learning under the umbrella of the relevant theory.

Language acquisition theories provide a particularly compelling starting point for interventions with children not meeting early milestones in syntax and morphology. In this early stage, many late-talking children are thought to be delayed but following the same language acquisition path as their typical language peers (Dollaghan, 2004; Rescorla & Roberts, 2002). Insights into the detailed process of how typical children learn early morphemes and word orders provide principles for clinicians to follow when they are working to accelerate learning in children with delays. The purpose of this review is to introduce emergentism, a theory of language ability as the product of interactions between the external language environment and the internal learning capabilities of the child (MacWhinney, 2006). Emergentist research focuses on the process of learning.

Emergentism can be compared to two other schools of thought on language acquisition, the nativist or generative linguistics school, and the social interactionist school. The nativist school has put more emphasis on language faculties that are innate, while the social interactionist school has put more emphasis on the influence of the environment. Both theories have influenced language intervention practices. Emergentism bridges some of the

nature versus nurture debate that separates the nativist and social interactionist perspectives. Before exploring emergentism, I will present brief reviews of the nativist and social interactionist positions.

## Nativist, Social Interactionist, and Emergentist Theories

Nativist perspectives on language acquisition can be viewed as having an inside-to-outside perspective (Hirsh-Pasek & Golinkoff, 1996). Language is thought to have originated first as a tool for thinking (inside), and only later as a means of communication (outside) (Chomsky, 2007). This inside-to-outside perspective is also found in the nativist view of learning language (Wexler, 1996). The focus of learning is on the rules of grammatical sentence construction. The language input that the child receives—the outside data—lacks explicit corrections for their grammatical errors (negative evidence), and does not have enough reliable information for the child to learn these rules as they learn other facts and relationships (Guasti, 2002; Radford, 2004). Most children do acquire the rules of language, however, because they have a genetically determined internal capacity for language acquisition, the Universal Grammar. The Universal Grammar is a set of mental modules largely dedicated to language. It provides the child with a reduced set of possibilities for how language is structured. This narrowing of possible language structures helps the child initially interpret language correctly, and later provides a pattern to the language output of the child and all typical humans (Pinker & Ullman, 2002). The rules specific to the child's language are acquired through exposure to exemplars of those forms, a process called parameter setting (Wexler, 1996).

Nativist theory has influenced language intervention practices (Ebbels, van der Lely, & Dockrell, 2007; Levy & Friedmann, 2009). Connell (1988), for example, explored language intervention as a search for triggers to the parameter setting process. His intervention focused on examples that clearly showed the contrast between the child's incorrect form and the correct form of the subject pronoun—setting the subject parameter appropriately for English. Nativist theory suggested that once this parameter was set, the children would show improvement on multiple structures related to subject properties. Connell provided evidence that such an approach may be effective, but of course this did not settle the debate about the nature of language acquisition.

Social interactionist views of language acquisition can be viewed as an outside-to-inside perspective (Hirsh-Pasek & Golinkoff, 1996). Here, language is viewed as having its origins in social exchange and communication (Beckner et al., 2009). Social interactionist theories initially focused on the earliest stages of language learning, an area that nativist theorists had neglected. Observing the behavior of infants with their caregivers led researchers to conclude that children were motivated to communicate with caregivers as a way to accomplish goals and to participate more fully in those interactions (Bates, Camaioni, & Volterra, 1975; Bruner, 1975; Ninio & Bruner, 1978). The caregivers' language input to the child and support of the child's incremental learning—*scaffolding*—are crucial for social interactionists (Vygotsky, 1934/1962). Particularly important is the way that caregivers adjust the focus of the language to the interests of the child. For example, children have been shown to learn new names for objects more easily if the words are presented when the child and adult are both focused on the named object (Tomasello & Farrar, 1986), a joint attention episode.

Joint attention is one of several general learning abilities that contribute to language learning, according to social interactionist theory. Learning language does not require a specialized innate ability, such as the Universal Grammar, but instead depends on the ability to understand that others have independent thoughts and motivations, and the ability to

extract patterns related to language forms from the context of routines (Bruner, 1975; Tomasello & Kruger, 1992). As a result language learning can be negatively affected by deficits in these abilities (Abbeduto, Keller-Bell, Richmond, & Murphy, 2006).

Social interactionist theory has provided the foundation for a number of language intervention programs. One example is the Hanen Program for parents (Girolametto & Weitzman, 2006). The program's focus is on the family as the unit of intervention and it emphasizes caregiver training. It encourages caregivers to engage children at their level of interest, to be responsive to children, and to expand children's utterances. Caregivers integrate the language-facilitating strategies into daily routines with their children. There is evidence that the program helps children to start combining words and to acquire early-developing morphemes.

