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11

Language and Reading Development Reflect Dynamic Mixes of Learning Conditions

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There is no question that human behavior is complex. Investigations ranging widely across phenomena, from how children learn to walk or sing or read, or to solve addition or balance beam problems or construct narratives suggest that most significant behavioral and cognitive advances result from the complex, dynamic interactions of multiple components. Dynamic systems perspectives are especially useful in investigating the complexities of childhood individual differences in a way that allows researchers to view the components and the results of the cooperating variables that underlie behavior.

In this chapter we first present key information on what components of developmental dynamic mixes contribute to display of current skills and to progress in learning new skills. The particular model we present, called the dynamic "tricky" mix (DTM) theory, is shown to have important implications for assessing children's skills and for providing innovations in teaching that may accelerate skills acquisition. We strongly emphasize prior studies and new possible studies in which close monitoring of mixes of learning conditions can lead to dramatic acceleration of a child's learning. Paradoxically, by keeping track of the genuine complexity of factors influencing performance and learning, "simpler" ways of boosting children's depth of engagement and their pace of learning emerge.

One value of any theory is its ability to foster new observations. DTM theory has led to some surprising and important observations on children's learning that we document here. We demonstrate that past learning rates of children with disabilities are not a good indicator of learning rates when care is taken to foster excellent, complex mixes of conditions that the children have previously rarely encountered. More broadly, this theory, and the observations already in hand, provide multiple reasons to be optimistic about future acceleration of children's progress in literacy, language, and other domains. To see how some future pathways to excellent learning might be laid out, it is necessary to examine theoretical details and supportive research findings.

DYNAMIC SYSTEMS THEORY

Dynamic systems theories stress the embeddedness of multiple, complex components within ongoing, real-time systems. Examples of dynamic systems include fluid dynamics, emergence of weather patterns, chemical reactions, protein synthesis, and embryological development, as well as childrens' and adults' behaviors. These systems are self-organizing in the sense that there is no overarching guideline for development, even though highly specific genetic, chemical, and physical structures comprise one kind of contributor. Rather, system behavior is the result of the ongoing convergence of many nonlinear components. Furthermore, human behavior is not determined solely based on internal or external influences, but through highly particular interactions between the here-and-now environment, past experiences, current activations, and anticipation of future experiences.

The example of young children learning to crawl and walk has been used to illustrate these dynamic system convergences of many factors in ongoing, convergent mixes. Thelen and Smith (2006) emphasize that crawling and walking behaviors, like all human behaviors, are assembled dynamically in real time in specific contexts. In their own words,

> Crawling is a coherent behavior that infants use to locomote when they have sufficient strength and coordination to assume a hands-and-knees posture, an environment to support it and to motivate self-movement, but a system not yet balanced and strong enough to walk upright. Crawling is a stable behavior for several months. But when infants learn to walk, the crawling behavior becomes destabilized by the patterns of standing and walking. There is no program for crawling assembled in the genes or wired in the nervous system. It self-organizes as a solution to a problem in a task context (move across the room), later to be replaced by a more efficient solution. (p. 281)

As another example, consider a 10-month-old who has stuffed giraffes at home but has no words for them. This child at a zoo may establish joint attention with a parent, then point excitedly to the zoo's baby giraffe. Child and adult then further participate in the emergent dance of parent–child gestures, visual attention, positive emotion, and words around giraffes and our human reactions to them. Whether the child achieves a successful mapping of *giraffe* as a word to important aspects of word meaning depends upon the dynamic interplay of these cognitive, language, and social exchange/engagement conditions in real-time episodes.

THE DYNAMIC "TRICKY" MIX THEORY OF DEVELOPMENT

Dynamic "Tricky" Mix theory or DTM is a relatively new example of a theory that makes use of the general framework of dynamic systems theories, while specifying in some detail the different components that contribute to children's learning (Nelson, 2000, 2001; Nelson et al., 2001, 2004). We suggest that learning is dependent upon a complex, tricky-to-achieve, converging set of conditions that must cooperate at high levels for high rates of learning to be achieved. The crux of the theory is this: Numerous social, emotional, motivational, cognitive, structural challenges and current neural *network* conditions must reach threshold levels of convergence to support any advance in learning and then increasingly high learning rates occur as above-threshold convergences intensify. Each contributing condition can in part be separately tracked, but also sits in relation to the other contributing components and the real-time, ongoing, emergent, interacting mix. The optimal convergence of the components that might contribute to children's highly accelerated learning is relatively rare for most children and most domains of learning—precisely because the complexity of needed interaction of conditions is so high, and because conditions sometimes detract from favorable mixes for learning. At the same time, and for the same theoretical process reasons, whenever a child experiences regular, repeated DTMs, then sustained levels of very powerful learning are seen across periods of months and years. This has occasionally been demonstrated in children with severe, multiple-year lags behind norms in reading or mathematics, or oral language, when they are placed in dramatically new mixes of conditions (Camarata, Nelson, & Camarata, 1994; Dickinson, McCabe, & Clark-Chiarelli, 2005; Lepper, Woolverton, Mumme, & Gurtner, 1993; Nelson, Welsh, Camarata, Heimann, & Tjus, 2001; Nelson, Craven, Xuan,

& Arkenberg, 2004; Nelson, Camarata, Welsh, Butkovsky, & Camarata, 1996; Nelson, Heimann, & Tjus, 1997; Torgeson, Wagner, & Rashotte, 1997). The potential for many more children to achieve such successes is high if theoretically guided interventions are more often provided, as discussed from several angles later in this chapter.

OVERVIEW OF RESEARCH DIRECTIONS FROM THE DYNAMIC TRICKY MIX PERSPECTIVE

From this Dynamic Tricky Mix perspective, convergent findings across naturalistic and experimental studies are stressed as being essential to refined understanding at the process level of children do and do not make progress. Research findings are integrated within this model from studies of children with no reading or language development disabilities; children with autism, language delay, dyslexia, and deafness; as well as at-risk children. For all these groups, it is argued that most theories, and most educational and clinical programs, systematically underestimate learning potentials in the reading and language development of children, because empirical research so seldom captures the accelerated learning rates observable when multiple converging conditions are highly favorable.

One implication is that we now know enough to create innovative, theoretically guided, excellent mixes of the complex conditions that support learning. This leads to the prediction that very strong accelerative effects will be created. At the same time, the same Dynamic Tricky Mix perspective implies that the success rates of educational and intervention programs will be further enhanced by tailoring of the overall mix of learning conditions to the constraints represented by the child's biological makeup. Rather than one-size-fits-all education, mixes should be set up, monitored, and revised to ensure that they accommodate individual, biologically based and experience-based differences.

In the context of this book, it is important to see that this theoretical framework accommodates multiple types of interactions that need to be understood to capture learning processes and to inform educational efforts; these interactions are explicated later.

A CLOSER LOOK AT DYNAMIC TRICKY MIXES AND LEARNING CONDITIONS

Learning occurs only when there is above-threshold positive convergence of some conditions from each of five components. We use the acronym *LEARN*: *Launchers* + *Enhancers* + *Adjustment* + *Readiness* + *Networks* = *LEARN*. As convergence of these components is progressively enriched, the rate of learning is progressively accelerated. Even though definite overlaps between conditions make learning complex, as we discuss later in the section on centrality of interactions, the LEARN organization provides one way to generate a dynamic convergence accounting for already observed phenomena in children's learning, as well as to make useful predictions about possible future discoveries.

Figure 11.1A illustrates the very modest learning that occurs when the LEARN conditions barely converge. In contrast, when multiple, strong learning conditions converge in real time at high levels, the dynamic result is rapid, excellent learning, as illustrated in Figure 11.1B.

