Neuropsychological Aspects for Evaluating Learning Disabilities

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Abstract

This review surveys the empirical literature for assessments of learning problems in children from a neuropsychological perspective. An evaluation of children with learning problems must consider measures of working memory, attention, executive function, and comprehension (listening and written), particularly for children who do not respond to intervention. These constructs must be tied to intervention techniques, and their connections must be empirically verified. The response-to-intervention (RTI) perspective provides excellent support for the process in young children but is still developing the process for students above the second grade. This review provides information about the existing research on neurobiological correlates of learning disabilities, possible areas for further evaluation, and the link to the RTI movement.

Learning disabilities have been defined in various ways over time. Terms such as minimal brain dysfunction, word blindness, and dyslexia were once widely used. The term learning disabilities became popular particularly with the passage of P.L. 94-142 in 1975 (Goldstein, 1997). A definition proposed by the National Joint Committee for Learning Disabilities in 1981 suggested that “these disorders are intrinsic to the individual and presume to be due to central nervous dysfunction” (Hammill, Leigh, McNutt, & Larsen, 1981, p. 340). This definition included difficulties with reading, mathematics, listening comprehension, written language, and expressive and receptive language. Although the term learning disabilities has been understood to be a heterogeneous term, most laypeople and many teachers interpret it to mean difficulties in reading. The empirical field also shows this emphasis on reading with the abundance of articles about reading disabilities compared with those written on mathematics, written language, or social learning difficulties.

Learning disabilities are comorbid with other diagnoses including attention-deficit/hyperactivity disorder (ADHD), anxiety, and depression (Martínez & Semrud-Clikeman, 2004). ADHD has been found to co-occur in approximately 20% to 50% of children with reading difficulties, depending on the method of calculating a learning disability (Semrud-Clikeman et al., 1992). ADHD has also been found to co-occur with difficulties in mathematics (Semrud-Clikeman, 2003), written language (Hargrave, Corlett, & Semrud-Clikeman, 2002), and social–emotional learning disabilities (Semrud-Clikeman, 2003).

Comorbidity of learning problems with other diagnoses makes it imperative to evaluate these possibilities when developing a remediation program for a child (Pennington, 1990). Moreover, we are just beginning to understand the contribution of these related but separate diagnoses to learning. Far more research is available that evaluates brain functioning in children with reading disabilities than in those with other learning problems or those who show a combination of difficulties. Although, because of restrictions on length, the focus of this article will be on reading disabilities, the other areas of learning disabilities are equally important and, I hope, can be highlighted at another time.

Learning disabilities have generally been identified through the use of a discrepancy between measured ability (IQ) and achievement (Joshi, 1999). As noted by other articles in this issue, this type of assessment is very narrow, does not directly lead to recommendations for remediation, and ignores the various neuropsychological functions underlying the ability to read, speak, comprehend, write, and do mathematics well. This model also has difficulties because it relies on a simple difference between two scores to determine the presence of a learning disability and provides little information as to the predicted learning curve of the child or adolescent being evaluated. Moreover, this practice has also been found to overidentify those children with high IQs and average achievement and underidentify those with lower IQs and below-average achievement (Birch & Semrud-Clikeman, 2002; Semrud-Clikeman et al., 1992).

The acknowledgment of deficient brain functioning in children with learning disabilities has become more widely
accepted, particularly with the advent of research evaluating the functioning of the brain. A discussion of the most recent findings about the neural structures involved in reading may highlight the various aspects of the learning process that need to be evaluated.

### Brain Imaging and Learning Disabilities

Emerging findings suggest that children with learning disabilities process information differently from those without learning problems. Differences in development have shown that fluent adult readers utilize the frontal regions more than do children who are beginning to read (Schlaggar, 2003). The left frontal region becomes more active over the course of development, and more fluent child readers activate this area more than do children with difficulties (Schlaggar et al., 2002). Moreover, children with learning problems show a differential pattern compared with normal readers; they activate the parietal and occipital areas more than the frontal regions, and also show more activation in the right hemisphere than in the left. This finding is important because activation of the left hemisphere, a region specialized for language functions, plays an important function in reading.

The change from posterior systems in early reading (visual–perceptual processes) to frontal systems by more fluent readers suggests that the progression from simple letter and word calling to comprehension requires a maturation of neural pathways from the back of the brain to the front (S. Shaywitz, 2003). Moreover, children show a more diffuse activation when they begin learning to read that gradually becomes more specialized as their reading improves. Similarly, when normal readers were asked to read single words, they showed left hemispheric activation, whereas those with dyslexia showed more right hemispheric activation (Breier et al., 2003; Papanicolaou, 2003). Changes from right hemispheric processing to left hemispheric processing have been found to occur with improvement in reading skills. These changes are also found when improvement in language functioning occurs. Such changes are not found for children with dyslexia, as their reading process does not become automatic and effortless.