Emergentist theories of language acquisition have been described as hybrids of the social interactionist and the nativist perspectives (Hollich, Hirsh-Pasek, & Golinkoff, 2000). In the emergentist framework, language may be viewed as a product of the interaction of the outside language environment and the inside learning capabilities of the child. What emergentist theory adds is a focus on the detailed mechanisms at work in learning language, both in the innate abilities of the child and in the specific characteristics of the language input available for learning (Elman et al., 1996). The child may not be born with specific biases for grammatical structures, but the ways that neurons are organized and function in the brain result in the ability to learn language associations (for example, verb sound structures and past tense forms). Further, learning language relies on the ability of young children to implicitly track regularities in the language they hear, such as which sound pairs usually mark boundaries between words, and which usually are within words (Aslin, Saffran, & Newport, 1998; Regier & Gahl, 2004). The human child is endowed from a very early age with this pattern extraction capability, an ability related to language, but different from the universal grammar proposed by nativist theory. Proponents of the emergentist perspective further indicate that children in natural settings use a range of clues to help them arrive at conclusions about language (Hollich, et al., 2000; MacWhinney, 2004). So, like the social interactionist perspective, emergentist theories suggest that language acquisition is very dependent on language input and the context of that input to the child.

The following section will explore the methods used by emergentist researchers to test hypotheses on the nature of language acquisition. I begin with the origins of the term "emergentism."

## Foundations of Emergentism

The basis of emergentism is the study of complex systems—a growing trend across many areas of science (Verenne, 2009). The emergentist perspective, like the nativist, acknowledges that language is quite complex. Complexity theory suggests that patterns and regularities of a complex system can emerge from the interactions of the many individual parts making up the system. These patterns would not be predicted or expected from observation of the behavior of any one of the component parts; rather the high-level pattern is the result of the joint activities and interactions of the components (Aziz-Alaoui & Bertelle, 2009)

Emergentist language research has sought to identify how relatively simple component mechanisms can result in complex language-learning patterns. The research has been advanced through the interplay of several different approaches, as indicated in Figure 1. One important element has been the use of connectionist models—small-scale, simplified simulations of how brain cells might process linguistic information (Bates & Elman, 2002). These simulations or neural network models are validated by comparing their results to

behavioral evidence—how human language learners perform a task similar to that presented to the connectionist model (Plunkett & Juola, 1999). Alternatively, the specific processes behind the results of an experiment with human participants may be explored by using connectionist models to find a pattern of results similar to that of the participants (McMurray, Samelson, Lee, & Tomblin, 2010). Connectionist models may also be validated by testing their predictions with observations of human brain activation, through neuroimaging (Joanisse & Seidenberg, 2005).

Connectionist modeling is guided by an understanding of brain structure and function (Rumelhart & McClelland, 1986). Like the brain, connectionist models focus on parallel processing of relatively simple individual operations. Figure 2 presents a schematic of an early connectionist model. Activation of neurons in the bottom layer depends on the presence of particular phonological features in an input verb stem (such as “walk”). Activations in the first layer neurons cause activations in the second layer via connections of varying strengths. The second layer neurons represent phonological elements of the past tense form of the verb (such as “walked”) (Elman, et al., 1996). Like this simple model, neurons in the brain are connected to many other neurons. Brain outputs are based on the sum of activations across many neurons, and learning is a function of incremental changes in the strength of connections between neurons.

Connectionist models are highly simplified models of the brain (Elman, et al., 1996; Rumelhart & McClelland, 1986). They represent only a tiny fraction of the number of neurons actually at work in the human brain and do not consider potentially important factors such as neurotransmitter levels. Since they are modeled on what is known about brain function, however, researchers argue that if these simplified models can learn a language process, it is plausible that the human brain may be able to learn in the same way. Skeptics argue that the plausibility of the models is suspect, suggesting that connectionist researchers may introduce elements into their models that are not well documented and which effectively introduce innate grammatical knowledge (Pinker & Jackendoff, 2009). Clearly, it is critical to fully consider the rationale for all elements of a connectionist model: There are cases when several different ways of specifying a model are all able to replicate the pattern of child language data (Thomas & Karmiloff-Smith, 2003). As a result, an element of a connectionist model found to be fundamental to a learning pattern must be validated through behavioral testing.

The process of connectionist modeling to build evidence for the emergentist perspective begins with the same challenge faced by language interventionists: how to teach an element of language. In the following section, I will argue that insights from connectionist research on the acquisition of early morphology and syntax can provide theoretical guidance for language intervention.