The Organization of LEARN

Launching Conditions

For children to acquire new information, structures, or skills, there must be an impetus and opening for that learning to begin. These are referred to as *launching* conditions. The idea behind launching conditions is that for children to learn new skills or information, there must be genuine challenges accompanied by some kind of processing attempts. Launching impetus may arise from a combination of beliefs, noticed challenges, active pursuit of a learning opportunity, modeling of learning by others, and expectancies.

Launching conditions thus must include challenges for the learner and

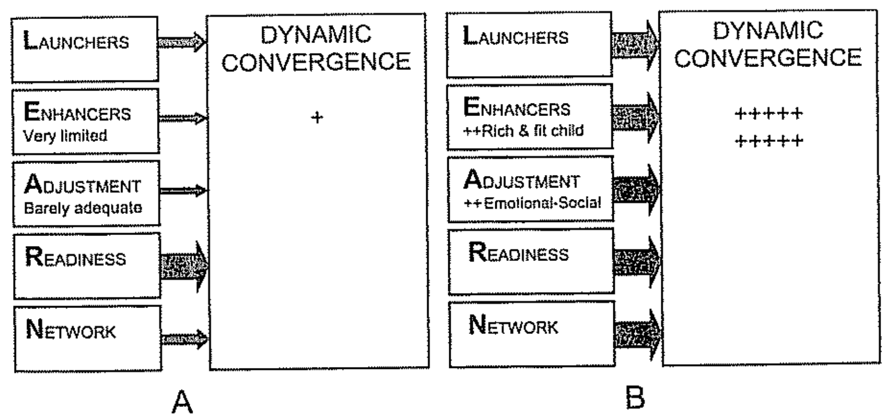

FIGURE 11.1. Dynamic tricky mix patterns of convergence shift from A to B. In A, Readiness is the one factor that is highly positive, and Enhancers and Adjustment are limited. Overall convergence is just barely adequate to support learning. In B, all five major factors are highly positive and converge strongly to support high rates of learning.

incorporate initial conditions of orientation and engagement. At the neural level, the early stages of one-trial, amygdala-mediated learning, as described by LeDoux (2000), fit extremely well here. This work shows that after establishment of such initial representations neurally, new and separate networks support long-term maintenance of acquired knowledge. Other conditions that contribute to the chances of getting a challenge noticed and into the initial launching steps toward long-term representation include priming of relevant neural *networks* and aspects of attention, interest, expectancy, belief, and arousal.

Enhancing Conditions

Enhancing conditions can be described as within-task strategy, processing, engagement, and awareness factors that bolster or augment learning. The role of *Enhancers* is to mediate the probability of successful learning through high attention and rapid pattern detection, and the rich and meaningful entry of new representations into long-term memory. Small shifts in this component, when the other four key conditions are favorably online, can have large consequences for learning.

The use of DTM to study children's behavior heuristically orients us toward different kinds of patterns of input–learner–context interactions rather than simply toward the questions of whether different components of a behavior may or may not contribute to that behavior. The next examples illustrate the important role of Enhancers in dynamic interaction with the other conditions of LEARN.

Metacognition serves nicely as one example of an enhancer. Several investigators have found support for the idea that metacognitive awareness can improve reading performance. For example, when Flavell (1979) examined metacognition in relation to reading comprehension, he found that older and better readers were more aware of the need to use strategies for comprehension. Similarly, Wagoner (1983) showed that poor readers often fail to recognize that reading requires self-monitoring. Similarly Johns (1979) provided evidence that beginning readers are oblivious of the need for helpful strategies in reading comprehension. Finally, de Sousa and Oakhill (1996) studied the relation among children's metacognition, their reading comprehension, and their level of interest. Two groups of good and poor comprehending 8- and 9-year-olds were matched on vocabulary and single-word reading. When children were asked to identify information from text they had read, a significant difference favoring the good readers emerged in terms of children's ability to assess their comprehension of material. However, when children were presented the same task in the context of a game, the poor comprehenders showed increased interest, increased metacognition, and increased performance. These results fit easily with the notion that relatively small shifts in procedure–context enhancement may perturb children away from poor overall dynamic mixes to mixes that engage their focus and motivation in real time and support higher levels of awareness and learning.

A second widely documented enhancer of children's progress in syntax is a particular kind of conversational responding by adults. The strategy of reflecting back a child's expressed meaning by "recasting" the sentence that carries the meaning has been shown experimentally to accelerate children's pace of syntactic growth (Fey, Cleave, & Long, 1997; Baker & Nelson, 1984; Camarata et al., 1994; Nelson, 2000). Recasts, such as "Yes, the cat was chased by that big black dog" as a reply to the child's "Doggie chase cat" illustrate this strategy.

Adjustment

The *A* in *LEARN* stands for *Adjustment* conditions. Adjustments that occur as learning episodes unfold cross the bridge between the traditionally dichotomized cognitive and social–emotional realms.

Consider the child who, after answering a basic reading comprehension question correctly in the classroom, reacts with a sense of ownership and pleasure. Contrast this with a child who has failed in this task. Whereas the child who answered correctly may feel pride and look forward to the next question, and to learning more of the material, the child who answered incorrectly may feel disappointment and embarrassment, and continue to ruminate about that failure. Both of these situations, if repeated, may set up classroom interaction spirals; however, the direction for the successful child may be positive, whereas that for the child who failed may be a downward spiral that moves the child toward a lack of interest, or toward fear.

Adjustment is not solely dependent upon the learner. Also involved might be a parent, teacher, peer, or sibling—those who are onlookers, partners, and potential teachers—who transactionally influences the ongoing social, emotional, and motivational states of the child during potential learning episodes (Nelson et al., 1997; Rogoff, Turkanis, & Bartlett, 2001).

One demonstration of Adjustment processes lies in Elliot and Dweck's work (1988). They showed that when late elementary school-age children were led to believe they had high or low ability, both children with learning goals (children who desire to learn the material because they value knowledge acquisition) and children with performance goals (children who desire to do well on the evaluation) were equally likely to learn new information when no strong challenges were presented. However, when confronted with difficulties, children who had learning goals were able to persist in learning across failures regardless of whether they were led to believe they had low or high ability. But for children with performance goals, only those who believed they had high ability also persevered. Those who believed they had low ability showed a decline in generation of useful strategies for solving a problem.

Thus, beliefs about oneself interact online to influence the child's dynamic Adjustment processes during instruction, with negative emotion and attributions contributing to poor activation of strategy resources (probable processing and learning Enhancers). These strategy resources otherwise would be available to the same child under more positive Adjustment conditions.

An excellent example of how favorable launching conditions (e.g., a theory or belief) may arise and then dynamically interact with Enhancer and Adjustment conditions comes from Dweck's work on how children's views about intelligence influence the way they approach a learning task (Dweck, 1999; Dweck & Leggett, 1988; Dweck, Mangels, & Good, 2004). Children who believe that intelligence is a fixed trait, that is, who hold an entity theory of intelligence, tend to be concerned with performance goals that demonstrate their intelligence. Thus, for these children, achievement is a way of looking smart. On the contrary, some children adhere to an incremental theory of intelligence, in which they view intelligence as the result of learning; therefore it can be increased by efforts that increase knowledge.

