Chapter 12
Language-Related and Learning Disorders

Neurodevelopmental disorders of childhood, including language-related and learning disabilities, constitute a large percentage of the childhood disorders seen by child clinical neuropsychologists. Language impairments and learning disabilities resulting from phonological core deficits are featured, as are mathematics difficulties resulting from nonverbal, reasoning, and perceptual deficits. Recently these disorders have often been combined with the new term, learning and language impaired. A large body of research has burgeoned over the past decade. There are some children who simply exhibit a language delay as well as a few children with a learning disability without a significant language delay. For that reason we will discuss language disability somewhat separate from learning disabilities although they are related and should be viewed as such.

Each of these neurodevelopmental disorders will be explored within a transactional model, where the genetic and prenatal/postnatal history affecting neuropsychological, cognitive, perceptual, and memory functions will be reviewed. The manner in which family, school, and social factors interact with and ultimately influence the manifestation of these disorders will also be discussed. Research and clinical literature will be incorporated, and implications for assessment and intervention will be addressed.

Articulation Impairment

Articulation Impairment (AI) decreases with age and is approximately 2:1 male to female in incidence (Petherham & Enderby, 2001). In the past, children with AI were considered to have primary motor system problems, and therapies were devised to address motor learning patterns. Recent conceptualizations suggest that linguistic abilities, particularly phonological processing skills, play an important role in AI. From this perspective, speech sound production is viewed in light of global language functions, including syntax, semantics, and pragmatics (Fox & Dodd, 2001).

Research has suggested that there are four types of articulatory difficulty: articulation disorder, delay, consistent use of atypical error patterns, and inconsistent pronunciation (Dodd, 1995). These subtypes have been found in German speaking populations (Fox & Dodd, 2001) as well as Cantonese children (Holm & Dodd, 2001). Further study has found that, in a large sample of English-speaking children referred for a speech evaluation, 57.5 percent had a phonological delay, 20.6 percent had non-developmental errors, 9.4 percent made inconsistent errors on the same sound, and 12.5 percent had an articulation disorder (Broomfield & Dodd, 2004b). In this sample no child had a significant hearing impairment, diagnosed learning disability, or physical disability. Although attempts have been made to determine whether children with articulation disorders also have general language deficits, it is unclear whether AI should be considered a linguistic (phonological disorder) or a neurogenic (developmental motor apraxia) disorder.

Neuropsychological Correlates of AI

Children with AI are more similar to typically developing children than to children with language disorders. There are no specific neuropsychological correlates for children with a sole diagnosis of AI. Children that were language impaired (LI) had more trouble with speech perception capabilities, whereas children with AI performed better than control children on these measures (Snow, 2001). AI children generally show fewer omissions, transpositions, and syllable additions, compared to LI children.

In a multivariate analysis differentiating AI from normal children, the following variables were predictive of group membership: weight, temporal ordering of visual graphemes (e and k), and identifying syllables hae/ compared to /dae/ (Stark & Tallal, 1988). In a smaller group of children with AI, weight, family history of speech disorders, history of motor delays, difficulty identifying syllables (/bad /due/), and problems discriminating light flashes were significant in differentiating AI children from normal controls. In this study, AI and LI children were all heavier and taller than the control group. There are no clear-cut answers as to why weight is associated with LI and AI, but speculations suggest that heavy children may be more socially awkward, particularly if they are also clumsy; that low self-esteem may be manifested in less spontaneous speech, especially if accompanied by poor expressive language skills, or that uneven or rapid growth periods may place challenges on speech musculature (Stark & Tallal, 1988).

While children with AI have difficulty controlling involuntary movements of arms as well as with rapid fine motor coordination tasks, they are able to produce CV syllables in rapid succession when speaking (Leonard, 1998). Compared to LI groups, children with articulation disorders did not show difficulty on measures of verbal auditory processing or speech discrimination. Further, children with AI who have mild expressive language problems appear to function more similarly to typically developing children than to LI groups. In general, very few children with articulation disorders are found to show similar difficulties compared to children with more serious language impairment (Tallal & Fitch, 2005).

Language Impairment

Language impairment and speech disorders are considered to be communication disorders, and are often discussed along with reading impairment (Tallal & Gaab, 2006). Language impairment is often difficult to untangle from learning disabilities (or dyslexia) and studies often include participants with both difficulties. While this section will attempt to focus on language impairment, some of the studies will have samples that have both disorders.

The incidence of pediatric speech and language disorders is estimated to be approximately 33 percent of children aged 5–12 years of age (Law, Boyle, Harris, Harkness, & Nye, 2000). The gender ratio has been found to be approximately 3:1 for a language disorder and 2:1 for an articulation disorder, with males more likely to be diagnosed with either disorder than females (Broomfield & Dodd, 2004a). Of the children evaluated in a large clinic in England 28 percent showed a mild disability, 39 percent a moderate disability, and 12 percent had a severe disability (Broomfield & Dodd, 2004a). It was found that children with a severe language disability showed problems with receptive language disorders, a finding not present for those with articulation disorders. Children who showed global language problems were more impaired and at higher risk of later academic difficulties than those with isolated difficulty (Johnson et al., 1999; Shriberg, Tomblin, & McSweeney, 1999).

The main risk factors that have been identified for a language impairment include pre- and perinatal medical problems, otolarynological problems, problems with early feeding due to sucking difficulty, and family history (Johnson et al., 1999). There also appears to be a genetic predisposition to language impairment (Stromsvold, 2001) with monozygotic twins showing a higher concordance rate than dizygotic twins. Most of the studies reviewed on genetics have been from clinic-referred samples. Studies that have used samples from the community have found a modest genetic influence on low vocabulary skills at two years of age (Price et al., 2000), and a stronger relation at older ages (Eley, Dale, Bishop, Price, & Plomin, 2001; Spinath, Ronald, Harlaar, Price, & Plomin, 2003).

Studies of large community-based twin samples have found a relation between language performance

and heritability (Spinath, Price, Dale, & Plomin, 2004; Viding et al., 2004). Heritability was found to be greater for children with more severe impairments than for those with mild impairments. It was also found that genetic and environmental influences appeared to be qualitatively and quantitatively similar for boys and girls. Similar to earlier findings, language impairment was present more often in boys than in girls.

Neuropsychological Correlates of LI

Fitch and Tallal (2003) indicate that impairment of spoken language and the underlying neuropsychological mechanisms may be the common thread between production and comprehension language difficulties, reading problems, mathematics problems, written language, and social difficulties in children with learning disabilities. It has been hypothesized that language disorders are a result of impaired temporal processing of auditory information (Tallal, 2004).

Children with specific language impairment (LI) or developmental dysphasia have been to found to have a number of difficulties:

- significant deficits in expressive and/or receptive language, with normal abilities in nonverbal areas;
- deficits in speech perception and poor vocabulary skills, including naming, memory, syntax (grammar), and semantics (word meaning), and
- impaired temporal sequence of nonverbal auditory stimuli and poor discrimination of sounds, particularly when auditory signals are presented rapidly (Semrud-Clikeman, 2006). Speech articulation, syntactic, and semantic deficits may also be present.

It is difficult to determine a causal link between brain functions and language impairment in children. However, several tentative hypotheses have been offered. One is that atypical patterns of symmetry of the planum temporale are associated with verbal comprehension problems, phonological processing deficits, and expressive language difficulties (Foster, Hynd, Morgan, & Hugdahl, 2002; Morgan & Hynd, 1998). The other assumes that perisylvian

temporal cortical activation is present for processing auditory speech stimuli . Both the right and left hemisphere temporal regions appear activated, and each hemisphere may have a different role to play in the analysis of sounds (Binder et al., 2000). A study using fMRI technology in adults with normal language abilities suggests that the superior temporal lobes are involved in the decoding of acoustic signals of speech, whereas the left frontal lobes are involved in semantic operations (Eckert, Leonard, Possing, & Binder, 2006). Binder, Frost, Hammeke, Rao, and Prieto (1997) suggest that language processing is probably hierarchical in nature, involving primary sensory levels and intermodal association regions for higher cognitive activities. As processing demands move from simple (unimodal) to complex (multimodal), more brain regions are likely to be involved. Further research into these mechanisms is underway and will undoubtedly shed more light onto the neurological basis of language, and further clarify the role of selective attention, memory, cognitive associations, and semantic functions on language processes.