## Elements of Learning Morphosyntax from an Emergentist Perspective

There are three key themes derived from emergentist theory that are relevant to young children’s acquisition of morphosyntax and to interventions targeting deficits in this area. First, emergentist research indicates that language learning depends heavily on the amount and quality of language input (MacWhinney, 2004). Input is well formed language that is available to the child as a model for language learning. Second, children learn language through active engagement with that input—processing and ultimately understanding the input. Finally, children are significantly aided in language learning by a series of factors that increase the odds that they will learn the correct form and meaning of language (Elman, 1993; MacWhinney, 2004; Rohde & Plaut, 1999). Each of these themes will be elaborated in turn.

## Input

Language input plays a crucial role in emergentist theories of language development. Two simulations of how children learn morphological markers show how the volume of language input and patterns in that input play a role in language learning. One model simulated the development of noun and verb morphology in English (Plunkett & Juola, 1999). A second model focused on the progression in children's use of tense markers (such as *-s* in "walks" or *-ed* in "walked") across four languages (Freudenthal, Pine, Aguado-Orea, & Gobet, 2007).

The connectionist model that simulated the acquisition of English noun and verb morphology was composed of connected neural units (Plunkett & Juola, 1999). The model started with neural connection strengths or weights at an arbitrary mid-point, but these connection weights changed based on how well the model's output matched the adult target. The process of adjusting the strength of neural connections represented the learning process: The weights help to accurately associate the inputs with correct outputs. For example, when the model was presented with the phonological representation of "buy," the model's target was to produce "bought." If the actual output was not accurate, the model adjusted the connection weights between the neural units with a goal of minimizing the error. When the model was trained using an irregular-rich set of common words that parallels the receptive vocabulary of early childhood, the model replicated the learning pattern of typical children. The model clearly learned differently based on the nature and pace of the language input it received. The model was also able to demonstrate generalization: When presented with a novel noun (not present in the training input), it added the appropriate plural suffix in nearly 100% of cases. Generalization took place with less training for nouns, and took place later for verbs, again paralleling children's language development. The authors attributed earlier generalization for nouns in part to the consistency in the mapping of noun stems to noun plural forms—many more nouns are regularly inflected than is the case with verbs. An important note, however, is that the model showed generalization only after it had received a critical mass of words in the training set, after which the generalized learning increased rapidly.

In the model simulating children's acquisition of tense markers (Freudenthal, et al., 2007), the researchers showed that the pattern demonstrated by children across four different languages could be explained by an interaction of an utterance-final memory bias and the frequency of particular verb forms in the language input. Young children go through a stage where they are inconsistent in their use of tense markers, such as *-s* in "He jumps." This pattern has been explained from a nativist perspective by proposing a maturational delay in children's grammatical knowledge (Wexler, 1996). The emergentist research indicated that the frequency of unmarked verbs in English sentences, such as "jump" in "He can jump," affects the extent to which children omit tense markers on verbs. A child focused on the end of the utterance may produce "He jump."

The two models suggest that the pace of children's acquisition of verb and noun morphology is affected by the frequency of these forms in their language input. A critical factor accounting for the earlier acquisition of English noun morphology was the greater frequency of nouns, particularly the high proportion of nouns with a regular plural form, in the connectionist model's training input (Plunkett & Juola, 1999). The rates of tense morphology errors in the Freudenthal and colleagues (2007) model depended on the frequency of verbs not marked for tense in the input.

This research suggests that learning language forms is related to both the overall volume of language input as well as the child's exposure to particular forms in that input. Given the importance of the language input to learning, the validity of the training input of these

models should be examined. A recent connectionist model of children's acquisition of aspect markers, such as the present progressive *-ing*, addressed this concern by using input drawn from a corpus of child-directed speech (Zhao & Li, 2009). The language input was also represented more completely to the model by providing both semantic and phonological features.

A further consideration regarding the input presented to connectionist models is whether the models only learn from positive language evidence—well-formed adult language that is not corrective of the child's errors. Emergentist research has challenged the nativist argument that language cannot be learned based solely on input because children's language input does not provide the required information (Elman, 2005). A component of this debate is whether children are presented with negative evidence—adult corrections to their language errors. Research now suggests that young children often do hear negative evidence in the form of adult reformulations of their language, and these reformulations or recasts have a significant corrective effect (Choinard & Clark, 2003; Saxton, 2000). Some connectionist models effectively assume this form of negative evidence (McClelland, 2010), whereas other models avoid assuming that corrective feedback is directly available (Zhao & Li, 2009). It would be informative for future models to test the effects of negative evidence.