In a recent neurophysiological investigation, Butterfield, Mangels, 2003; Mangels, Butterfield Lamb, Good, and Dweck (2006) used event-related potentials (ERPs) to examine how students' theories of intelligence influence the allocation of attention to negative performance feedback, and how attention is directed toward subsequent feedback that could be used to repair errors in knowledge. ERPs measure electrical activity in the brain through recordings on the scalp. In contrast to continuous electroencephalography (EEG) signals, ERPs allow for an investigation into the time course and rough brain location of processes time-locked to different kinds of stimuli. Of particular interest to this investigation were two neurobehavioral correlates: (1) P3, a frontal positive-going amplitude that occurs around 300 msec poststimulus, which is thought to measure unpredictable, unlikely, or highly significant stimuli, where increases in amplitude are related to the level of significance; and (2) the amplitude and duration of negative-going activation in the left temporal region in response to learning-relevant feedback suggestive of the level of processing of corrective and related information relevant to later increased performance (Butterfield & Mangels, 2003).

In Mangels et al. (2006), students holding either entity theories or incremental theories of intelligence were asked to answer a series of general knowledge questions from varied domains, then to rate how confident they were of their answers. Two types of feedback then followed this task: (1) performance-relevant feedback that indicated whether the student's answer was correct or incorrect; and (2) learning-relevant feedback that provided the correct answer regardless of whether the student's answer was correct or incorrect. At the end of the procedure was a surprise retest of those questions that the students had answered incorrectly.

The authors found that, compared to students with an incremental theory of intelligence, students who held entity theories of intelligence showed a greater anterior frontal P3 to negative feedback for answers that they had rated with either high or low confidence, suggesting that these students were more influenced by negative feedback of any kind than were students holding an incremental theory of intelligence. These results were coupled with differences in negative-going activation over the left temporal lobe for entity versus incremental theorists; students holding incremental theories exhibited greater left inferior temporal negativity at longer durations than did entity theorists, suggesting a difference in reactive control processes toward learning-relevant information. An increase in duration of activation in the left temporal lobe is thought to be indicative of activation of conceptual representations related to to-be-learned information that assists in enhancing memory of that information.

These results, together with behavioral results showing that incremental theorists performed significantly better on the retest portion of the experiment, suggest that how students react initially to negative feedback can influence later learning of new correct information. Thus there is neurophysiological evidence that students with different theories of learning are in contrasting ways dynamically adjusting their attention and their processing to the same steps in a learning/feedback procedure.

Readiness

Readiness conditions refer to the state of the child's already-established knowledge, emotion, and information-processing systems relative to the impending challenges. These conditions include working memory capacity, basic domain knowledge, planning skills, the capability to abstract patterns or to draw analogies, attentional and inhibitory control, perceptual skills, and emotion regulation mechanisms. Children's Readiness at any age can be expected to be highly variable and depends on their biological makeup, their current levels of maturation, and their prior histories of learning.

Neural Networks

Within each child there will be high fluctuations across learning episodes in terms of how easily and appropriately already-established neural Networks are activated. Current states and patterns of functional activation are crucial. Change simply cannot occur if the system is too far offline. There must be a minimal level of arousal or energy for the system to function, and core processes of attention, perception, abstraction, and memory must be online to provide any substantial potential for learning. Stronger activation of the functional Networks underlying these processes increases processing and learning speeds.

In addition, the degree of relevant parallel processing may also be a powerful catalyst toward the rate of learning. The successful abstraction and storage of new text and language structures may be boosted substantially by more working memory analytic buffers operating in parallel, and more parallel long-term memory retrieval–storage pathways, (cf. Calvin, 1990; Damasio, 1994; Elman et al., 1996; Nelson, 1987, 1989, 1998, 2000; Nelson et al., 2001, 2004).

More on the Interactions Dynamically of All LEARN Conditions

Unlike most variants on theories of learning, DTM suggests that learning emerges from the convergence of these multiple, complex underlying LEARN conditions. DTM theory is consistent with one earlier theory, Rare Event Learning Theory, which had less elaborated detail but also stressed that learning will be infrequent until mixes of complex supportive conditions come into place (e.g., Nelson, 2000). Whether learning occurs depends on whether the LEARN conditions meet threshold levels of activation. More and more dynamic convergence then leads to higher and higher rates of learning.

For learning to commence, children must be engaged, motivated, and focused. Furthermore, they must have the background knowledge and background experiences needed for the learning situation, as well as the emotional tone and regulation that support acquisition. For learning to proceed at near-optimal rates, multiple task-relevant Enhancers must be brought into the dynamic interplay of conditions. In everyday situations, the likelihood that these conditions will emerge in an optimal or near-optimal pattern is quite unlikely. Children often are in states of emotional dysregulation, are not paying attention, and do not have the relevant background knowledge or strategies.

Furthermore, preschool, school, and clinical situations that are structured specifically for learning to occur rarely take into account the ways that *individual children's* patterns of experiences, knowledge, abilities, personality, and level of interest and motivation interact in complex and dynamic ways with the social and cognitive patterns of teaching encounters. However, we can structure situations in theoretically guided ways, so that high or very high levels of convergence and rates of learning are more likely to occur. In such conditions we would expect learning in many instances to proceed in a dramatic way. The next section covers some empirical demonstrations of these kinds of shifts in learning rates when dynamic mixes shift.

ILLUSTRATIVE STUDIES OF RAPID LEARNING IN TYPICAL CHILDREN AS REFLECTING DYNAMIC MIXES

Vocabulary Growth

The National Reading Panel (2000) suggests that vocabulary is one component for reading success. Because vocabulary continuously expands across the lifetime, the potential for reading success may also be expanding similarly. For this reason, examining vocabulary rates and growth may be an essential component in understanding complex skills such as reading.

It is well known that at around 17–19 months of age, some children demonstrate explosive growth in their vocabularies, in the same period when other children are only creeping along in lexical growth (Dale & Fenson, 1996; Hart & Risley, 1999). As an example, Smith (1926) suggested that the average 18-month-old knows between 3 and 100 words. Others have been more optimistic in their analysis. Nelson and Bonvillian (1978) suggest that a vocabulary of approximately 600 words is more likely. In fact, Aitchison (2003) proposed that, by 2 age years, children may range in the terms of the number of words known from 6,000 to 14,0000 words. It is likely that these hugely variable estimates are neither correct nor incorrect. Rather, it may be that individual differences in vocabulary are this large, and that this variability reflects the patterns of transactions that have accumulated from the initial onset of vocabulary learning (Weizman & Snow, 2001).

Very low vocabulary levels may be indicative of children whose learning spirals have resulted in not only stalled learning but also an actual decrease in the tendency for LEARN components to converge in above threshold ways. In contrast, higher vocabulary levels represent the kind of learning that is possible when highly positive spirals of learning are created. However, the fundamental reasons for such huge individual differences have not been sorted out from naturalistic studies. From the DTM theory, it is predictable that many children have in place needed cognitive and language Readiness factors, but await the arrival of highly favorable interactive conditions that mix in processing supports, lexical challenges, and mutually high engagement with a caregiver, before their learning potential leads to a burst in vocabulary growth. At least two experimental studies support this contention.

Work by Smith, Jones, Landau, Gershkoff-Stowe, and Samuelson (2002) used causal experimental methodology to demonstrate how changing the dynamics of the learning situation could lead to dramatically increased learning rates. Matched groups of children received either no lexical training or lexical training for 8–9 weeks on nonsense words that mapped to clear, shape-based categories of objects. The key result was that children who were provided repeated exposures to unfamiliar objects that shared that same shape were able to generalize the name of the new objects based on shape. Smith et al. concluded that learning a coherent category structure allowed children to refine their attentional strategies, and that this refinement led to changes in vocabulary acquisition that could be seen outside the laboratory as well.