Other research indicates that children with LI are less efficient on neuropsychological tasks involving rate of motor performance (rapid alternating finger movements); dihaptic stimulation (simultaneous perception of bilateral tactile stimulation), and left-right discrimination (Talcott et al., 2000). LI children also had less control over involuntary movements than control children, and although signs of involuntary movements are observed in both groups, LI children have movements of longer duration.

Studies have indicated that children with LI experience difficulties with working memory and short-term memory (Adams & Gathercole, 2000; Balthazar, 2003; Gathercole, Tiffany, Briscoe, & Thorn, 2005; Montgomery, 2004). Phonological working memory and impaired language ability are related (Marton & Schwartz, 2003; Norrelgen, Lacerda, & Forssberg, 2002). A link has also been found between visual-spatial working memory and language development (Marton & Schwartz, 2003).

A possible link between visual-spatial working memory and language impairment has been found, but requires additional study to fully understand how these difficulties translate into language performance (Adams & Gathercole, 2000; Hoffman & Gillam, 2004). To investigate these relations more

closely, a large study of kindergarteners evaluated the relation between working memory and language skills (van Daal, Verhoeven, van Leeuwe, & van Balkom, 2008). Findings indicated that phonological working memory was predictive of semantic and syntactic abilities, while visual memory was weakly related to speech production skills. It was hypothesized that phonological working memory is related to maintaining lexical semantic information while processing the verbal information. Baddeley's model of working memory (discussed in Chapter 6) was confirmed for language ability and disability for the phonological loop and the central executive, but not strongly for the visual sketch pad. These findings are consistent with previous research showing a strong link between phonological working memory and language ability (Alloway & Gathercole, 2005). In conclusion, working memory deficits particularly in phonological coding as well as in lexical retrieval appear to be important for our understanding of language impairment and likely interfere with cognitive processing as well as learning.

Cognitive Processing Features of LI

Children with language impairments exhibit problems with rate processing deficits; that is, children with LI have auditory processing deficits or difficulty in processing auditory signals that have short segments or are presented rapidly in a series (Fitch & Tallal, 2003). Some suggest that this is the basic deficit that underlies many of the neuropsychological and cognitive features associated with LI (Tallal, 2004). Rate processing weaknesses have been found in rapid speech production; finger identification (two fingers); association of consonants and vowels (ba versus da); processing of cross-modal, nonverbal stimuli, and simultaneous tactile stimulation (face and hand). Auditory masking may explain some of the auditory deficits found in LI children, where the rapid presentation of signals runs on top of or masks other, later occurring signals. Masking also may account for other problems observed in both the tactile and motor areas, where a sequence of stimuli or movements interferes with discrete single stimuli.

Tallal (2004) concludes that there may be a common thread through interacting neural substrates for both speech and nonverbal processing that "incorporate rapidly changing temporal cues" that appear to be deficient in children with LI (p. 183) (Tallal, 1988). Normal infants discriminate subtle temporal signals (i.e., speech and nonverbal stimuli), that were problematic for LI children 5–9 years of age. Research suggests that children with LI are characterized by deficits in the ability to perceive and to produce information in rapid time sequences. This deficit is not specific to language, but includes other processes (e.g., motor, tactile, memory). Stark and Tallal (1988) hypothesize that "a basic neural timing mechanism" interferes with the simultaneous processing and production of information. While other higher level linguistic deficits may also be present, the timing mechanism deficit seems to have a significant negative impact on various processing skills. Ways to alter the functioning of this "neural timing mechanism" are explored in the discussion on intervention implications.

Rate processing deficits appear in both children with learning and language problems. Tallal and Gaab (2006) have found that these rate processing deficits and sensorimotor delays are consistently found in children with language impairment. Infants with a family history of learning and language problems take longer to learn how to discriminate between two tones than those without such a history (Benasich & Tallal, 2002). The difficulty in learning how to discriminate between the tones was strongly linked to later difficulties with language development independent of the language being learned. Similarly, Foxton et al. (2003) found that problems in the ability to acquire phonological discrimination and speech intonation knowledge were related to later difficulties in language as well as in reading. Children with LI frequently develop later reading problems, and as many as 50 percent of young children with impaired language also show math difficulties and reading problems in elementary school (Tallal, 2004). There have been links between language impairment and reading and writing difficulties.

Social-Psychological Correlates of LI

The psychosocial functioning of children with language problems is often not investigated separately from that of children with learning disabilities. In

general, discussions of social difficulties in children with learning disabilities have focused on the communicative competency of children in social situations, level of moral development, perspective taking and empathy for others, understanding of nonverbal cues, and problem solving abilities (Beitchman et al., 2001). Children with LI tend to have a higher rate of emotional and behavioral disorders than would be expected, with some finding that 80 percent of juvenile delinquents either show a current language delay or have a history of language impairment (Beitchman, Nair, Clegg, Ferguson, & Patel, 1986; Hall & Moats, 1999). Children with LI are at a higher risk to develop emotional difficulties compared to typically developing peers (Conti-Ramsden & Botting, 2008).

The extent to which social-emotional difficulties are related to language impaired children without learning disorders in general needs further exploration. It does seem evident that communication and verbal intelligence are important variables in determining social adjustment, in conjunction with other cognitive and behavioral factors. If a child is unable to express what he/she needs, then it is likely he/she will turn to a more physical manner to express feelings or to turn those feelings inward and not express them.

Implications for Assessment

There is a paucity of decent measures for language impairments in both young and older children. It is especially difficult to find one adequate test that measures phonemic awareness, syntax, and semantic skills, and analyzing subtests from more than one instrument presents psychometric measurement problems (e.g., comparison of grade or age levels from different tests with dissimilar reliability and validity standards). Language pragmatics are also often overlooked, so it is difficult to determine the effects of LI on communication in general. Table 6.1 provides a list of commonly used measures for assessing language. It is important to use parts of tests in order to answer particular questions about the child's functioning. For this reason, the astute clinician will be aware of all these measures and select the most appropriate ones for the child at hand.

Implications for Interventions

Interventions for language disorders may be (1) preventive, by reducing the probability of reading disorders; (2) remedial, by addressing the language or communication deficits, or (3) compensatory in nature (Stark, 1988). Early identification and intervention at preschool age are crucial to increase the likelihood of preventing the associated features of severe communication disorders. However, most intervention research has focused on children with cognitive delays or hearing impairments, a fact that complicates the picture when evaluating the efficacy of such research when these disorders are not also present.

Fast ForWord Language (FFW-L) (Scientific Learning Corporation, 1998) is a popular intervention tool that has been suggested to correct difficulties in temporal processing of information thought to be related to learning and language difficulties. Some have found gains of 1–1 ½ years following six weeks of training (Merzenich et al., 1996; Tallal & Gaab, 2006). This program is based on Tallal's theory that language difficulties are due to problems with fast processing of auditory information and that an intense intervention that basically reprograms the brain to recognize sounds and blends will improve language ability. FFW-L consists of two-stage computer-generated lessons. In stage 1 of the training, speech was temporally modified by lengthening the speech signal by 50 percent; during stage 2, fast (3–30 Hz) transitional features of speech were enhanced by as much as 20 db. The speech tracks were presented on CD-ROMs. The speech sounds have a staccato quality, with consonants (usually fast elements of speech sound) exaggerated compared to vowels (typically slower speech sounds). Intervention outcome may be best for children with expressive language problems who do not have accompanying receptive language disorders (Merzenich et al., 1996; Tallal et al., 1996).

Independent researchers have also evaluated the FFW-L program to determine its effectiveness with children who have LLI (learning and language impairment). One study included a group of 54 children with LLI assigned to one of three intervention groups focusing on auditory training: FFW-L, Earobics, or the Lindamood Phoneme Sequencing Program (LiPS) (Pokorni,

Worthington, & Jamison, 2004). All children showed significant difficulties with language and reading ability. Children were tested 4–6 weeks prior to the intervention and 6–8 weeks after the intervention ended. Gains were not found on retesting for any of the interventions.

Similarly, Cohen et al. (2005) compared Fast ForWord to commercially available home programs and no programs in three groups of children with severe mixed receptive and expressive language disabilities. All groups received speech and language intervention services in addition to these programs during the intervention period. At nine weeks and six months after the intervention period all groups showed significant improvement on standardized testing, but no difference was found among the groups. Cohen et al. (2005) suggested that the groups did not provide any additional support apart from the speech and language services that were provided individually.