In summary, emergentist theory suggests that the amount and type of language input are critical factors in language learning. Forms that have a more consistent pattern of inflection are learned more easily, as is the case with noun plurals. Low frequency forms take longer for connectionist models to learn. High frequency forms, conversely, are learned earlier by typical children and by models. Connectionist models demonstrate that language learning patterns can be explained in part by the amount and composition of the language input a model receives, with some models assuming negative evidence in the language input, and others not. The regularities found in the input are extracted by slowly adjusting the connection strength between neurons that associate the input with the correct form of output.

### Active Engagement

An observation from emergentist research is that the input cannot be viewed simply as passive bombardment of the child. The child must become an active user and processor of the input. Connectionist models learn by comparing model output to the adult target and calculating the difference between the two, or by seeing if the incoming pattern matches and reinforces prior patterns (Zhao & Li, 2009). For example, as a model encounters more words with the word body “\_ought” (/\_ɔt/) for past tense, it increases the likelihood of using “\_ought” in the output (as in “bought,” “sought,” and “caught”).

MacWhinney (2004) extended the importance of active engagement from the connectionist model to the child through the concept of monitoring. Children comprehending the language in their environment will be able to pick up the differences between what they hear and what they would typically say. Children in the phase of overgeneralizing past tense may hear “went” and match it to the same meaning in their system, “goed.” The child may hear the correct form as part of an explicit adult reformulation of their language (Saxton, 2000), or as part of ongoing conversation. Either way, the realization of the difference may cause the child, like the connectionist model, to become more likely to use the correct and frequently-heard “went” in future productions. The foundation of comprehension to this monitoring process is consistent with the frequent finding that children's receptive language abilities are more advanced than their expressive capabilities. So children learn a complex system such as language by actively processing language they hear and making gradual adjustments when their output differs from the input in their language environment.

Children's comprehension is developed from language heard in context. A criticism of connectionist models is that they simply assume that children are attending to the language. From the social interactionist perspective, children's attention is related to their motivation to communicate with adult caregivers or peers. The attention and response of conversational partners and the interests of children are critical. A recently proposed model of early child language acquisition acknowledges this gap in the connectionist approach, and suggests a multi-network approach that accounts for these social components (Nyamapfene, 2009). One benefit of including more contextual factors will be the ability to test factors that point children toward the correct interpretation of language.

### Increasing the odds

Language becomes easier to interpret under circumstances where the range of possible meanings is highly constrained. For nativists, the constraints are provided by the Universal Grammar (Radford, 2004). Emergentist research has sought to more fully specify constraints that increase the odds that the child will make the correct meaning to form linkage for a speech stream. Among the constraints explored by emergentist researchers are early limitations on the child's working memory, cues provided by word meanings and context, and the child's ability to implicitly extract patterns in language (Aslin, et al., 1998; Elman, 1993; MacWhinney, 2004; Rohde & Plaut, 1999).

The limited working memory of young children could affect their language learning, as demonstrated by the early utterance-final bias of the Fruedenthal and colleagues (2007) model discussed above. An earlier connectionist model demonstrated that an initially more limited working memory could help a model learn syntactic structure (Elman, 1993). An alternative connectionist simulation suggests that grammatically complete language models ultimately benefited a model's grammatical learning (Rohde & Plaut, 1999). Rather than limiting working memory, the model added of semantic constraints—word meanings—which enabled the model to learn grammatical regularities with complete adult language input (Rohde & Plaut). In either case, factors narrowing the range of possible form-to-meaning mappings assisted grammatical learning.

These examples highlight a limitation of connectionist modeling: There may be multiple ways of developing connectionist models to match the patterns of language observed in child development (Thomas & Karmiloff-Smith, 2003). The strength of the connectionist approach, however, is in generating plausible hypotheses for how specific factors, such as the availability of semantic information in addition to phonological information, can assist children's language acquisition.

Cues in the context or language input increase the likelihood that children will produce the correct word ending or word order. Cues may be pragmatic, aided by the child's understanding of the situation (Givon, 1999; Goldberg, 2004). The cues may also be in sound patterns of words, word order, or word meanings (Chang, Dell, & Bock, 2006; MacWhinney, Leinbach, Taraban, & McDonald, 1989). For example, the gender or phonological form of a noun provides cues that a connectionist model—and child—can use to arrive at the correct morphological choice for German case marking.