The DTM interpretation is that the lexically trained children were "perturbed" in their dynamic learning systems by the training experiences, leading to a vast acceleration of their lexical progress *outside* the experimental sessions. In each of the studies, the pace they showed outstripped the control, untrained children's vocabulary progress in home language use by 178–253% across 2 months.

Experimental studies, such as that by Arkenberg (2006), provide additional evidence of the high rates of learning that are possible when the dynamics of the learning situation are changed. In that study two groups of ten 4-year-olds were matched on vocabulary knowledge, awareness of print concepts, working memory, phonological awareness, attention, and ability to generalize. One group of children participated in a 12-week word-learning intervention, in which they were exposed to 450 unfamiliar animal names. In accordance with DTM theory, children were exposed to these new words under highly engaging, child-directed sessions in which the investigator followed the child's lead by allowing him or her to dictate the next animal to be learned, and by building into playful discussions at least eight tokens of each of the new lexical items. This scenario translated into a mix that we would expect to create high rates of learning. Launching conditions included children's interest in the material sparked by embedding the goal learning within the context of free play that the child directed; Enhancers such as numerous and varied visual and verbal tokens of the to-be-learned items were provided. Furthermore, children were rewarded with praise for remembering the animal names, and they were never provided with discouraging remarks if they did not remember. These contingencies provided an opportunity for increasingly positive Adjustments. Children's Readiness for the material was determined through the use of multiple cognitive assessments prior to the intervention. Finally, children's growing knowledge was assessed regularly through tailored interactions used to gauge children's Network conditions.

Results from the intervention portion of the experiment showed that when children were taught new lexical items during these intensive, rich, positive, and highly engaging episodes, they demonstrated exceptionally high rates of gain of up to 20 words per hour. By way of contrast, estimates of fairly typical naturalistic rates for 4-year-olds are much lower, at between 2 and 20 words per day (e.g. Anglin, 1993). A classic Matthew effect (Stanovich, 1986) was also observed, in which children's rate of learning in intervention increased by more than 10% across the 12-week period. That such a high rate of acquisition can occur suggests that children certainly have the capability to learn many new words when the conditions for learning are favorable. In addition, it appears that multiple cognitive gains contributed to these findings. Because we assessed cognitive ability in the two groups of children prior to, halfway through, and at the end of the intervention, we were able to compare changes in working memory, phonological awareness, attention, and generalization abilities for children who did and did not participate in the intervention. The children in both groups were well-matched on these cognitive abilities prior to the intervention; however, we saw significant cognitive gains across time only for children in the intervention group.

Experts in many fields routinely show the same kinds of cognitive and learning increases in both skills and knowledge seen in the studies we have presented. In fact, "expertise" is defined according to those benefits. To illustrate, Bedard and Chi (1992) compiled a list of characteristics experts typically show as the result of having learned a certain domain extensively:

- Experts, by definition, know a lot about their domain of expertise.
- Compared to individuals who do not know as much about a topic, experts show evidence of a highly cohesive and complex knowledge base (Gobbo & Chi, 1986; Johnson & Mervis, 1994).
- Experts show clear memory and perceptual advantages for information about their domain of expertise compared to novices (Chi & Koeske, 1983; Johnson & Mervis, 1998; Reingold, Charness, Schultetus, & Stampe, 2001).
- Experts use different processing strategies for domain-related information than do novices (Larkin, McDermott, Simon, & Simon, 1980).

Presumably these expertise advantages lead to the phenomenon that, compared to novices, experts more quickly learn new information in areas about which they already know a lot. It is interesting that children who are learning language show these same kinds of characteristics. Thus, although not typically described in this way, lexical acquisition can be thought of as the development of expertise. We might refer to this as the "Lexpertise" model of word learning. The main tenet of this model is that basic cognitive abilities not only set the stage for word learning to occur but also change in response to that learning, thus creating a dynamic upward spiral that promotes increasingly more efficient future word learning. We are not entirely alone in making the connection between expertise and linguistic proficiency: Wagner and Stanovich (1996) made similar claims with regard to learning to read. What is pertinent to this argument is that Dynamic "Tricky" Mix theory is as well-suited for explaining advances in normal word learning, syntax growth, and reading skills development as for explaining changes associated with expertise.

Syntactic Growth

In large-sample, naturalistic studies of syntax development, a remarkable phenomenon still awaits explanation. By about age 24 months, some children show complexity in syntax far beyond that of their agemates, and far beyond what most theoretical accounts encompass for that age. For example, in Fenson, Dale, Reznick, Bates, and Thal (1994), whereas the top 10% of children raced ahead in multiword combinations and syntactic constructions, the bottom 10% of children have barely progressed in syntax. How is that possible? *Readiness* constraints, which, the literature suggests, should prevent these levels of complex acquisition in the fastest 10% of children until 6 or more months later, are not operating to keep these children's language simple.

One possible solution to this conundrum might be to demonstrate that only those 24-month-old children whose levels of perception, motor planning, pattern detection, selective inhibition, goal-setting and monitoring, and working memory are at a 36-month level or higher can pull off complex syntax. This seems unlikely, however, and another straightforward interpretation is available: For most children, complex syntax foundations are in place long before the children encounter excellent Dynamic Tricky Mix conditions for syntax learning. Experimental, causative studies on syntax acquisition from multiple research groups support the same conclusion. It is the rich, well-specified mix that incorporates the high levels of joint attention, social–emotional engagement, scaffolding dialogue, and few demands for immediate response that propel ordinary 2- to 4-year-old children to learn with extreme rapidity syntactic structures (e.g., passives) that are far ahead of normative expectations (Akhtar & Tomasello, 1997; Baker & Nelson, 1984; Fey, Cleave, & Long, 1997; Nelson, 2000).

In summary, these studies show that remarkable acceleration of vocabulary and grammar acquisition rates can be achieved readily in ordinary 14- to 60-month-old children, across 2–3 month periods under optimal conditions of above-threshold convergences of learning conditions.

IMPLICATIONS FOR WORK WITH ATYPICAL CHILDREN

If we look to create new learning episodes that reflect insights from dynamic systems perspectives, there should be many opportunities to design curricula and interventions for both atypical children and typically developing children. In all cases, the particulars of the "mixes" of systems conditions can be expected to be critical.

In this section we look at the surprising gains made by school-age children with autism spectrum disorder. Both of the studies we briefly review here involved Swedish children who objectively had a history of slow to zero rates of gain over many preschool and early grade years in two communication modes—speech and text.

In these studies, fundamentally new mixes were created in which individual children again and again took the lead in using computer software to create messages. By selecting words from printed displays on the screen, children created text sentences, then the computer displayed sentence meaning through both visual animations and oral Swedish. In these new mixes the teacher's role shifted toward more close observation of the children's interests and communication, along with timely responsive recasts of what the children created, along with emotional and social positivity. The children's monthly rates of gain in literacy accelerated more than 5 times over baseline (control) rates. In Swedish speech, for which the new mixes provided fewer scaffolded challenges than they provided for text challenges, the children also made strong gains. The bottom line for these children with autism spectrum disorder is that after years of extremely slow progress, when new dynamic mixes differed dramatically from what they were already receiving, children demonstrated high potential for progressing at normative rates in both literacy and spoken language (Nelson et al., 1997; Nelson et al., 2001).