Gillam et al. (2008) studied 216 children aged 6–9 years in four intervention programs: Fast ForWord Language, academic enrichment, computer-assisted language intervention, or individualized language intervention. Each child had treatment five days per week for six weeks for one hour and 40 minutes each day. All groups showed improvement on a standardized language test after the intervention with no difference among the groups present. These findings indicate that interventions that provide intensive experiences with a great deal of feedback and support improve language functioning. Gillam et al. (2008) concluded that the temporal processing hypothesis of language impairment may not fully explain the difficulties these children have and in and of itself, is not sufficient for our understanding of language impairment. Thus, auditory processing is likely a very important, albeit complex, aspect to language development, and requires one to include many aspects in understanding LI, not solely temporal processing of stimuli (Johnston, 2006).

From the studies, it appears that auditory processing deficits may result in both expressive and receptive language deficits, while speech motor deficits may result in expressive problems. Further, if auditory processing abilities are intact, these abilities may facilitate the development of expressive language and speech motor problems, while the opposite does not appear to be the case. That is,

intact speech motor abilities have little impact on improving language problems resulting from auditory processing deficits. The best treatment approach is not always evident. As discussed briefly earlier, learning and language disabilities go hand in hand, and many children have both disorders. The following section discusses learning disabilities from a neuropsychological point of view.

Learning Disabilities

Children with learning disabilities (LD) constitute the largest and fastest growing population of special needs children in schools. Estimates place the incidence of learning disabilities (LD) in general to be at 5–8 percent of public school students (Semrud-Clikeman, Guy, Griffin, & Hynd, 2000). While there is a large body of research indicating that learning disabilities are more common in males than females with the incidence generally running at 2:1 (Flannery, Liederman, Daly, & Schultz, 2000; Miles, Haslum, & Wheeler, 1999), others have found the ratio between males and females to be relatively closer (Shaywitz et al., 1995). The study that found equal distribution of males and females, however, did find that when looking at the more severe form of a reading disability, males were more affected compared to females by at least 2:1.

Liederman, Kantrowitz, and Flannery (2005) completed a comprehensive review of the literature in male vulnerability for reading disability. The findings from this review indicate that while the literature does support a preponderance of males with reading disabilities, more research is needed to evaluate the incidence using more than one definition of LD, to compare genders based on their own gender rather than across genders, and for researchers to report effect sizes for their findings. Siegel and Smythe (2005) suggest that the discrepancy definition for LD (see below) may bias selection to males. In addition, it has been found that early reading skills (word identification, phonological processing) often differ between the genders until fourth grade when the differences generally disappear for most children (Share & Silva, 2003; Siegel & Smythe, 2005). More research is needed to examine male and female differences based on the definition of a

learning disability, and possibly also evaluate differences in severity over development. The definition of a learning disability continues to be an area of contention and the issues are discussed in the next section

Definitions

Currently, the field is replete with controversies affecting how we think about, diagnose, and design educational interventions for children identified as LD. Learning problems can arise from divergent sources including genetic, neuropsychological, cognitive/perceptual, social-psychological, and environmental (i.e., home and school or classroom) factors. The extent to which we can reliably identify which factors or combination of factors affects a child's learning may be helpful in distinguishing children with LD from other slow learners or "garden-variety" poor readers. For example, we might expect to see differences across variables depending on whether the learning difficulties result from neurobiological, cognitive-perceptual, intellectual, or instructional opportunities and experiences.

Learning disabilities have been defined in many different ways over the years. Some have used the term "dyslexia" to be synonymous with learning disabilities when, in fact, dyslexia refers to problems solely with reading. The general term "learning disabilities" refers to problems in any one of seven areas of learning including listening comprehension, expressive language, basic reading skills (word identification, phonological coding), reading comprehension, written language, mathematics calculation, or mathematics reasoning. Many assume that LD is due to a central nervous system difference that contributes to the problems in deciphering both written and oral language (Shaywitz, 2003).

Learning disabilities is a heterogeneous grouping that generally includes children with difficulty learning despite adequate ability and instruction in one of seven areas related to language, reading, and mathematics. The definition generally assumes a significant discrepancy between ability and achievement that is often not well-defined. Differences in defining this discrepancy has led to various incidences of LD across the country, with some states

defining the discrepancy conservatively (children achieving below the second percentile for their age) and others more liberally (a difference of 16 standard score points between ability and achievement).

Many children may experience difficulties in more than one area, and have difficulties with attention, emotional adjustment, and/or behavioral problems as well (Lyon, Shaywitz, & Shaywitz, 2003). The majority of children identified with a learning disability have difficulties in reading with many of these also experiencing difficulties with written language. Poor phonological processing is the most predictive of continuing reading difficulty (Shaywitz, Mody, & Shaywitz, 2006).

When a severe learning disability is present, even despite intensive remediation, achieving average reading ability may be questionable (Lyon et al., 2003). It is likely that these children show significant problems with emotional adjustment and with social competence and, thus, academic interventions are complicated by these concomitant difficulties. Comorbidity with other disorders is present with learning disabilities similar to that with ADHD.

One theory for the mechanism that is faulty in learning disabilities is the double-deficit hypothesis (Wolf & Bowers, 1999). This theory suggests that readers be grouped by their ability on measures of phonological coding and automatized naming skills. There are three, suggested subtypes: phonological deficit, naming speed deficit, and phonological and naming speed deficit. The phonological deficit subtype is those children that have difficulty with phonological processing, but have average ability in naming. The naming speed subtype has difficulty in automatized naming, but not in phonological coding. When phonological coding and rapid naming are both present, it is believed that the disorder is of a more severe nature.

Research has supported the finding of naming speed and phonological difficulties in children with learning problems. A sole problem with naming speed, however, has not been found in children with learning problems (Morris et al., 1998). Other studies have found a strong relation between phonological processing and reading ability, and a weak or modest relationship between reading skills and rapid naming ability (Hammill, Mather,

Allen, & Roberts, 2002; Pennington, Cardoso-Martins, Green, & Lefly, 2001). Rapid naming and phonological processing also correlate with poorer phonological coding skills strongly related to poorer automatized naming skills (Compton, DeFries, & Olson, 2001; Schatschneider, Carlson, Francis, Foorman, & Fletcher, 2002).

Comprehensive reviews of research on the double-deficit hypothesis have found that phonological coding and double-deficit subtypes do exist, but that the naming speed subtype has not been confirmed and that naming speed and phonological processing are strongly correlated skills (McCardle, Scarborough, & Catts, 2001; Vukovic & Siegel, 2006). This review also found that phonological interventions improve rapid naming speed, thus supporting the idea that these skills are not independent. The review concludes that naming speed deficits are not characteristic of a reading problem and are only important when they occur in conjunction with phonological processing difficulty. Further discussion of assessment and definition issues is presented below. One of the areas that has challenged the research in learning disabilities is the frequency of other disorders that co-occur with a learning problem.

Diagnostic Issues

One of the major issues in the field of learning disabilities is the precise definition of a learning disability and who should be served under this category. Tied to this difficulty is the problem of appropriately assessing a child to determine whether a significant learning problem does exist. Previous definitions have generally included an IQ-achievement discrepancy that is called "significant," but is not well-defined. As a result, different states and, in some cases, school districts define eligibility for services differently. Other definitions have included the idea that the learning problem is due to a developmental lag. These definitions will be reviewed in the following section.

A meta-analysis of the relation between ability and reading level was conducted to evaluate the use of the IQ-Achievement discrepancy to define a learning disability (Fuchs, Fuchs, Mathes, &

Lipsey, 2000a, 2000b). This meta-analysis found that children with the poorest reading ability, compared to poor readers with lower ability levels, were most appropriately served using the discrepancy model. Hoskyn and Swanson (2000) also conducted a meta-analysis looking at children with reading disability and those with reading delays and lower ability. There was no differences between the groups on reading and phonological processing, but the brighter group performed stronger in vocabulary and syntax skills. The difference between these two meta-analysis studies is likely due to differences in sample selection for the studies as well as the emphasis on an ability measure. The Fuchs et al. (2000a, 2000b) study did not restrict the study to a certain IQ level, while the Hoskyn and Swanson (2000) review included studies that utilized significantly below average IQ samples. These differences in study selection changed the findings and account for the findings' discrepancies.

Steubing et al. (2002) conducted a further evaluation of the LD literature with regard to the IQ-discrepancy issue. Their sample included studies that used two groups to classify poor readers (IQ discrepant and concordant), studies were not included that utilized poor readers with significantly below average ability, and additional domains such as behavioral functioning were included in addition to cognition and achievement variables. In addition, effect sizes were evaluated to determine whether the size estimates were consistent across domains.