Emergentist theory suggests that children's capacity to use cues develops over time. Early cues to language meaning and structure are initially bound to the context. Later, children develop the capacity to benefit from more abstract, language-based cues (Hollich, et al., 2000). For example, a connectionist model that learned to produce well-formed sentences was trained based on both event situations (linking meanings to words and locations) and word order patterns (Chang, et al., 2006).

The Chang and colleagues (2006) model respects but may under-represent the role of context and the guidance of a knowledgeable adult suggested by social interactionists. What the connectionist approach adds, however, is a more detailed specification of the pattern-extraction capabilities for language learning. Aslin, Saffran and Newport (1999) indicated that the nativist account has not sufficiently attended to the process of learning, while the usage-based accounts, such as social interactionism, have not sufficiently attended to the potential for innate mechanisms for learning.

One apparently innate learning mechanism is statistical learning. Aslin, Saffran and Newport (1998) conducted a series of experiments suggesting that infants are able to implicitly track statistics that are helpful for identifying word boundaries in the speech stream. The infant's ability is based on detecting differences in the probabilities of one phoneme following another. Some phoneme pairs are more likely to indicate the end of one word and the beginning of another, while other pairs are more likely to fall within words. This ability is clearly related to early word learning, and further research has suggested that the same ability may assist young children's learning of grammatical categories, a foundation for learning syntax (Christiansen, Onnis, & Hockema, 2009). A similar statistical mechanism has been shown to support learning of another element of syntax, the linkage of referents to reciprocal expressions, such as "that one" in the expression, "I'll play with this red ball and you can play with that one." (Regier & Gahl, 2004). The referent could be either any ball, or "red ball." A model relying on a statistical learning mechanism could learn the correct referent from a small number of exposures to the context and to language input containing reciprocal expression. The model did not require implicit knowledge of phrase structure, as nativists would argue.

Research on statistical learning has helped to characterize a factor in the child that may be present at birth, and may be of considerable value in child language acquisition. A limitation of the research is that statistically-based language learning has been observed in tightly controlled experiments and has only demonstrated a very narrow piece of the total language learning challenge (McMurray & Hollich, 2009). It is unclear how much statistical learning mechanisms contribute to the development of full language competence under natural conditions, and there is conflicting evidence on whether these mechanisms are general learning mechanisms or specialized for language (Marcus & Rabagliati, 2009). A more fundamental question is whether the statistical regularities in language drive the grammatical learning (outside to inside) or whether the innate human competence in grammar (the Universal Grammar) drives the statistical regularities in language production (inside to outside) (Pinker & Ullman, 2002). While clarity on the direction of causality may be difficult to obtain, the value of the emergentist perspective is that it attempts to clearly describe and test the factors within the child, such as statistical learning, that may be fundamental to early syntactic ability.

Two important conclusions can be drawn from the emergentist research on syntactic learning reviewed in this section. First, the interaction of language input with learning mechanisms that are clearly specified by emergentist researchers may be sufficient for learning morphosyntactic regularities. Innate knowledge of syntactic principles does not appear to be necessary. Second, the way that this learning may be successful is through narrowing the range of possible answers for a language learner's hypotheses about the meaning and structure of language. The narrowing may involve context or meaning cues, phonological cues, or the child's sensitivity to statistical patterns in language.



## Applications in Clinical Practice

The emergentist insights into children's acquisition of syntax and morphology lead to three broad implications for clinical practice. Learning requires sufficient language input, the child's active engagement, and some means to increase the child's odds of correctly matching form to meaning. The importance of sufficient input goes beyond item frequency to the requirement for a critical mass of input: Mastery of a morphological or syntactic form takes place only after the learner has substantial experience with that form (Chang, et al., 2006; Elman, 1993; MacWhinney, 2004). The learning required for generalization involves actively processing language input. Connectionist models compare their output—their "hypothesis" for the right form—to the positive input from their environment. Further, learning morphosyntax depends on some means of narrowing the range of possible interpretations or productions, increasing the odds that the learner will extract the correct patterns.

For children with delayed language, intervention brings about change by more intensively exposing children to the conditions that result in language learning. The following discussion will review language interventions that provide these conditions as outlined in emergentist research. The examples focus on learning elements of syntax and morphology. Intervention techniques are included as examples that put emergentist principles into practice. Connectionist models have not specifically tested intervention approaches for language delays. Behavioral evidence, however, is available for the effectiveness of these interventions, and a selection of that evidence is cited.