Gabrieli (2003) found that the region most responsible for auditory processing and language is more activated in good readers than in those who had compensated for their dyslexia. These researchers found that more activation correlated with higher scores on reading measures. These studies also found that improvements were found in activation following remediation of auditory processing ability. It is not clear at present whether these changes continue over time. Further study is needed to understand possible brain response to remediation.

### The Neuropsychology of Learning Disabilities

An evaluation that centers solely on the simple process of subtracting, or regressing IQ from achievement, is a narrow one that misses many of the difficulties frequently seen in these children. The processing of information is a complex and distributed operation. To evaluate the child’s learning skills, one must understand the child’s ability to process language, to understand what he or she hears, and to organize information; the speed with which the child processes information; and the child’s attention, ability to hold information in mind while solving a problem, and ability to self-monitor the reading process.

Language difficulties have frequently accompanied problems in learning to read. These language problems may be in receptive or expressive language. The phonology of the language can be tricky to master. Language is a natural process of our brain, and brain structures are devoted to its development. Reading, however, is an acquired skill that children must be directly taught. When a child has a language problem in addition to reading deficits, the progress is much more difficult. Approximately 70% to 80% of children learn phonological coding skills without difficulty. The remaining 20% to 30% show differing levels of success, and based on previous studies, the determining aspect may be the intervention provided as well as the child’s overall verbal skills.

The ability to decode words is a fairly well-known area of difficulty for children with learning disabilities; however, more recent research indicates that the main difficulty is not just the decoding of the word but also the rate of decoding (Joshi, 1999; Woodcock, 1991). Speed of information processing separates fluent from nonfluent readers (Semrud-Clikeman, Guy, & Griffin, 2000). Children with reading disabilities are slower at naming words and nonwords as well as at naming letters and numbers (Aaron et al., 1999).

An important aspect and goal for reading is comprehension. The same cognitive processes mediate listening comprehension and reading comprehension, but they do so through a different modality (Joshi, 1999). Assessing the ability to process information without the confound of decoding allows one to more fully evaluate the child’s ability to understand and process language and to determine whether the difficulty lies with decoding or comprehension. An evaluation of these skills is necessary to understand where the breakdown in skills lies and, thus, to develop the most appropriate intervention.

An additional neuropsychological process that is important to reading skills development is working memory. Working memory is the ability to hold information in mind while solving a problem, remembering a phone number, or decoding a word. Working
memory is a crucial skill for early reading recognition and later reading comprehension; one must assess it if one is to develop the most appropriate method of intervention (Teeter & Semrud-Clikeman, 1997).

Adele Diamond studied working memory in young children. She had a child observe her hiding an object and then asked the child a few seconds later where the object was. Children younger than 1 year could not find the object and used the rule of “Out of sight, out of mind.” Before age 1, the frontal lobes are unable to process delayed information. However, as children grow, they become more able to retain information for a short amount of time while processing information. To decode words, the child’s working memory must be functional and allow the child to retain a “template” of the letters until the word is sounded out. If a breakdown occurs in the ability to hold this information in mind, or if the time required recalling the sound–symbol relationship is prolonged, the child will experience difficulty reading (Semrud-Clikeman et al., 2000).

Working memory has also been linked to the ability to organize a task’s temporal aspect. Not only is input encoded; the task is also tagged to a time when it was learned (Gazzaniga, Ivry, & Magnus, 2002). The prefrontal cortex is linked to memory systems that allow the child access to previously learned materials. If difficulty is present at the outset, or at the working memory stage, the child will have difficulty recalling previously learned skills (i.e., the letter c in c-a-t has a certain sound), and thus decoding will be slower and effortful. Similar difficulty arises in spelling and in learning mathematics. For example, in mathematics the child needs to remember certain mathematics facts as well as when to use a particular procedure.

Executive functions are also skills that are important for the learning process. These skills apply to how something is accomplished rather than just to what is accomplished. They help a child evaluate his or her performance, and they also inhibit response to irrelevant stimuli. The selection of what is important to encode is essential in learning to read, write, and do mathematics. In addition, a child needs to learn to listen to what he or she is reading (either orally or silently) and evaluate its correctness. This skill becomes more important in older grades, as the child must self-correct mistakes. The awareness of “how I’m doing” is crucial to the learning process and allows the child to change behaviors or to take corrective action as necessary. These skills do not come into full fruition until early adulthood, and some would suggest that not until we are 32 years of age do we have a fully mature brain (Dencukla, 2003). Thus, an important issue to assessment would be to evaluate the child’s ability to understand his or her thinking processes.