This analysis found few differences among the IQ discrepant and IQ concordant groups on measures of phonological awareness, rapid naming, verbal short-term memory, and vocabulary ability. The IQ discrepant groups showed stronger effect sizes for the Verbal IQ, Nonverbal IQ, and Full Scale IQ measures. Some studies have shown that once decoding skills have been attained, comprehension skills may be slightly better for children with specific reading disabilities than for children with generalized cognitive deficits (Stanovich, 2005). In addition, the IQ-discrepant group scored better on measures of fine motor skills, concept formation, spatial ability, planning skills, perceptual motor skills, and nonverbal short-term memory. These measures were not believed to affect reading skills, but are separate areas that would discriminate the groups.

One of the issues that arises when IQ discrepancy is utilized to diagnose a child with a learning disability is the difficulty that children with lower ability have to qualify for services. It is much more difficult for a child with an IQ of 85 to qualify for services than a child with an IQ of 110, particularly at a younger age. Some have questioned the discrepancy model's use and argue that it delays services to those children who need help the most at an early age. This concern is particularly apt as interventions have not been found to be as successful if started after second grade, compared to early intervention (Lyon et al., 2001; Torgesen et al., 2001).

The difference between slow learners (those children who do not read well, but read roughly commensurate with their ability) and children with severe learning problems has been evaluated to determine whether differences in reading skills are present as well as response to intervention. Research on this issue has yielded mixed results. LD and non-identified slow learners do not differ in terms of demographics or psychoeducational test scores, including both cognitive and affective measures (Strong, Silver, & Perini, 2008). Further, slow learners and LD groups show similar skills on cognitive tasks related to reading (Lyon et al., 2001), including phonological awareness, and on measures of reading achievement.

LD and garden-variety poor readers differ on cognitive tasks not directly related to reading, such as nonverbal reasoning skills and verbal-conceptual abilities which, in turn, may ultimately affect intervention efficacy (Hulslander et al., 2004). It has been suggested that garden-variety poor readers have global deficits across a variety of cognitive measures, whereas children with reading disabilities have core deficits in the phonological area and, thus, have more domain-specific deficits (Stanovich, Siegel, & Gottardo, 1997). Further, problems in phonological awareness are shared by the two groups and serve as causal factors for reading problems (Stanovich, 2005).

Developmental lag theories may be more appropriate for children with mild reading problems than for children with severe reading deficits or dyslexia (Chiappe, Stringer, Siegel, & Stanovich, 2002). There is evidence that when children who are delayed in reading are compared to children with the same reading level, but who are younger than the children with reading difficulties, the differences between the groups are smaller than when the child is compared to same-aged peers (Stanovich, Siegel, Gottardo, Chiappe, & Sidhu, 1997). Measures of vocabulary development, pseudo-word decoding, phonological processing, verbal fluency, and picture naming tasks are similar in children with the same reading level. Differences are found in vocabulary level and metacognitive ability with children who have reading difficulties scoring higher (Goswami, 2006; Goswami & Bryant, 1990).

Chiappe et al. (2002) studied adults and children with and without reading disabilities to determine whether phonological problems remained throughout the life span. The adults with LD showed poorer performance compared to the typically performing adults on measures of phonology. These difficulties were present even when compared to same reading level children, particularly on phonological processing and on naming tasks.

These findings lend preliminary support to the developmental lag theory for children with mild reading problems. The developmental lag theory is not as robust for severe reading disabled and dyslexic groups. When matched to reading skills with younger children, studies of children with specific reading disabilities show mixed results. In a critical review of studies, Stanovich, Nathan, and Vala-Rossa (1986) concluded that, "The presently available evidence would appear to suggest the hypothesis that the 'garden-variety' poor reader is characterized by a developmental lag; whereas the much rarer, dyslexic child displays a specific phonological deficit, in conjunction with compensatory use of other skills and knowledge sources" (p. 280). Further, although mildly reading-impaired children should not be overlooked in our schools, they may be expected to progress in reading when given instructional resources and will eventually develop reading abilities similar to their other cognitive skills. The same may not be the case for the more severe and specific reading problems found in children with LD.

Best practice now suggests that the technique, Response to Intervention (RTI), is most appropriate for initial work with children with reading problems before these children are identified as having a learning disability. This technique is generally thought to be most appropriate in the initial stages of treatment when it is not clear how the child will

respond to treatment. As discussed above many children will respond to treatment, both those with a mild learning disability and those who are considered slower learners. These children benefit from interventions that are designed prior to identification, and an IQ discrepancy is not required to provide such support (Semrud-Clikeman, 2006).

RTI generally consists of three tiers for intervention. Often the first tier provides additional training for teachers in teaching reading. Tier 2 is small group reading instruction which is provided three times per week, and tier 3 is either individual or two group members who meet daily (O'Connor, Harty, & Fulmer, 2005). The tier system improves reading skills in children in early school grades (Vaughn, Linan-Thompson, & Hickman, 2003). There is limited support for RTI for older students, particularly in high school (Kavale, 2005). While the new IDEA re-authorization suggests using empirically validated interventions when working with children with RD, RTI interventions have small to moderate effects, suggesting only modest validation. In addition, these interventions are generally for phonological processing and phonemic awareness only, thus limiting their applicability to all aspects of reading (Scruggs & Mastropieri, 2002; Strauss, 2001). Further work is needed and, based on concerns that RTI may delay support for children with severe RD, the technique should be evaluated for different levels of disability. It is helpful to attempt interventions before a RD or LD diagnosis is made, and RTI can be very helpful to that end. Concern has been expressed that the technique has not been empirically validated beyond the early grades and that it identifies both too many false positives and false negatives to be used as a sole manner for diagnosing RD/LD (Kavale, 2005).

Comorbid Disorders

When a reading disability is coupled with other learning problems, a more severe form of the disorder is likely present (Semrud-Clikeman, 2007). Most children with a language-based learning disability have difficulty with reading as well as with written language (Lyon, 1996b). Difficulties in written language frequently involve problems with

spelling, organization of ideas, planning of the writing process, and ability to utilize appropriate punctuation and grammar (Harder, Semrud-Clikeman, & Maegden, 2006).

Many children who experience difficulty in reading also have problems in mathematics. Approximately 6 percent of children have a learning disability in mathematics (Semrud-Clikeman, 2006). Most often children with reading disabilities also show difficulty with mathematics calculation while those with reading comprehension problems also struggle with mathematics reasoning. Very few children are diagnosed with a sole disability in mathematics. Problems with visual-spatial and visual-motor skills are linked to problems with nonverbal learning disabilities and are discussed later in this chapter.

Approximately 35 percent to 75 percent of children with learning disabilities also have significant problems with attention (Semrud-Clikeman et al., 1992; Spencer, Biederman, & Mick, 2007). It is likely that attentional and impulse difficulties make it problematic for the child to attend to classroom instruction particularly on tasks that are already very difficult for the child. In addition those children with an ADHD diagnosis have a higher risk of having problems with phonological processing, compared to those in the general population (Lyon, 1996a). Children who have ADHD (particularly with the predominately inattentive subtype) and LD show more difficulty with their peers in social desirability as well as significant signs of social anxiety and low self-esteem (Kellner, Houghton, & Graham, 2003). In contrast, children who were diagnosed with ADHD Combined subtype and LD showed problems with externalizing behaviors and with social functioning due to impulse control and hyperactive behaviors. In addition, children with ADHD: Combined subtype also become more resistant to interventions and require more intensive support due to significant behavioral difficulties (Teeter, 1998).

Children with LD also are more susceptible to emotional difficulties (Martinez & Semrud-Clikeman, 2004), and are more likely to show internalizing disorders such as anxiety and depression as well as withdrawal and low self-esteem. These problems may stem from frustration with the learning process as well as lower expectations for employment and financial success (Lyon, 1996b).

Difficulties in emotional adjustment have been found to extend into adulthood and to require ongoing treatment through psychotherapy for low self-esteem and social difficulties (Brieger & Majovski, 2008; Gregg, Coleman, Lindstrom, & Lee, 2007).

Genetic Factors

The search for the genetic basis of reading disabilities has been helpful in determining the relationship between environmental and genetic factors. The Colorado Reading Project (Decker & Vandenberg, 1985; DeFries, Fulker, & LaBuda, 1987), one of the largest studies of its type, found a strong relationship between reading disabilities in identical or monozygotic twins (MZ) and in same-sex fraternal or dyzgotic twins (DZ). The concordance rate was 71 percent for MZ twins and 49 percent for DZ twins, confirming a strong genetic basis for reading disabilities in children. When the proportion of variance accounted for by both genetic and environmental factors was measured, the genetic factors were found to be more important than environmental factors for explaining differences in reading between MZ and DZ twins (DeFries & Alarcon, 1996; DeFries et al., 1997).