### Input

In connectionist models, learning takes place gradually as the training input is presented (Chang, et al., 2006; Elman, 1993; Plunkett & Juola, 1999). The models perform well and generalize to untrained stimuli only after they have processed the input with sufficient repetitions and exemplars to extract the target patterns—a critical mass of input. An implication for intervention for children with language delays is that they too will require a significant amount of input to reach higher levels of functioning—perhaps more than what is required for children with typical language. There is corroborating behavioral evidence that effective language interventions provide a higher number of effective language learning episodes per hour or per day than would be available to children in their typical language environment (Proctor-Williams, 2009). The implication is that one option for providing more language input is through a higher intensity of input for the child's target forms.

Children with language delays may receive less language input from parents and peers without appropriate intervention. Research suggests that children's language abilities affect the rate of parental language input: Improvement in children's language encourages the parent to interact more frequently and more intensively with the child, providing the meaningful, context-based language that is critical to language learning (Robertson & Ellis Weismer, 1999). Peer interaction may also be affected (Gertner, Rice, & Hadley, 1994). Language disorders have been shown to impact social standing, resulting in fewer interactions for the child with delayed language. The effectiveness of changes in peer language input levels has not been specifically evaluated. There is evidence, however, that training parents to more frequently interact with their children and to use target forms can benefit morphosyntactic development for children with language delays (Girolametto, Pearce, & Weitzman, 1996).

Given that the input deficit for children with language impairments may be in selected infrequent forms rather than the overall level of input, parents and clinicians can provide more intensive input through telling stories loaded with target forms. Cleave and Fey (1997)

provided a model of a specially constructed “syntax story” that provided numerous exemplars of *be* forms. They showed that such stories, tailored to the child and intervention target, can also be used as models for parents on how to provide intensive positive input to their children. Syntax stories have been associated with significant improvements in young children’s grammatical development as part of an integrated treatment package, but the effects of syntax stories have not been tested in isolation (Fey, Cleave, & Long, 1997). A similar tactic is to use children’s literature loaded with the forms targeted for intervention. Westby (2005) provides a host of titles that can help clinicians and parents enhance the intensity of input for target forms.

The requirement of providing a sufficient quantity of input is most clearly addressed by the emergentist perspective. The quantity of language input required for learning grammar is thought to be minimal for nativist theorists, given a reliance on innately specified principles (Radford, 2004). Social interactionist views are more focused on the context of input rather than the quantity (Ellis Weismer & Robertson, 2006). In contrast, connectionist models explicitly consider and report the number and form of language exposures required for a model to reach a level of language proficiency. Such models clearly suggest that interventionists should carefully consider how to increase the amount of input for target forms, but leave open the question of how much input any given child will need.

### Active engagement

Emergentist theory and evidence indicate that language learning takes place as the result of active language processing. Connectionist models learn by comparing their hypothesis for the correct form (the output) to adult forms found in the training input (Elman, et al., 1996). A very similar argument is made for interventions designed for children with language disorders, such as focused stimulation and conversational recasting (Laing Gillam & Gillam, 2006).

Focused stimulation involves adult modeling of targeted grammatical forms for children in the context of natural, enjoyable interactions and activities (Fey, et al., 1997). Ellis Weismer and Robertson (2006) cite connectionism as a theoretical rationale for focused stimulation. They suggest that focused stimulation is effective for strengthening the neural connections needed for the child to produce the correct language forms because of the high volume of input for targeted language structures. Another component of focused stimulation is that the input is adjusted to the children’s language level, enhancing the likelihood that they will process the information.

Focused stimulation involves manipulating the environment and using materials that lend themselves to conversation using the target form (Ellis Weismer & Robertson, 2006). No response is required from the child, but the child is encouraged to test his or her hypothesis for the correct grammatical form. When children do, they receive a rich source of immediate adult input for comparison to their utterance. Furthermore, the entire process is centered on activities that follow the interests of the child. These conditions enhance the probability that the child will actively process the language input and gather the evidence they require to slowly adjust their hypotheses about the correct form. Group studies and single-subject treatment studies provide evidence that focused stimulation can result in meaningful gains on morphology and syntax goals for young children with language delays (Culatta & Horn, 1982; Fey, Cleave, Long, & Hughes, 1993; Robertson & Ellis Weismer, 1999).

Conversational recasting involves follow-up of a child’s utterance with an adult model using a similar but corrected, and sometimes expanded form. Active processing is thought to be a critical factor in the effectiveness of conversational recasting therapy (Nelson, Camarata, Welsh, Butkovsky, & Camarata, 1996). Recasts are provided as part of conversations that

follow the child's interests. This results in a dialogue of interest to the child, bringing the child's attention more fully to the language target and well-formed input provided by the recast.