NEW, THEORETICALLY GUIDED DIRECTIONS IN SUPPORTING LANGUAGE AND READING DEVELOPMENT

Ideas from DTM theory set up an interesting set of teaching/learning possibilities for accelerating language learning in both typically and atypically developing children. Parents, teachers, aides, and clinicians who are striving to accelerate spoken language or literacy skills in both children without disabilities and those who are far behind in these domains would be wise to combine Launchers (i.e., challenges) that are appropriate for an individual child's Readiness. These Launchers should be mixed dynamically with Enhancers, Adjustment, and Networks conditions into small, ongoing episodes.

One possibility is for parents and practitioners to be aware of a particular child's initial and changing level of knowledge, skills, experience, and interest to create and maintain the most favorable *LEARN* conditions. By remaining committed to continual individual and frequent online assessment, adults can provide tailored, child-specific input that capitalizes on the child's knowledge, cognitive strengths, and interests. An expertise framework (discussed earlier, see Arkenberg, 2006) also may help in creating favorable Adjustment and Network activation, Enhancers, and related conditions by pointing toward contents of a domain in which a child is most expert. When those contents are activated for a child in learning episodes, working memory may quickly retrieve basic information, accompanied by clear organizers with rich associative links. Then, when challenges for potential learning enter working memory, these representations can be more efficiently used in comparison processes leading to detection–abstraction of the new challenging structures (cf. Case, 1998). As an example, consider a child who is interested in, and knows a lot about, dinosaurs as a domain of expertise. Introducing new, difficult syntactic forms in the context of playing with dinosaurs might aid in very rapid syntactic advances. Sentences with easily activated lexical items about dinosaurs would reduce overall processing load, allowing most of the child's online processing resources to be used in abstraction and encoding of new syntactic structures.

Leveraging Higher-Order Skills from One Domain to Support Other Domains

Once language and literacy skills are both framed in terms of expertise theories, it becomes natural to look outside those domains for expertise that a child may already possess that might somehow facilitate teaching of communication skills. The potential for interesting transfer would be especially high once a child has reached a level of expertise in which all the following hold true:

- Great depth of knowledge
- Rich and rapidly retrievable organizational schemes
- An extensive and flexible toolkit of strategies
- Higher-order planning and monitoring of plans

This package of characteristics is very similar to what Nelson and Nelson (1978) discussed as "Stage 5: Flexible Extension" for the acquisition of complex systems. These authors also stressed that strong individual differences in the relative pace of moving through varied domains, such as narrative, syntax, vocabulary, music, and mathematics, would set up the likelihood that one child might achieve powerful transfer from advanced levels in one domain that would be entirely different than the source of high transfer for another child.

How might such potential transfer be set up in school settings for children who are far behind in literacy, spoken language, or both? For a child with "incidental expertise"—incidental in the sense that it would not usually be brought into serious instructional planning, for example, in drawing or music—the most complex performance levels in the expert domain might be shared with the class or with just a dyadic teaching partner. Then the ways that the child narrates orally and in text could be demonstrated in relation to a drawing or musical sequence, providing a basis for teaching more complex reading, writing, and oral storytelling, with their accompanying lexical and syntactical complexities. Using and reflecting on the higher-order plans and monitoring the already-expert domain may guide and motivate aspects of the child's progress toward spoken and/or written language. This appears rarely to have been attempted in preschool or school settings.

Looking from another angle, the domain of oral language often may leverage literacy advances. Spira, Bracken, and Fischel (2005) provide one relevant set of data (cf. Scarborough, 2001). They show that there are strong Readiness differences in a broad range of oral language skills among children with significant reading disability (RD) at Grade 1, and that progress in overcoming reading disability by grade 4 is significantly associated with such language Readiness over and above grade 1 reading scores.

The Value of Exploring High Challenge in Dramatically New Tricky Mixes

Many of the studies we reviewed earlier showed that a variety of children were capable of learning complex challenges at remarkably high rates compared with their nil or low rates for seemingly simple challenges. Two-year-olds readily learn passives that 10-year-olds may more typically still be acquiring, but only when an experiment or a culture provides the younger children with meaningful, conversationally embedded, well-mixed social learning encounters (Allen & Crago, 1996; Nelson et al., 2004). These passive-competent 2-year-olds deliver multiple important and surprising conclusions:

- They demonstrate Readiness in terms of brain maturation, prior linguistic structures, memory, attention, processing speed, rapid speech processing, and other necessary cognitive systems to extract passive structures from ongoing receptive language, and subsequently incorporate them in their speech output.
- This high potential for processing and learning is mobilized effectively when social–emotional positive conditions and Enhancing dialogue accompany a wide range of passive sentences used by their conversational partners.

The same set of conclusions also applies to 6-year-olds with severe language impairments (language age of 3 years), who participated in 10–40 hours of newly-mixed, focused conversations designed to facilitate acquisition of passives, relative clauses, gerunds, and other complex syntactic structures (e.g., Nelson et al., 2001, 2004).

These examples should help motivate us as researchers, teachers, and clinicians to look skeptically at our typical assessments and insights for estimating the potential of children with and without disabilit,y and what "zones of challenge" may be within their processing reach. Once we try new challenging mixes with rich Enhancers and see a particular 2- or 10-year-old enjoying the process of moving rapidly ahead in reading, spelling, writing, speaking, or listening–comprehending, then our "playing field" of possible favorable learning procedures and contexts expands enormously.

High or low challenges in a mix no doubt interact in complex ways with the expectancies, emotions, and social processes that evolve over many episodes of potential engagement with a learning partner. A child who is learning over many episodes but realizes (as does the teacher) that she or he is creeping along may have a fairly low excitement and attention level. When a greater range of challenge levels is mixed in, and the child and the teacher come to recognize that the child is learning many of the most complex challenges easily, then motivation, anticipation, and enjoyment all may spiral upward in ways that make the online mix during instruction highly positive and convergent. Over weeks and months, this may result in learning that is dramatically greater than what we would have seen in a more traditional instructional scenario.

An implication of the "trickiness" of establishing a mix of learning conditions to support an individual child's development may be seen in the usual preschool conditions; that is, many children at different skills' levels have just one teacher and one aide. If the adults use a narrow set of strategies for interaction, with a narrow focus on a few skills considered interesting and appropriate, then it is extremely unlikely that very many children will receive optimal learning conditions. As Dickinson et al. (2005) observed relative to usual preschool settings, "Indications are that far too few children receive the type of support for language and literacy development that is associated with optimal growth" (p. 214).

In their own research with an intervention termed the Literacy Environment Enrichment Program, Dickinson et al. (2005) trained and coached teachers on an expanded set of strategies incorporating multiple challenge components. These components included phonological awareness, vocabulary, reading dialogues, and emergent writing. From the DTM perspective, within the expanded set of challenges and teacher strategies, teachers create new mixes of conditions, thus enhancing the probability that a particular child receives a mix that substantially impacts learning. Results indicated that, on average, over and above learning rates in comparison preschools,

there were enhancements for children's vocabulary, phonological awareness, and early literacy. Similarly impressive gains in early academic skills, together with gains as well in social–emotional skills, have been shown by 4- to-5-year-old Head Start children in a project that trained teachers explicitly on strategies for facilitating language, literacy, and social–emotional skills (Bierman et al., 2007; in press). Beyond encouraging demonstrations of this kind, we believe that a further level of intervention effectiveness is likely when repeated rounds of coaching and monitoring more directly assess and try to perturb ongoing dynamic mixes. In the next section we discuss some possibilities.

Moving toward Optimal Mixes

A Scenario

Consider 20 different children in a grade 2 classroom, each of whom is 2 years behind norms in both reading and oral language. From dynamic systems perspectives, we can predict that many of the particular mixes of learning conditions include challenges that are productive for one child and a waste of time for other children, because they already know what is being presented, or because other conditions do not converge adequately to support processing of relevant challenges.