When gender differences and severity issues were evaluated using a sample of MZ and DZ twins, heritability and shared environmental influences were not found to differ between the genders (Hawke, Wadsworth, Olson, & DeFries, 2007; Wadsworth & DeFries, 2005). Other researchers have found that the heritability of LD in more severe populations was greater for males than females (Harlaar, Spinath, Dale, & Plomin, 2005). One of the differences was the definition of severity. When a more severe cutoff was utilized (the most severe 5%, rather than 10%) a male gender bias was found (Harlaar et al., 2005). Differences may also be due to the various methodologies and instruments used to measure reading skill. Harlaar et al. (2005) administered timed tests over the phone while Hawke et al. (2007) administered non-timed measures in-person. In addition, the earlier study used younger children while the other study used older children (Hawke et al., 2007). These finding indicate

that further study that controls for the age and type of measure used is needed to determine whether there is a genetic link to severity and gender in LD.

Continuing study in the Colorado longitudinal twin study has followed 124 twins with a history of reading difficulty, and 154 twins with no history of learning problems over 5–6 years. Initial findings of significant learning problems were present at the follow-up testing 5–6 years later. The most stable measure was the reading measure with a stability correlation of 0.80. In addition the shared genetic influences accounted for 86 percent of the phenotypic relations for the twins with reading problems, and 49 percent for the twins without reading problems (Wadsworth, DeFries, Olson, & Willcutt, 2007).

Some studies have also evaluated the shared environment variable for families with twins. Emerging evidence is present that shared environment effects may be important during the early years of development and schooling, particularly for phonemic awareness and letter identification (Byrne et al., 2002; Harlaar et al., 2005; Petrill, Deater-Deckard, Thompson, & DeThorne, 2006). Variables that have been found to be important in the shared environment and reading outcome include parental education and cognitive ability (Christian, Morrison, & Bryant, 1998), and the family environment for promoting reading and parental involvement in schoolwork (Foy & Mann, 2003; Petrill, Deater-Deckard, Schatschneider, & Davis, 2005; Senechal & LeFevure, 2002). A further study of shared environment with adoptive parents of twins was conducted to determine effects that are separate from genetics. This study found that the adoptive parents' skills in pseudo-word decoding and phonological awareness were related to the child's reading skills, but only for the youngest readers (Petrill, Deater-Deckard, Schatschneider, & Davis, 2007). It was also found that these shared environmental influences decrease with adolescence to the point of almost zero.

In addition to a strong genetic influence for reading ability and the contribution of shared environments for younger children, there have also been studies evaluating the various aspects of reading and heritability of those skills. Word reading and reading comprehension are highly correlated in the early grades, but this correlation decreases with mid-elementary school years when reading

comprehension becomes paramount for success in school (Catts, Hogan, & Adlof, 2005; Scarborough, 2005).

Orthographic aspects of reading have also been studied to determine the behavioral genetic contribution to these skills. Orthographic processing is the ability to recall the spelling pattern of a word that is retrieved from memory without decoding the word (Ehri, 2005). Adept readers can use rapid and automatized retrieval of words particularly those with irregular spellings or pronunciations (prevalent is not pre' valent) (Byrne et al., 2008). Previous studies have found a genetic correlation between phonological awareness and print knowledge (Samuelsson et al., 2007), combined word and non-word identification and spelling, rapid naming, and reading comprehension (Byrne et al., 2007) and language ability (Bishop, Adams, & Norbury, 2006).

Byrne et al. (2008) evaluated the contribution of genetics to orthographic processing as well as skills such as nonverbal reasoning. Twin pairs (225 MZ and 214 DZ) in the second grade were compared on measures of orthography as well as the Block Design and vocabulary tests from the WPPSI-R. Heritability for orthography was found to be significant, but not shared environment variables. Further analysis found that there is a shared genetic influence between orthography and phonological coding. In addition it was found that while there was some genetic overlap between overall ability and reading skill, reading variables were substantially separate from IQ.

Reading comprehension difficulty exists separately from word reading accuracy (Oakhill, Cain, & Bryant, 2003). Further studies have found that these children experience problems outside of phonological and orthographic (word form) deficits, thus suggesting that reading comprehension and these skills are dissociable (Perfetti, Landi, & Oakhill, 2005; Scarborough, 2005). In addition, these children also experience listening comprehension difficulties, both with and without coexisting problems with phonological working memory (Catts et al., 2005; Kovas, Oliver, Dale, Bishop, & Plomin, 2005; Nation & Norbury, 2005).

Keenan, Betjemann, Wadsworth, DeFries, and Olson (2006) sought to evaluate the genetic involvement in word recognition, listening comprehension,

and reading comprehension. The second part of the study also evaluated the relation between IQ and these reading skills in view of genetic and shared environment contributions. Seventy monozygotic twin pairs, 61 same-sex fraternal twin pairs, and 60 opposite-sex fraternal twin pairs were compared on measures of reading and listening comprehension. Word recognition was found to have a strong genetic influence and was strongly related to reading comprehension and less strongly to listening comprehension. Reading comprehension and listening comprehension were also found to be related in the genetic analysis apart from the relation with word reading. Environmental aspects were equally related to all the reading aspects and not significantly related to genetic influences. IQ was significantly heritable with the genetic path; IQ to listening comprehension was stronger than listening comprehension to word reading. Word recognition had a significant genetic influence after IQ was controlled, which was also true for reading comprehension. In all cases shared environmental influences were not found to be significant for any variable. The authors suggest that lower power may have influenced these findings.

The finding of a relation between IQ, heritability, and reading disability was also evaluated by Wadsworth, Olson, Pennington, & DeFries (2000). This study found that the genetic influences of IQ were a more important cause of reading disability for higher skills, and the environment had less of an impact for those children with higher ability. Conversely, the children with lower ability showed less genetic influences of IQ and more influence from shared environment. These findings suggest that children with lower abilities may require alternative, earlier intervention. Response to intervention in this group has been very successful (MacMillan, Gresham, & Bocian, 1998).

Prenatal/Postnatal Factors

To date, prenatal factors affecting a child's capacity to develop phonological awareness deficits are virtually unknown; however, there are several environmental factors that have been found to be related to general language deficits and reading disabilities.

Although a biogenetic foundation for language is virtually indisputable, postnatal factors associated with language development typically emphasize the influence of environmental stimulation. Infants 1–4 months of age are quite adept at discriminating speech sounds, and can make discriminations between ba and ga, ma and na, and preschool children seem to utilize phonetic representations when processing language in short-term memory (Molfese, Molfese, & Molfese, 2007; Molfese, Molfese, & Pratt, 2007). Studies with newborn infants have found that children at this age may be aware of and able to discriminate phonemes, even though they may not be aware that phoneme units exist (Cheour et al., 2002). It is likely that experience plays a role in the child's development of speech perception and vocabulary, both of which are related to language acquisition and reading; however, the role of the environment on these factors has not been adequately investigated for poor readers. A predictable growth spurt in phonemic awareness occurs in children at about the age of six years, which appears related to efforts in teaching children to read (Guttorm et al., 2005). The genetic studies suggest that while experience plays a prominent role in the development of phonemic awareness, children with phonological deficits appear to have some biogenetic factor that limits their ability to profit from exposure (Petrill et al., 2006).

Prematurity is another prenatal factor that has been evaluated in children with learning disabilities. Preterm infants who were also of low birth weight have different responses to auditory information and detection (Therien, Worwa, Mattia, & deRegnier, 2004). These differences have been tied to problems with recognition memory and, later, reading disabilities (Curtis, Lindeke, Georgieff, & Nelson, 2002; Rose, Feldman, & Jankowski, 2002). It has also found that these neural circuits can discriminate between term and preterm infants and may be reversed with appropriate interventions (Peterson et al., 2002).

Frequent ear infections may possibly relate to later difficulties with auditory comprehension and phonological coding. Children with frequent middle ear infections do not show long-term language impairment, but do show a more pronounced right ear advantage compared to children without such a history (Asbjornsen et al., 2000; Asbjornsen et al., 2005; Winskel, 2006). It was suggested by these authors that early hearing difficulties relate to differences in how auditory stimuli are processed and that the increased right ear advantage seen in children with early and frequent ear infections relates to compensation for problems with hearing. Further study is needed to more fully understand these mechanisms.