Learning Disability Identification Process

Remediation suggests that an understanding of the underlying processes in learning have been evaluated, either formally or informally. The multi-tiered process suggested by response to intervention (RTI) ties assessment to intervention for those children requiring more specialized and intensive treatment than is available in the first tier or in the general education classroom. A feature of RTI is academic and behavioral screening with a valid assessment measure and continued monitoring if substantial progress has not been demonstrated. However, the screening tool to be used is not defined or even explained. This difficulty is reminiscent of the original definition of a learning disability that required a “significant discrepancy” but did not define what significant entailed. Such ambiguity has plagued this field and appears to be continuing. Recommendations for better defined specific tools or measures are important to help standardize these procedures nationwide.

The research base for learning disabilities has been complicated by difficulties with definitions. States vary in how learning disabilities are defined; definitions range from few criteria to very stringent. In Texas, for example, a child can be identified as learning disabled by a 16-point standard score point discrepancy, whereas in Minnesota, the discrepancy must be more than 2 standard deviations. Moreover, a child who does not meet criteria for a learning disability in Texas but who shows at least an 8-point discrepancy from IQ is classified as dyslexic. Such unevenness of definitions makes identification of these children as well as determination of appropriate interventions for them more difficult.

The RTI model suggests that for some children, identification would not occur until they had failed, and use of the model may lead to denial of services to some children clearly at risk for learning disabilities. A full assessment would also not occur until after the child had repeatedly failed at some of the interventions. Although the goal to tie how the child responds to intervention has interesting possibilities, the difficulty lies in how this response to intervention is evaluated. If this process is considered evaluative, then psychometric properties for the assessment need to be developed and at this point are not provided.

Emerging evidence also indicates that particular times in development may be most advantageous for remediation. The developing brain learns new information through a set of neuropsychological processes, and these processes lay down new neural connections that, once formed, may be difficult to reteach. Also important from a neuropsychological point of view is the finding that the brain is most ready to learn these connections within certain points of time, namely between the ages of 5 and 8, and for higher level thinking skills from the ages of 12 to 15 (Teeter & Semrud-Clikeman, 1997).

The longitudinal study of dyslexia by S. Shaywitz (2003) found that
poor readers who had compensated for their difficulties through remediation utilized brain areas that were different from those used by readers who continued to have difficulty. More important, the children who showed compensation not only had higher verbal ability scores than those who did not; they also attended less disadvantaged schools. A control group received the “usual” interventions and showed very little improvement. By delaying intervention until failure, the compensated systems may not develop, or they may develop less well than with younger children. The study of the time window in which remediation is most effective has not been fully completed, but response to intervention may differ depending on the age of the child.

A partial solution may lie in developing appropriate screening instruments that can assist in isolating those children most at risk for later difficulties and tracking their progress carefully through the early school years. The multitier system can easily utilize this procedure, but agreement is needed as to what the most important aspects are that are evaluated and monitored early on. In addition, besides behavioral measures, measures that tap neuropsychological constructs such as attention or working memory could be incorporated into this screening.

Coupled with these concerns is the suggestion that children with learning problems be provided instruction in the regular classroom until significant failure occurs. This model assumes that the regular education teacher has been taught the skills needed not only to identify children with learning problems but also to devise an intervention to offset these difficulties. Most of the RTI research has centered on children in kindergarten and first-grade classrooms. Very little empirical evidence suggests that this program is appropriate for children at older ages. Prior to implementation of this program for all children, studies with children in middle school and high school must be conducted to determine the appropriateness of the model for children of this age. In addition, sorting out variables such as attention and emotionaluity that may also be part and parcel of a reading problem is important.

Such assessments require specialized skills among staff, and experience in administering these measures is required in a comprehensive individual assessment. To achieve the laudable goal of introducing regular education professionals to working with these children, it is necessary to provide additional education for these teachers, as well as providing master teachers for support. Understanding the nature of learning is also important. The link from neuropsychological processes to intervention has not yet been forged, but the previous section on brain imaging suggests that there is much to understand about how we learn which will, one hopes, lead to appropriate interventions.

The simple RTI model incorporates several features that are very useful in our understanding of learning disabilities and, more important, our understanding as to appropriate interventions. The implementation of a universal screening procedure for specified skills is very useful. Moreover, tying this screening procedure to proven effective interventions is invaluable. These steps are necessary for the identification of children with learning disabilities but are insufficient for the following reasons.