This kind of limitation holds true for the mapping of new text to existing vocabulary, for the learning of new vocabulary and syntax, and for the learning of new narrative and composition skills. Another limitation is that because expertise begets new knowledge, children who are already significantly behind in communication skills tend to have a disadvantage in learning rates compared to children already at or above norms. This is similar to the idea that the rich get richer and the poor get poorer—deemed the "Matthew effect" by Stanovich (1986).Together these considerations might lead one to an extremely pessimistic view concerning communicative progress for children with RD and/or language impairment. However, if traditional ways of teaching are transformed in multiple ways, the prognosis for such children becomes far more positive.

Mixes of Innovative Procedural Moves

To create online interactive dynamic mixes that contribute to rapid learning by children, a combination of procedural moves requires attention. Four of these moves are presented:

1. Better monitoring of what each child already knows is essential. This serves as a base for small- or large-group planning that minimizes "false-teaching" activities, in which all the targeted structures

are already known to all the children. Clearly, rich monitoring will also support 1-1 or 2-1 teaching episodes in which there is substantial tailoring of challenges in phonological awareness, vocabulary, syntax, and narrative to children's existing repertoires.

2. Mistrust any single way of teaching. Instead deploy exploration and effectiveness monitoring of at least two distinct ways of teaching toward the same challenges.
3. The choices of ways of teaching under trial also should include tailoring to what is known about the social, motivational, emotional, and cognitive conditions that have so far been monitored as being relatively high in supporting an individual child's engagement and learning. In this regard, new teaching research could build on findings such as those of Ladd, Birch, and Buhs (1999), who found that kindergarten achievement was influenced by teacher–child relationships, peer relationships, child participation patterns, and child cognitive maturity.
4. These tailorings, and the monitoring of their effectiveness, should evolve, so that what is least effective in Time 1 monitoring is replaced by new distinct mixes of conditions in Time 2 (e.g., the next month's teaching), and the majority of teaching practices in place are producing better learning than in the prior period.

When implemented, all of these innovations dramatically improve the likelihood that, over time, children's growth rates will accelerate. Moreover, to the extent that the convergent mix of learning conditions achieved in classrooms becomes as positive as those observed under favorable experimental conditions documented in the literature, it is predictable that despite poor prior histories of learning text and oral language, many children with communicative disabilities may learn at very high rates. Levels of 20–50 words per day for new oral and text vocabulary should be approached for 6- to 9-year-olds. These speculative rates are high compared with what has been observed to date in most classrooms, but the multiple theory-based innovations described would create learning mixes that would be new and powerful. Though less precisely anchored in prior literature, very high rates of learning for new syntactic and narrative structures, and fluent comprehension of connected text and oral discourse should also be achievable.

In summary, for children at high risk for, or already demonstrating, impairments in language or reading, there is a strong basis for expecting improvements in learning that lead many children into normative and above-normative rates of skills acquisition. This has been achieved and reported in short-term studies in the literature (Dickinson et al., 2005; Nelson et al., 1996, 2001, 2004; Torgeson et al., 1997). For broader-scale and longer-term successes, we argue that we have specified the foundation for theoretically guided multiple innovations. The goal is to bring far more children into learning contexts that provide a very high frequency of learning challenges, accompanied by all the other, needed interactive, dynamic conditions that support highly efficient and often-optimal processing and learning.

NEW THEORETICALLY GUIDED DIRECTIONS IN ASSESSMENT

In typical preschool and school settings, assessments before instruction begins are exceedingly thin. Only a few potentially relevant skills are examined at all, and these are only narrowly tested by a single examiner in a decontextualized fashion. Instruction in reading or oral language most often provides the same instructional episodes to all children in a class. When finer-grained instruction is arranged, it is based upon two or three levels of perceived skill in different subgroups of children who may receive different books, games, drills, or other activities, roughly dependent on their perceived skills levels. From a DTM perspective, this set of procedures is virtually guaranteed to lead to low probabilities of engaging very many children in instructional mixes that approach optimum motivational or learning efficiency characteristics.

The Nature of Assessments

Consider first the nature of assessments. Dynamic systems theories hold strongly that if a child "knows" and in one context can deploy some part of language, say, a noun phrase or a syllable, or a vocabulary item such as "unicorn," whether the child will be able to achieve online, timely, and appropriate use in a new context is a complex proposition. Thus, if a child passes an item on a language or reading subtest administered in standard, decontextualized fashion by a single tester, we should expect—particularly for recently acquired skills—high variability in deployment. Variables dynamically interacting to produce this variation are the dynamic systems variables we have so far discussed (e.g., Adjustment socially and emotionally, Enhancers, and current Neural Networks activation).

Other difficulties arise from assessments that indicate a lack of language or reading skills in a child. Based upon narrow assessment, a child may receive instruction on all skills not demonstrated in the assessment. However, this instructional effort may be wasted if most of the skills were already in place but just not demonstrated under the particular dynamic conditions of testing.

Assessment Mixes

Taken together, the inherent risks of either underestimating or overestimating the child's current skills repertoire from typical assessment procedures imply that multiple changes would work toward better learning opportunities for children with and without language and reading difficulties. Some recommendations follow:

1. Assessments should always be viewed as subject to dynamic conditions, and should be broadened to include sharply contrasting testing packages—different testers, physical and social contexts, and interactive patterns between the child and testers.
2. Instruction should continue to examine and to contrast, as argued elsewhere, different instructional packages that try to achieve positive dynamic mixes through different pathways.
3. Instructional phases should try to move new oral and text representations for a child from initial deployment in whatever context proves feasible to increasingly rapid, fluent, flexible deployment across multiple social partners, multimedia formats, and communicative goals.
4. It can be expected that the particular pathways to a child's achievement of such consolidated and flexible communicative skills will be dramatically different for many children in terms of how social–motivational engagement is achieved and what scaffolding activity patterns contribute efficiently to a child's progress. As a consequence, a necessity will be frequent monitoring and *Adjustment* of both social–emotional processes and specific, presumed cognitive-processing facilitators or *Enhancers* throughout instructional phases.

THE CENTRALITY OF INTERACTIONS

We have incorporated in the previous discussions the importance of interactions from a number of different theoretical and practical angles. Here it is appropriate to highlight and contrast seven types of interactions.

Biology by Experience

Biological makeup at every point in development interacts with experience. For children who are progressing well, and for children who are not, there is still a great deal to be learned about how individual differences in (partly) biologically based *Readiness* characteristics, such as attention, memory, pattern detection, and planning, interact with individuals' experience to produce development. In many instances, we have seen that for children with learning difficulties, however, when new experience in rich transactional, dynamic mixes was provided with some rigor, children's demonstrated bursts in learning rates forced a reappraisal of levels of biological *Readiness* that were already in place but underestimated prior to enriched intervention.

Dynamic Systems Frameworks of Interacting Conditions

Dynamic systems theories argue that systems for performance and learning are inherently dynamic interactions of multiple, complex, nonlinear factors that frequently move from chaotic states to structured states, and back again. Part of the emphasis provided by the variant on these theories we have presented, the Dynamic Tricky Mix theory, is on the "trickiness" of moving into and maintaining (with reasonable probability, but not certainty) well-structured positive mixes of conditions that support learning. To cross the *threshold* into learning, one crucial level of real-time interaction is to "mix" is enough convergence of social–emotional and cognitive–linguistic factors. Beyond that level, increasingly positive interactions, with highly favorable levels of many variables and well-timed dynamic convergences, can lead to increasingly high rates of learning. These rates may approach the *maximum*, optimal level achievable given the individual learner's current state of *Readiness*.