Neuroanatomical Variations and Neuropsychological Correlates

Brain imaging has increased our knowledge of neuroanatomical and neurofunctional contributions to learning and learning disabilities. Early studies found differences in the area of the planum temporale, a structure implicated in phonological processing (Hynd, Semrud-Clikeman, Lorys, Novey, & Eliopulos, 1990; Morgan & Hynd, 1998). The planum temporale in the left hemisphere is consistently larger in a majority of adults (Galaburda, 2005; Geschwind & Galaburda, 1985; Steinmetz et al., 1992) and in fetuses, newborns, and infants (Chi, Dooling, & Gilles, 1977). The left planum temporale is thought to be the primary site for linguistic processes and reading (Morgan & Hynd, 1998) because of its proximity to the auditory association region and Wernicke's area. The expected leftward asymmetry is rare in dyslexics, whereas symmetry in the temporal regions is more frequent (Hynd & Semrud-Clikeman, 1989; Kibby et al., 2004; Shaywitz et al., 2006). A number of studies report that the symmetrical patterns appear to be the result of larger plana in the right hemisphere (Galaburda, Sherman, Rosen, Aboitiz, & Geschwind, 1985; Larsen, Hoien, Lundberg, & Odegaard, 1990). Although others found smaller left plana, different measurement techniques may be responsible for these divergent findings.

Children with reading disabilities have symmetrical or reversed asymmetry (R > L) in parietooccipital regions, which is found less frequently in normal groups (Helenius, Tarkiainen, Cornelissen, Hansen, & Salmelin, 1999; Tarkiainen, Helenius, Hansen, Cornelissen, & Salmelin, 1999). This region of the brain, called the occipitotemporal system, is involved in rapid recognition of words and has been implicated in the orthographic route to reading and

spelling (Pugh, Mencl, Jenner, Lee et al., 2001; Shaywitz, 1998). In addition, in the parietal, occipital, and temporal association areas including the angular gyrus (also called the temporoparietal system) are areas that are activated in reading of pseudo-words and phonological processing (Pugh, Mencl, Jenner, Katz et al., 2001). This region is important to translate unfamiliar words by using phonics and step-by-step decoding.

The final area responsible for reading is in the frontal regions of the brain. In children without reading difficulty, this region is well connected to the posterior region by the superior longitudinal fasciulus (see Chapter 2). This system connects the areas of the brain responsible for oral reading in the frontal area to those responsible for reading understanding in the temporal lobe of the brain. It is believed that this system is important to prepare for oral word reading and is related to phonological processing (Pugh, Mencl, Jenner, Lee et al., 2001).

As the child develops these systems also develop interdependently. When first learning to read the posterior regions of the brain responsible for orthographic and phonological coding are activated and allow the child to decode and analyze the word. Once the word has become automatized (that is overlearned), a neural trace is formed and the pronunciation, spelling, meaning, and the way the word looks are all stored in long-term memory within the written lexicon for that child. When the word is then encountered the reading of the word is automatized and fast and the posterior regions of the brain in the occipitotemporal regions are able to fluently read the word quickly (Shaywitz et al., 2006).

Children without reading disabilities develop these systems simultaneously and are able to store words in memory both phonologically and orthographically (Pugh, Mencl, Jenner, Katz et al., 2001). As the child becomes more adept in reading the occiptotemporal region shows increased activation, allowing for smooth access to the word lexicon (Shaywitz, 2003). Children with learning disabilities experience a disconnection between these systems, making word reading labored and effortful. Functional imaging has found that children with dyslexia show hyperactivation in the frontal system (associated with naming and oral reading) which may be related to trying to compensate for hypoactivity with phonological processing subserved by the posterior systems (Fiez, 1997; Milne, Syngeniotis, Jackson, & Corballis, 2002).

Hoeft et al. (2007) sought to evaluate the hypoactivation in the left posterior systems and the left frontal hyperactivation in a group of adolescents with dyslexia. There were four groups: two groups with a diagnosis of dyslexia, one control group matched on age to one of the dyslexic groups, and one control group matched on reading level to the other dyslexic group. Relative to the age-matched group, the dyslexic group showed hypoactivation in the left parietal regions and hyperactivation in the left inferior regions as well as in the caudate and thalamus. When compared to the reading matched group, the dyslexic group showed hypoactivation in the left parietal regions, but similar activation in the frontal regions. The dyslexic group also had reduced gray matter volume compared to both control groups. These researchers concluded that the hyperactivation was a result of an attempt to compensate for the reading problems. The hypoactivation regions were believed to be a true brain abnormality that is associated with reading disabilities and problems with learning to read (Hoeft et al., 2006). To support this view, findings from intervention studies have indicated that increased activation in these regions occurs after intense intervention, thus suggesting that these regions are a core deficit for dyslexia (Aylward et al., 2003; Shaywitz et al., 2004; Simos et al., 2002).

Structural Differences

Differences have been found that discriminate between children with and without learning disabilities at the molecular as well as the structural level. Autopsied brains show misplaced and misaligned cells particularly in the regions of the perisylvian area, the left frontal region, and the language areas (Galaburda et al., 1985; Grigorenko, 2001; Humphreys, Kaufman, & Galaburda, 1990). Structural differences have been found in the planum temporale (Duara et al., 1991; Hynd et al., 1990; Rumsey et al., 1986), the corpus callosum (Duara et al., 1991; Fine, Semrud-Clikeman, Keith, Stapleton, & Hynd, 2006; Hynd et al., 1991; Larsen, Hoeien, & Oedegaard, 1992), and the frontal lobe area (Semrud-Clikeman, Hynd, Novey, & Eliopulos, 1991).

Semrud-Clikeman et al. (1991) found that atypical patterns of symmetry in the planum temporale were related to word attack skills, passage comprehension skills, and rapid naming abilities. Thus, the left planum was postulated as a central language processing center. Researchers have also explored other neuropsychological postulates and have focused on deficient or abnormal patterns of hemispheric lateralization related to attentional activation processes as plausible explanations for the academic deficiencies exhibited by children with LD.

Dichotic listening has also been utilized to evaluate children with reading disabilities and hemispheric specialization for auditory processing. Findings have indicated that typically developing children show greater ease in focusing attention when provided with a verbal cue while children with LD do better when a tone cue is presented (Obrzut, Boliek, & Asbjornsen, 2006). Other studies have found that the usual right ear advantage for language is not present on a dichotic listening task in children with LD (Helland, Asbjornsen, Hushovd, & Hugdahl, 2007). Since there was no cue to trigger attention to the task, children with LD showed less right ear advantage and in some cases heightened left ear advantage due to activating both hemispheres in order to solve the problem. Thus, the child with LD is dividing attention between both ears and is not as efficient as the child without LD.

Therefore, neither ear is as good as when attention is direct and auditory processing is efficiently managed. These difficulties are related to poorer verbal processing of auditory information, an area of significant difficulty for children with a reading problem (Lamm & Epstein, 1997). These findings are consistent with functional neuroimaging studies that have also found lower activation when processing oral information in children with LD (Heiervang, Stevenson, & Hugdahl, 2002; Helenius et al., 1999; Hugdahl et al., 2003)

These studies raise questions about whether children with learning disabilities have attentional imbalances between the two hemispheres or whether there are problems in interconnected attentional systems. Further research is necessary to determine the relationship between morphology and attention control mechanisms during language tasks in children with LD. Padlonsky (2008) found that children with ADHD and LD who had a history of otitis media showed a more severe form of disability characterized by deficits in phonological processing. The extent to which these neuropsychological aspects are further related to the cognitive, academic, and perceptional deficits associated with LD also needs further exploration.

Implications for Assessment

The difficulties that are present with a definition of a learning disability have not been resolved at this point in time. Ongoing research, however, has evaluated the different problematic areas in learning disabilities to attempt not only to understand the problems posed for the child in learning to read and write, but also to design interventions that are helpful to the child.

Reading Disabilities: Phonological Core Deficits

Phonological awareness deficits are a primary cause of reading deficits (Shaywitz et al., 2006). As described earlier in this chapter, children with phonological reading disabilities (PRD) experience trouble in early reading and also have associated difficulties in speech perception, speech production, and naming tasks. Phonological awareness is the ability to use the phonemic segments of speech, including the awareness and use of the sound structure of language. Related difficulties in phonological processing include difficulty understanding how sounds relate to one another (phonemic awareness deficits), problems with auditory discrimination, naming and vocabulary deficits, and problems with working memory for sounds and sound combinations. Reading requires learning the relationship between graphemes (written letters) and phonemes (sound segments). Thus, children with phonological deficits have difficulty applying the alphabetic principle when reading unfamiliar words (Torgesen et al., 2001). Table 12.1 summarizes selected research findings.