Conversational recasting has a strong evidence base to support its use with young children with expressive morphosyntactic intervention targets (Fey, Long, & Finestack, 2003; Laing Gillam & Gillam, 2006). Multiple group studies as well as single-subject studies have indicated that the technique facilitates children's correct productions, particularly when the recasts provide a simple change to a single element of the child's utterance. Evidence that typical children modify their productions after recasts provides additional support for this approach to intervention (Choinard & Clark, 2003; Saxton, 2000).

The requirement for active engagement of the child for language learning is clearly addressed by both the social interactionist and emergentist frameworks. The social interactionist focus on the social motivations for learning and the importance of following the child's direction of attention clearly leads to active engagement as an intervention goal. Connectionist models provide a complementary view on the value of active engagement by focusing on the process by which the comparison of model output to target forms in the input results in changes in neural connection weights, a physiological basis of learning.

### Increasing the odds

Emergentist theory and evidence indicate that children learn language in part because of a narrowed range of possible form-to-meaning mappings (Elman, 1993; MacWhinney, 2004; Rohde & Plaut, 1999). Increasing the child's odds of learning can result from a wide array of constraints or biases based on factors in the child or in the situation. These include the context of the language or efforts by the child's conversational partner (Hollich, et al., 2000). Language interventions such as focused stimulation and shared book reading (Cole, Maddox, & Lim, 2006) contain elements that increase the child's odds of learning the targeted language forms.

Focused stimulation interventions may use pretend play to create natural contexts for production of language targets (Ellis Weismer & Robertson, 2006). Such contexts provide many cues of familiar objects in familiar locations to map onto language structures, providing the child with many cues to the correct meaning and increased odds for correctly mapping language forms onto the correct interpretations (Chang, et al., 2006).

*Language is the Key*, an intervention focused on shared book reading, is also grounded in emergentist theory (Cole, et al., 2006). Parents are trained to engage in a conversational exchange regarding the shared book. The book provides a clear focus of joint attention, and helps to provide a supportive context for language use. With the supportive context, children are better able to map the meaning of their parent's language to the shared referent, the book. This narrows the possible meanings of the parent language, increasing the odds that the child will arrive at the correct interpretation. *Language is the Key* has been shown to increase the mean length of utterance (MLU), grammatical complexity and expressive vocabulary of children age 2–4. Group studies have demonstrated the effectiveness of other shared book reading interventions designed to enhance syntactic development of children with language delays (Crain-Thoreson & Dale, 1999). A group study enhanced by random assignment of participants to shared book reading or waiting list conditions showed that a significantly greater percentage of children with early language delays moved into the typical language range after participating in a shared book reading treatment (Buschmann et al., 2008).

Social interactionism, nativism, and emergentism all address notions of increasing the odds for children to learn language. Social interactionism does so by focusing, for example, on the ability of parents to scaffold children's language learning (Crain-Thoreson & Dale, 1999). Nativism proposes an innate mechanism that limits the possible range of grammatical sentences (Radford, 2004). Emergentism builds on both contextual aids to learning and on potentially innate language learning mechanisms that increase the likelihood that children will map language form to meaning. The interventions reviewed here address the benefits of contextual aids to language learning, but do not directly address ways to enhance statistical learning, a factor specifically contributed by the emergentist perspective. The issue is that ways to enhance statistical learning in intervention have not been validated by research. Hypothetically, a limitation in a child's statistical learning ability could be compensated for by increasing the number of exposures to the language pattern, or by taking steps to reduce the working memory load that may be required to extract patterns from language (Evans, Saffran, & Robe-Torres, 2009).

For the language interventionist, approaches that enhance input for target forms and engage the child have an evidence base that supports their use with young children with language delays. The following clinical example incorporates these notions and the use of context to increase the odds of language learning.

### Clinical Example

Martin was a 3;3 year-old child with a history of language delay. His caregivers brought him to the clinic for evaluation because they were concerned that he had not met developmental language milestones after a period of repeated ear infections. They were also concerned that Martin's speech and language delay was affecting his ability to interact with peers at his pre-school. Martin's mean length of utterance (MLU) in a spontaneous language sample was 2.0, whereas the predicted MLU for his age was 2.7 to 4.2 (plus or minus 1 *SD*) (Miller, 1981). He produced possessive *-s* in 20% of obligatory contexts, often did not produce the correct pronoun for the sentence context, and had difficulty understanding basic *wh*-questions. These observations were validated with his caregiver as representative of his behavior in other contexts. Given his caregiver's concern that he be as well prepared for peer interaction and elementary school entry as possible, he was enrolled in language therapy.