What is already in the child's head, as we have seen in many experimental demonstrations, is very often sufficient as a foundation of *Readiness* for progress in language or literacy, even for children with a poor history of progress that qualifies them for disability status in either or both of these areas. Multiple projects have shown that children far behind in communication do learn at normative rates, and sometimes even faster than matched comparison children with disabilities, when new learning mixes bring substantial challenges into episodes that also carry positive tone, social–emotional engagement, and scaffolds for processing. In *Readiness* terms, it has been demonstrated that children with deafness and autism, as well as those with dual deficits in language and literacy, can progress in literacy without waiting for new progress in vocabulary and syntax (Nelson et al., 1997, 2001). Similarly, children with specific language impairment progress under new, conversationally engaging mixes without first requiring any advances in their current auditory processing skills or working memory abilities (Nelson, 2000; Fey et al., 1997). Thus, applied progress can move in coordinated fashion with theoretical progress. By taking clues from very diverse methodologies and instructional frameworks, the field can use much more brainstorming of particular new mixes of learning conditions, with close monitoring of both engagement processes and learning advances.

Complex Perturbation Effects

DTM theory organizes learning conditions according to five categories (with some admitted overlap), each of which must contribute positively to produce any convergence that leads to learning. These five spell the acronym, LEARN (see Figure 11.1). The account given here and in other writings, however, needs some future elaboration along the lines of yet another kind of interaction pattern. As a potential learning episode unfolds, the five broad LEARN categories of functional activation—Launchers, Enhancers, Adjustment, Readiness, and Neural Networks—interact. As one category shifts level when a perturbation is encountered, it not only contributes differently to new rounds of online mixes with other conditions, but it also often indirectly influences better mixes by interacting with the levels of other factors. Let us say that an adept social, humorous move by a teacher impacts the child's Adjustment socially and emotionally toward greater positivity. This change may lead rapidly to new Network activations of long-term language representations that are most relevant to challenges being presented in reading by the teacher. So, in the next few minutes after the child's Adjustment level shifts, the Network activations also shift, and the overall dynamic mix of conditions is doubly "tricked" toward a higher probability that reading challenges will be processed and learned.

On the applied, practical side, it is of great interest to look for any innovations in teaching or context arrangement that may lead to double- or triple-"whammy" effects on multiple conditions and their overall convergence to support learning. Similarly, on the theoretical side, it is important to provide refined accounts of how these kinds of interactions are created, which of them have the most impact on learning, and which real-time neural mechanisms parallel and support them.

Learning Cycles across Many Learning Days

Another level of interactions occurs when we examine relationships between current episodes of learning encounters and either earlier episodes or those that follow by weeks or months. The possible dynamic mixes of conditions in current episodes interact with what mixes have occurred; what learning took place; and what attitudes, expectations, or emotions shifted in recent episodes in a similar context, with similar partners and learning challenges. The child as learner and social partner, and the teacher as instructor and social partner often shift patterns that tend to promote increasingly positive or increasingly negative probabilities of new episodes with a positive DTM.

We see the importance of monitored learning cycles across time in cases when children's biological readiness appears low in some important

processing capacity. For instance, let us suppose that a particular child with significant language delay also displays definite impairments in working memory during language processing. An effective dynamic mix shifts other conditions during conversation, so that, despite the memory limitation, learning of new language structures occurs. The theory emphasizes that new mixes may be created in multiple ways, and that only monitoring can determine whether an attempted mix actually promotes learning for an individual child. Enhancers that could be tried would include "priming" already known language structures by redundancy in a short stretch of conversation. Within these priming stretches of conversation, presentation of challenging structures would also occur. Thus, the child's system potentially can more easily handle old meanings/structures using fewer memory resources, so that more memory resources are devoted to analyzing and encoding new language structures. For a particular child, however, this particular attempted enhancement might have no impact unless it is dynamically combined in the same stretches of conversation with high-interest topics and multiple recasts/paraphrases, and somewhat slower speech by the child's conversational partner. Monitoring variations along these lines, and their impact on engagement and learning by the child, are crucial to finding what mixes of new conditions interact productively with the child's current cognitive capacities.

Interactions across Domains and Subdomains of Expertise

Children's progress toward expert levels often shows highly uneven profiles for different domains. Similar unevenness is evident whenever close analysis is provided, as in microgenetic studies of levels of expertise in different subdomains, such as the lexicon, grammar, writing, reading, music, mathematics, chess, or art. Examination of learning from the point of both larger and smaller branches of many varied domains allows for increasing specificity, as well as generality in thinking about the mechanisms of development in areas such as vocabulary and reading. More work on cross-domain interactions and individual paths is needed, particularly for the higher levels of expertise within a domain. It is at these higher levels of domain mastery that one can see the greatest potential for powerful transfer processes concerning organization, mindfulness, strategies, planning, monitoring, and editing. Multiple theoretical ideas relevant to the discussion of these issues were provided by Nelson and Nelson (1978), who speculated:

> we have made clear for each of the systems separately, and also for the patterns among the systems of relative acceleration or delay (e.g., discourse rules far ahead, far behind, or on a par with sentence rules), that there are strong individual differences which eventually need explicit theoretical de-

> scription. The other kind of question that our account leads toward is the question of how the child uses available evidence to make the transitions between successive stage levels. Our theory implies that such processes of transition could look quite different for the child's different systems at any one point in general cognitive development, particularly if some systems have already reached the next-to-final stage when other systems are at one of the first two stages. (p. 275)

Complex Interactions of Foundational Cognitive and Emotional and Social Processes

In many respects the literature on correlates and apparent underpinnings of children's mastery of important developmental achievements in language and in literacy is "too good"; that is, there are so many reasonable, evidence-based variables that correlate with communicative progress when group designs and statistics are employed that designing interventions for children in developmental trouble or at risk for delay might seem very daunting. Intervening on all apparently relevant cognitive and language processes appears to be beyond the scope of anyone's resources, and choosing instead a small and feasible set of variables for intervention appears to require improved theoretical grounding to become an approach that might work for most or all children.

This set of circumstances leads us to return to the observation that children's demonstrated bursts in learning rates under multiple, theoretically guided causal experiments force a reappraisal of what levels of biological *Readiness* were already in place but underestimated prior to enriched intervention. This point requires some elaboration.

In the studies reviewed earlier demonstrating that children with a history of extremely poor progress in literacy and/or language do learn at or above normative rates with new dynamic mixes—child-focused challenges, together with social–emotional positivity and interactional processing supports relevant to the challenges—insight is provided into three levels of common misassumption about these children with "learning disabilities." First, without waiting for greater maturation or new cognitive skills, children can reach developmental levels that are substantially above levels at which they may have plateaued for months or years. Second, multiple assumed, possible prerequisites turn out not to be true prerequisites for progress, because many or most children proceed without those typically correlated cognitive or communicative skills in place. Third, the rate at which progress can occur is far beyond what was seen in the past for these children or expected by school or clinical plans.

Future research could build foundations for designing even better

new mixes of conditions by directly addressing the social–emotional *Adjustment* processes. For example, more attention could be given to the work of Pianta and colleagues (e.g., Hamre & Pianta, 2001) and their overall finding that positive teacher–child relationships in the early school years are associated with children's academic gains across multiple years of school.

Contextual Savvy Interacting with All Other Learning Conditions

Children who possess more text skills, who feel more confident in a particular assessment or teaching context, and who have well-established, expert-level "context scripts" are more likely to display their current skills effectively in tests or to engage their current skills more effectively in active comparisons to new challenges in teaching episodes. It is important to see that the scripts children acquire about contexts will powerfully interact with other conditions to affect their performance.