Guidelines for classifying and treating LD may be more clearly articulated and systematically investigated within this transactional framework.

Table 12.1   Summary of specific deficits associated with reading disabilities: Phonological Core Deficits (PRD)

Biogenetic Factors	*Environmental Factors: Prenatal and Postnatal*
– 40% variance in word recognition is genetic – h2g = .62 phonology/reading deficits – h2g = .22 orthographic/ reading deficits	– Orthographic deficits related to exposure to print and learning opportunities – Development of speech and vocabulary related to language acquisition and reading – Growth spurt in phonemic awareness at 6 years related to reading efforts – Despite strong heritability of phonological awareness, deficits can be modified
Temperament	*Birth Complications*
– No known correlates	– No known correlates

CNS Factors
– Gray matter dysfunction
– Left temporal anomalies
– Larger plana in right hemisphere
– Symmetrical R/L[a] temporal lobes
– Symmetrical or reversed parieto-occipital regions
– Abnormal asymmetry (R > L) in prefrontal regions
– Abnormal asymmetry in parietal regions

Neuropsychological Factors
– Rapid naming
– Abnormal hemispheric lateralization
– Attention activation of RH interferes with LH verbal processing
– Attentional control mechanisms between hemispheres
– Phonemic hearing, segmenting, and blending

Intellectual	*Perceptual*	*Memory*	*Attentional*
– Verbal weaknesses – Vocabulary knowledge – Verbal associations – Word similarities – Verbal fluency – Receptive language – Expressive language – Verbal IQ – Comprehension	– Phonemic – Speech	– Digit span – Speech sounds – Word series – Letter strings – Phonetic strategies	– Strong comorbidity of reading problems and ADHD – Attention to phonemes
Academic/Behavioral		*Psychosocial*	*Family*
– Motivational problems – Chronic reading problems – Disengaged in learning – Spends less time reading – Reading and spelling		– Research is sparse – RD in general show internalized disorders (e.g., depression)	– Research is sparse on PRD – Prenatal and postnatal risk factors related to general learning and behavioral problems – "Disorganized" and/or poverty, environment more important with age

Note: PRD refers to phonological reading disabilities, while RD refers to reading disabilities in general. L and LH refer to left hemisphere, R and RH to right hemisphere.

Although not every child is expected to demonstrate all of the associated features presented, Table 12.1 suggests an interaction among the neuropsychological, cognitive, academic, and psychosocial problems that may accompany reading disabilities resulting from phonological core deficits.

Intellectual, Perceptual, Memory, and Attentional Functions

Intellectual Functions

Children with phonological core deficits evidence weaknesses on a variety of verbal measures,

including vocabulary knowledge (Berninger, Abbott, Abbott, Graham, & Richards, 2002); auditory memory and verbal associations (Shaywitz et al., 2006); receptive vocabulary, word similarities, and verbal fluency (Fletcher, Morris, & Lyon, 2003), and receptive and expressive language (Wills, 2007). Measures of intelligence relate to the child's exposure and experience with language, a skill that is often compromised in children with a learning disability (Siegel & Smythe, 2005). Stanovich (2005) refers to the Matthew effect to describe the reading-IQ relationship, where reading has "reciprocal causation effects" on other cognitive skills. Children with reading deficits read less, acquire less general and specific knowledge, and may fall further and further behind in achievement and verbal skills (Wong, Strickland, Fletcher-Janzen, Ardila, & Reynolds, 2000).

Perceptual Functions

Difficulty in phonemic processing underlies reading deficits in many children. The child's ability to perceive spoken words appears related to reading difficulties and is less than accurate, particularly under adverse or noisy conditions (Riccio, Cohen, Garrison, & Smith, 2005). Deficient speech perception seems evident, but children with phoneme awareness deficits may also have poor memory for speech sounds as well. (Tunmer, Chapman, & Prochnow, 2003).

Memory Functions

Research does provide evidence that children with reading disabilities do poorly on a variety of memory functions, including deficits on digit span, recall of letter strings, nonsense words, and word order (Jarrold, Baddeley, Hewes, Leeke, & Phillips, 2004). The ability to remember a series of words precedes a reading disability diagnosis and appears to be a risk factor rather than a consequence for reading problems (Adams & Gathercole, 2000). Poor readers are unable to use the phonological structure of language to hold letter strings in short-term memory (Riccio, Garland, & Cohen, 2007). Some have suggested that poor readers rely on word meaning in an effort to remember words, and do not appear to use

visual rather than phonetic memory strategies. To support this hypothesis, error pattern analysis suggests that poor readers make errors that are consistent with phonological processing and in a manner similar to good readers, but that their error scores are quite high (Mann, 2003). These findings indicate that they are not using good orthographic coding to recall the spelling and word form in order to read a problematic word.

Academic and School Adjustment

Early reading failure has been shown to create motivational problems in children. Children with chronic reading problems often dislike going to school, and develop secondary self-esteem problems (Martinez & Semrud-Clikeman, 2004). Wills (2007) further reports that remedial classes often drill in phonics or word recognition, but may deemphasize passage comprehension so that the child spends less time reading. Eventually the child develops more generalized cognitive deficits involving numerous subject areas due to delays in reading skills.

Social-Psychological Adjustment

Research addressing the socioemotional functioning of children with phonological core deficits is sparse. Other research shows that children with LD who demonstrate distinctively lower verbal abilities with intact visual-spatial skills were rated by their parents as having more internalizing disorders, particularly depression (Bender, Rosenkrans, & Crane, 1999). The extent to which this applies specifically to children with phonological core deficits is yet to be established. In addition, it appears that children with basic phonological processing disorders are prone to develop psychosocial disturbances if parents and teachers have unrealistic expectations or if acting out serves as a mechanism for avoiding school and/or schoolwork. Others have found that children with conduct disorders (CD) also have lower verbal intelligence (Grigorenko, 2006). The extent to which CD and language-based difficulties are associated with poor achievement and learning problems needs further study (Sundheim & Voeller, 2004).

Children with neurological signs who also have learning disabilities have been found to be at higher risk for emotional disturbance (Glassberg, Hooper, & Mattison, 1999)

Family and Home Factors

There are few studies addressing family home factors and reading disabilities, specifically for children who display phonological awareness deficits. The research that has been conducted generally shows genetic linkage to be stronger than environmental variables (Petrill et al., 2006). Studies investigating family and home influences on learning disabilities in general have found that prenatal and postnatal conditions are highly related to risk factors, including the development of general behavioral or learning problems during the first 20 months of life (Pennington, 2006). Further, risk conditions were found in families that were characterized as disorganized and/or in poverty, and these environmental factors became more significant as the children became older. Children who continued to demonstrate moderate to severe problems tended to come from families with low economic status and with a high degree of disruption and psychopathology in the family. Socioeconomic status, home conditions, and educational attainment of family members may act as compensatory variables for children initially identified as at risk for reading problems, but who later show normal achievement progress (Capozzi et al., 2008). It is premature to generalize conclusions reported in studies investigating children with general learning problems to students with phonological core deficits. However, stable and consistent home situations, strong emotional family bonds, and child characteristics (e.g., easy temperament) appear to be important factors associated with the "resilient" child who appears less susceptible to the adverse effects of risk factors (Elksnin et al., 2001).

Implications for Intervention

Evidence indicates that phonologically impaired children show normal progress in math, but continue to show severe delays in reading despite remedial attempts in school (Torgesen, 2004). When remedial techniques specifically address phonological core deficits, the outcome is more positive for at-risk students and children with PRD. Studies have also shown increased reading abilities when phonological awareness is combined with metacognitive techniques (Cunningham, 2007), and when phoneme awareness is contextualized within the reading curriculum (Cunningham, 2005).

Early identification and remediation have been offered in order to provide the children with early support who may be at risk for reading difficulties (National Reading Panel, 2000). Early remediation has also been suggested to help prevent the Matthew effect which is related to poorer readers reading less than good readers, thus widening the gap between the two groups (Torgesen, 2004). Specific training in phonemic awareness for young children in kindergarten and early elementary grades has proved successful and seems preferable to control conditions where children are not exposed to these skills (Bishop & Snowling, 2004). Further, children as young as two years of age are at extreme risk for severe reading problems when they have a family history of dyslexia and also possess even mild syntactic fluency problems in language development (Olson, 1999; Petrill et al., 2006). Research has suggested that phonological processing is a key deficit and early intervention needs to stress these skills, as well as develop phoneme-grapheme correspondence (Jackson & Coltheart, 2001). A meta-analysis of studies evaluating phonological intervention found large effects for the immediate aspect of the intervention, but weaker long-term effects (Bus & van Ijzendoorn, 1999). The long-term effects on reading, spelling and reading comprehension after one and one-half years following the intervention were very small or nonsignificant. Another study found long-term effects for children who received phonological training in preschool did show significant improvement, but again the long-term effect was small yet significant (effect sizes ranging from 0.33 to 0.39) (Byrne, Fielding-Barnsley, & Ashley, 2000).