From an emergentist theoretical perspective, the clinician's objective was to increase the amount of language input Martin received related to his language goals. For example, one of his goals was to use possessive *-s* in 80% of obligated contexts. In addition to providing numerous examples of possessive forms in therapy, the clinician wrote a "syntax story" (Cleave & Fey, 1997) for Martin's caregiver that included numerous possessive exemplars in a story that was tailored to Martin's interests and play habits. The clinician also modeled play-based focused stimulation techniques for the caregiver to use at home. These provided ways for Martin to receive more input on this form outside of therapy time.

To ensure that Martin was actively engaged with the input, the clinician began by selecting a play activity of interest to Martin. For example, Martin and the clinician played simple games, and included a silly creature (named Bob) as a participant in the games. This provided opportunities to ask what happened on *Bob's* turn, or whether Martin wanted to help with *Bob's* move. After Martin demonstrated an understanding of the possessive form, the focus moved to production. Production was elicited as part of Martin's preferred activities, such as the use of modeling clay. The clinician re-stated Martin's utterances with the appropriate form, and expanded his language with other possessive forms. Following Martin's interests during play increased the odds that Martin would correctly map the

possessive form to its meaning: The examples of the possessive form had clear referents provided by the context.

After a baseline of use of possessive *-s* in 20% of obligated contexts, Martin increased slowly to 50% for several sessions. After several more weeks of therapy, which included work on several of Martin's other key goals, Martin improved to 90% use in obligated contexts. Martin's gradual improvement was consistent with the predictions of emergentist accounts for syntactic learning as a process of incremental adjustments in knowledge and performance. His rate of improvement, however, did not appear to be consistent with the rapid acceleration in performance that occurs in many connectionist models following the model's exposure to a critical mass of input. Tracking the number of exposures to a target form and the child's rate of improvement on that form would permit a clinical test of the critical mass effects predicted by connectionist accounts.

Martin's therapy was tailored to his interests, needs, and family situation, but it demonstrated how emergentist findings can provide a framework for constructing a language intervention for a young child.

## Limitations and Conclusions

This review has introduced emergentism as a theory explaining the acquisition of syntax and morphology in young children. I have argued that emergentist research provides a sound theoretical framework for those providing language interventions because of its focus on the process of language learning. The review was not exhaustive: There are other findings in the emergentist literature which provide important guidance for assessment and intervention in language disorders. For example, Evans (2001) took an emergentist perspective that stressed the variability of children's language abilities with the demands of the task and the situation. This dynamism has important implications for assessment and in determining whether performance meets goal levels in therapy. Perkins (2005) has developed an emergentist framework which suggests that pragmatic disorders may result from compensatory choices and constraints on language or cognitive abilities in the context of interpersonal communication demands.

This review focused on children with language delays. The premise was that the delayed child's developmental path was similar to that of typical children, but more protracted. Recent emergentist work has developed hypotheses on elements of language processing that may fundamentally differ in language impaired children, including speech perception and statistical learning differences (Evans, et al., 2009; Joanisse & Seidenberg, 2003). Emergentist researchers have yet to fully validate these hypotheses, and have not developed or tested interventions designed to address these impairments.

Beyond the current limitations, however, emergentism and the connectionist models that inform it have already yielded important insights about learning morphology and syntax, and the theory is already being integrated into language interventions. Emergentism moves beyond social interactionism's position on the importance of language input by exploring the role of the volume of input and the effects of the relative frequency of some forms versus others. Emergentism moves beyond nativist accounts of innate mechanisms for language learning by exploring factors such as statistical learning that explain language acquisition without reference to internalized grammatical rules. With a dedication to identifying how complex language patterns emerge from an array of interacting forces, emergentist research is likely to offer many important insights for language interventionists well into the future.

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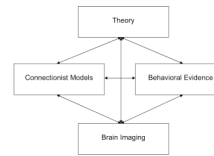
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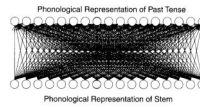
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**Figure 1.** Emergentist theories of child language acquisition have been advanced by the interplay of the theories with evidence from connectionist models, behavioral or experimental evidence, as well as validation of the theories and models with brain imaging techniques such as fMRI.



**Figure 2.**

A representation of Rumelhart and McClelland's early (1986) connectionist model of how a verb stem (such as "show") can be related to production of the past tense form ("showed") through weighted connections between two layers of neuron-like units. Reprinted with permission from *RETHINKING INNATENESS: A CONNECTIONIST PERSPECTIVE ON DEVELOPMENT*, edited by Jeffrey Elman, Elizabeth Bates, Mark H. Johnson, Annette Karmiloff-Smith, Domenico Parisi, and Kim Plunkett, published by MIT Press.