First, the evaluation is skills focused and does not provide information as to the ability of the child to generalize learning or to complete more inferential or abstract tasks. This emphasis on skills may be appropriate for early grades but becomes less appropriate for higher grades, beginning at around Grade 4. For example, a child may be able to read all of the words in a passage but may not be able to comprehend the meaning behind the words. A child in first or second grade may not show a significant problem in this area, but if this difficulty continues into third grade and beyond, the problem becomes more serious; it transcends the reading class and has implications for content courses such as science and social studies as well as mathematics word problems.

Second, RTI is unable to differentiate learners with varying learning needs. A child with an attentional problem may have a reading problem, but the appropriate intervention is not the same as one for a child who has decoding difficulties. Both children may respond to small-group instruction, but for different reasons. When these children are reintroduced to the larger classroom, the likelihood is high that the child with attention problems will not succeed—not because he or she cannot do the reading, but because he or she cannot follow through on the work (Semrud-Clikeman et al., 1999). The RTI framework does not directly acknowledge the contributions that can be made by neuropsychology and thus lacks an integral part of our understanding of how children learn and process the world around them.

A possible solution to these seemingly discrepant models would be the melding of the neuropsychological framework and RTI into a more complex model. Such an integration would contribute to our understanding of children who are not responding in the manner that we would expect in the initial tiers of RTI. Screening children on predictor variables such as working memory, attention, and executive functions would be helpful not only to monitor progress but also to “catch” children who are a higher risk of not responding to the intervention at an earlier stage. The use of cutoff scores could readily be incorporated into the screening already routinely completed by RTI. These measures are not time-intensive and can provide additional information for the teacher and the parent and for older children themselves. Performance that is more than 1 standard deviation below expectations for the age of the child should be closely monitored, and children scoring 2 standard deviations below average should be referred for an evaluation to rule out
any conditions that may interfere with their progress. Moreover, those students that do not respond to the early stages of RTI are appropriate for a more comprehensive evaluation to determine why they are not responding to appropriate interventions.

Summary and Conclusions

Educational practice is at an exciting time in development. Not only have we evidence that children with dyslexia (and possibly other learning disabilities) have brain differences compared with typically reading children; emerging data indicate that they respond relatively quickly to brain-based and comprehensive teaching approaches that have empirical support (Berninger, 2003). Additional findings indicate that the most effective interventions are those that involve systematic instruction that is explicit and continues throughout their school experience (B. Shaywitz, 2003). Moreover, predictions of response to intervention are best completed by neuropsychological measures of language and attention rather than through the use of a discrepancy model (Stage, Abbott, Jenkins, & Berninger, 2003). These findings support the use of a multi-method evaluation of skills required for successful reading. Strassner, Semrud-Clikeman, and Gerrard-Morris (2003) found that teachers have lower expectations of academic performance for children who have ADHD or learning problems. These expectations may, in turn, lead to less attention in the classroom and fewer appropriate interventions.

One of the most important conclusions from research is that for children with learning problems, learning is hard work. A corollary to this finding is that for their teachers, instruction is very hard work and requires an enormous amount of training and support. Children who have difficulty learning to read or completing mathematics problems will likely not benefit from “more of the same” but require an alternative method of teaching to assist their learning.

Until now, we have emphasized a specific type of educational placement (resource or inclusion). However, based on the data from neuroimaging studies, we need to develop methods from scientifically supported instructional strategies, and we need to understand whether different types of interventions are interchangeable or work as efficiently for most children. Work on this aspect of RTI has not been completed.

The definitional struggle that has characterized the field of learning disabilities is continuing. An important piece of this puzzle, which has been missing in the debate, is how children respond to various interventions and how we can match the intervention to the difficulty. We have several years of experience showing that the “usual” method of teaching reading works for most children and with an adjustment (going from phonics to look-say, etc.) works for many children who cannot profit from a single method. What we have not fully discovered, and what is now developing, is the ability to work with those children who have been defined as “treatment resistant,” that is, those children who do not seem to profit from either general approach. We also need to learn how these children may differ early on, so that our intervention can occur before significant failure sets in.

The multtier approach to intervention has much promise, but again, we need to prepare our teachers so that they are best able to identify the children who need a fuller evaluation of their abilities. Given the findings from the neuroimaging and neuropsychological fields of deficient performance on measures of working memory, processing speed, auditory processing ability, and executive functions, evaluation of these skills is necessary to determine the most appropriate program to fit the individual child’s need. The danger with not paying attention to individual differences is that we will repeat the current practice of simple assessments in curricular materials to evaluate a complex learning process and to plan for interventions with children and adolescents with markedly different needs and learning profiles.

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