An interesting demonstration of this phenomenon is provided by Gee (1997) for reading test contexts for undergraduates. Honors undergraduates showed how much they knew about the expected frameworks for reading comprehension passages and questions when they were given the Educational Testing Service (ETS) multiple-choice questions, without glance at the relevant text passage. They correctly sorted out most of the answers based upon general scripts! There is little doubt that, at every level from kindergarten on, there is rich opportunity for such context scripts sometimes to conceal what has really been comprehended or learned. Yet with explicit attention to such scripts, there may also be many occasions when new learning may be facilitated by emphasizing how new challenges fit within an already familiar framework.

CONCLUSIONS

Oral, written, and sign communication are inherently complex and dynamic, integrating a rich variety of social, emotional, motivational, cultural, attitudinal, linguistic, and cognitive–information-processing components. Understanding how typically and atypically developing children proceed through the stages of acquisition in language and literacy requires that these more complex, dynamic, real-time processes be more richly documented than they have been in prior literature. However, we have shown that we already know enough to enrich theoretical accounts and innovations in education.

Research has demonstrated that by rearranging the mixes of conditions present in child–adult interactions, some startling accelerations of children's progress in language and literacy often can occur, without waiting for the acquisition of presumably prerequisite skills levels in cognition. Children—whether typically developing children or those with language delay, autism, deafness, or motor difficulties—often can "do more with less"; that is, they can achieve excellent rates of progress in language or reading or writing, with less memory, attention, or other skills than are assumed necessary by much theory and educational practice.

The DTM model calls attention to complex issues in assessing children's skills. In test-taking contexts, there is a high risk of a child demonstrating less complex performance than his or her current skills set could support under different contextual conditions.

A third strand of emphasis is that much can be gained by looking at communication domains in terms of the acquisition of expertise. Doing so helps to shift preschool and school curriculum goals away from possibly arbitrary educational objectives, toward flexible skills in language production and comprehension, and in reading and writing. This "expertise" perspective invites the implementation of some high standards of communication skills that would have to be assessed in real-time communication performance. In addition, the perspective raises expectations. Put bluntly, may we dare to expect that by adolescence, all, or nearly all, children are capable of reaching high expertise levels in all the above domains for first language and also in at least one second language?

Fortunately, the feasibility of future achievement for these kinds of expert levels appears much enhanced by findings discussed within the DTM theoretical perspective. It is fully predictable from this theory that with a one-teacher, one-curriculum approach for language or literacy for 30 children in a class, there will be extensive portions of a day when each child will encounter no mixes of learning conditions that reach a needed threshold for learning to begin. Furthermore, it is predictable that even when learning does occur, the mixes present will be far below optimal for a child most of the time. From the DTM perspective it appears unlikely that any strong shift toward optimal learning rates will be achieved by trying to refine testing of cognitive and language components in decontextualized, brief procedures and to couple such test results to any one-size-fits-all curriculum that presents step-by-step, small incremental challenges in language or literacy. Instead, moving more children toward excellent skills levels in all modes of communication will require assessment, initial teaching attempts, and continued monitoring and revision of teaching–learning procedures that jointly take into account individual differences in children and teachers, and the power of theoretical models, such as "expertise" and dynamic systems, to frame innovations.

CURRENT LIMITATIONS AND FUTURE DIRECTIONS

Every theory has its limitations and the DTM theoretical perspective is no exception. Current challenges include the need for researchers and practitioners more often to take seriously the claim that individual, frequent, online assessment of engagement, coupled with individualized and frequently adjusted lessons/scaffolds that capitalize on a child's interests, talents, and readiness, may be keys to achieving optimal or near-optimal communicative growth. We agree that this often is a daunting task even for an individual working with one child, let alone a classroom full of children. At the same time, in future work, there are potentially very high payoffs from this approach. By identifying which episodes of teaching are not highly effective, and why, then the same resources can then be applied to create substantially more positive impacts on motivation, initial learning, and generalized flexible use of knowledge and skills.

Further possibilities arise, particularly relative to which dynamic assessments and adjustments occur. Continual improvements in computerized technology provide headway toward allowing intensive assessments of learning progress and minute-by-minute adjustments in teaching/presentation strategies. Yet everyday teaching practice seldom employs these tools, and it almost never links this kind of information dynamically to how motivation, learner attitudes and theories, and social–emotional adjustment converge, or fail to converge, with presented challenges to the learner.

As mentioned earlier, the DTM theory is not without limitations. DTM is a general theory of learning, yet it has been applied to a relatively small set of populations and, within those populations, to relatively few participants. Thus far, systematic investigations have focused on small groups of middle-income, developmentally normal preschoolers; children with specific language impairment; or children with autism spectrum disorders. With only a few studies that attempt to test the limits of DTM, the ability to generalize to other populations, including children living in poverty, is still quite limited. In addition, investigation of DTM has been limited to specific aspects of literacy and language acquisition, such as early stages of reading, lexical learning, and the acquisition of specifically targeted syntactic structures. To demonstrate DTM is a widely useful explanatory theory, investigations into more varied linguistic and nonlinguistic domains need to be undertaken. In addition, DTM is still in development, and LEARN components are sometimes underspecified in any particular study. For example, Adjustment conditions may be interpreted as applying to how a child is regulating emotions during a learning episode, or to changes in how a child feels about the learning material, yet individual studies have not yet monitored both of these possibilities. One strength is that DTM attempts to explain learning and to describe the components that factor dynamically into that learning, and this heuristically has led to monitoring of multiple conditions as the learning itself is occurring within episodes. This same strength of drawing attention to components and their measurement dynamically could also be extended to how favorable convergences of learning conditions occur across cycles of many learning episodes. However, this strength also places restrictions on the type and extent of investigation that can feasibly be performed in particular everyday contexts. Investigation of multiple online conditions may be difficult or impossible to study on the time scale that DTM proposes, because either the methods and tools of assessment are difficult to employ in usual learning scenarios, or the time it would take for teachers and investigators to assess each component at enough moments in time is simply unrealistic when average learning, rather than individual child performance, is the primary focus.

Despite these limitations, experiments that have addressed multiple LEARN components as part of their methods have shown dramatic results in terms of children's learning capacities. These high learning rates suggest that although DTM theory may not yet be fully elaborated or complete, it has the potential to make important contributions to advances in learning.

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12

Individual Differences in Oral Language and Reading

It's a Matter of Experience

ELAINE R. SILLIMAN
MARIA MODY

Kelly,[1] 10½ years old and midway through grade 4, does not have a history of delayed language development. She also does not have a family history of dyslexia; however, her 7-year-old sister is currently receiving intervention for an articulation problem. At the beginning of the school year, Kelly tested below the basic level in reading and, according to her mother, needed to work harder than normal to maintain decent grades. She enjoys math but dislikes reading. In addition, Kelly still has difficulty with time concepts. Based on school monitoring data, Kelly is struggling with text comprehension, especially inferencing. Expository text is especially difficult for her. In comparison to her classmates' performance on reading comprehension, Kelly's scores place her at the 19th percentile. Teacher comments on her written work indicate that Kelly has significant problems with spelling and punctuation, and with producing more complex sentence structure and selecting more complex vocabulary.

Caren, also 10 years old and midway through grade 4, has a family history of dyslexia. Her father was diagnosed with dyslexia as a teenager. Caren was evaluated for dyslexia in grade 2 by a licensed psychologist. Results indicated a marked gap between her intellectual

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