Some main types of programs have purported to do so include the Reading Recovery Program, Phonological Awareness plus Synthetic Phonics (PASP) (Torgesen, 2004), Orton-Gillingham approach, Process Assessment of the Learner (PALS) (Berninger, 2001), and the Lindamood Phoneme

Sequencing Program (Lindamood & Lindamood, 1998). The Lindamood and Fast ForWord programs were discussed in the language section of this chapter and will not be discussed further in this section. These programs will not be reviewed in-depth in this section, but will be described and the interested reader is encouraged to seek out further information as wanted. The research indicates that early intervention is important, but it also suggests that intervention needs to continue, particularly for children who are at higher risk for learning problems. This suggestion is supported by a recent study comparing children who showed significant reading problems with those exhibiting milder difficulties. Early intervention improved reading, but did not show long-term effects when intervention ended (Hurry & Sylva, 2007).

Reading Recovery

The Reading Recovery Program (Clay, 1993) effectively increases reading achievement of children in the early grades (Ohio Department of Education, 1995), but does not show continued progress in later grades when the children again fall behind their peers (Venezky, 1998). The program incorporates aspects of whole language while also emphasizing decoding instruction. Decoding is taught in the context of reading and writing, where the teacher selects strategies depending on the child's unique reading problems. It is helpful for early intervention with less support provided for long-term outcome if the program does not continue (Chapman, Tunmer, & Prochnow, 2001). Some have suggested the Reading Recovery does not fully teach phonics, but relies on a whole language approach, thus children who have significant problems with phonological awareness are at a great disadvantage and are not assisted by this approach (Reynolds & Wheldall, 2007).

The research does not support using this program for children with significant phonological processing deficits. It may be helpful for those children with orthographic difficulties, an area that is discussed in the next section of this chapter. The research also supports the idea that while early intervention is good, it needs to be continued in order to affect good long-term outcomes.

Orton-Gillingham

The Orton-Gillingham (OG) method is a systematic and multisensory approach to reading and writing (Gillingham & Stillman, 1997). It is an intensive type of instruction that needs to be accomplished either on a one-to-one basis or in a small group. A phonetic approach to reading, it that stresses sound-symbol correspondence, morphology, syntax, and meaning. It involves training using visual, auditory, and kinesthetic/tactile learning exercises which have also been called the *Language Triangle* (Gillingham & Stillman, 1997). Children are taught the components for learning and provided many opportunities to practice until mastery occurs; assessment of their progress is built into the program.

A meta-analysis of the research with the OG method evaluated 12 studies that utilized a comparison group (Ritchey & Goeke, 2006). Of the 12 studies reviewed five showed OG instruction was more effective, compared to all other interventions. Four studies found improved word reading, word decoding, spelling, and reading comprehension. Two studies found improvement in vocabulary skills and only one study evaluated fluency ability. The conclusion from this review was that there was only one study that evaluated OG in an experimental fashion and whether this program is experimentally validated as required by the No Child Left Behind Law (No Child Left Behind, 2002).

Whether the OG method is feasible for more than a few children has been challenged in the courts, and the school districts have won in over 75 percent of the cases brought before a mediator or a court (Rose & Zirkel, 2007). One of the issues has been the cost of providing the OG method in a regular school district (Torgesen et al., 2001). In addition, response to the intervention (RTI) model and the reauthorization of IDEA have suggested a shift from the discrepancy model to one that includes pre-referral interventions provided in the regular education classroom. Given the shift to early intervention and some funding for this intervention, the OG method may become more common in regular school districts as part of RTI (Rose & Zirkel, 2007). However, IDEA's proposed regulations require research-based interventions and the

research supporting most of the interventions is not clear and empirically validated.

The PASP program (Torgesen, 2004) stresses the use of phonological awareness and decoding ability. Similar to OG and Reading Recovery programs it stresses systematic instruction in phonemic decoding as well as in reading comprehension. Research support has not been reported at this point in time and requires additional empirical validation prior to becoming a widely accepted program.

Reading comprehension is another area that requires remediation for many children. Most children that have difficulties with reading comprehension also have trouble with decoding skills. Generally, problems are present in vocabulary, listening comprehension, and working memory and likely underlie problems with reading comprehension (Leach, Scarborough, & Rescorla, 2003). Interventions often require learning how to think about what is being read, mapping advance organizers on the topic at hand, and utilizing strategies for reading and learning (Vaughn & Klingner, 2004). A program developed by Schumaker, Deshler, and McKnight (2002) is designed to directly teach reading comprehension through the use of metacognitive strategies.

Although phonemic awareness is essential for early reading success, several researchers have found that orthographic and visual-spatial deficits are present in some children with severe reading disabilities. These problems have not been as well studied as phonological coding. This type of learning disability will be briefly reviewed next.

Visual/Orthographic Deficits in Reading

Although PRD seems well established, there also appears to be a smaller group of children who have major difficulties accessing the orthographic or visual features of written words (Berninger & Fuller, 1992). Chase and Tallal (1991) describe the sequential order of reading including the logographic, alphabetic, and orthographic. During the logographic stage, reading occurs through a visual or graphic analysis of letters and words (lexical system). Visual memory plays an important role

during this stage, and the child begins to develop a sight-word vocabulary. The alphabetic stage is characterized by the phonological decoding (phonological system) of words using grapheme-phoneme (letter-to-sound) conversions. To develop into a fluent reader, the child must then proceed to the orthographic stage, where larger morpheme units (i.e., syllables) are used. Decoding is quicker during this last stage and this model assumes that later stages are dependent on skills acquired at earlier stages. It has been suggested that orthography is a direct route to understanding meaning of a word while phonology first requires decoding of the word and then the orthography/meaning (Harm & Seidenberg, 2004; Seidenberg & McClelland, 1989). The proposed model of Harm and Seidenberg (2004) suggests that orthography and phonology are cooperative and not separate. Both are tied to semantics with orthography being direct and phonology being indirect.

Berninger (2001) describes numerous measures of orthographic coding skills and methods for assessing the lexical processes of reading. A number of research tasks have been employed to measure orthographic coding skills, including pseudohomophone choice (e.g., raiwane), letter verification, homonym verification, recognition of orthographic patterns, rhyme judgments with orthographically dissimilar words (e.g., great-state), and brief exposure of words. Lexical impairments have been found in a small proportion of children with dyslexia, although impairment in the phonological system seems to be a more consistent finding across studies.

There may be a gender difference in orthographic ability. Some evidence show that males have more difficulty with orthographic skills compared to women with no difference between the genders in motor ability (Berninger, Nielsen, Abbott, Wijsman, & Raskind, 2008a). In addition, males had more difficulty with accuracy and rate of reading passages orally both due to orthographic and phonological problems. Further study is needed in the area of orthography and its relation to phonology. One of the major studies conducted has linked orthography to difficulties with written language (Berninger, Nielsen, Abbott, Wijsman, & Raskind, 2008b). The following section discusses written language disorders.

Written Language Disorders

Written language impairments are often overlooked in discussions of learning disabilities. The prevalence of written language disorders is approximately 1.3–2.7 percent for handwriting deficits, 3.7 percent to 4 percent for spelling deficits, and 1 percent to 3 percent for written expression (Berninger & Hart, 1992). The most recent estimates of difficulties in writing have indicated that 69 percent to 77 percent of typically developing students in fourth, eighth, and 12th grades did not meet writing proficiency goals as measured by the National Assessment of Educational Progress (Graham & Perrin, 2007b). Children with specific problems with learning show significant difficulties in composition, spelling, handwriting, and grammar at higher levels due to the learning disability (Graham & Perrin, 2007a).

Written language disorders (WLD) can have profound effects on the academic attainment of older children and adolescents. In fact, young children with learning disabilities differ from typically developing children on writing conventions, while older LD children show significant deficits from typically developing children on composition skills (Berninger et al., 2006). Further, children with LD have difficulty writing narrative text, generating expository, and finding ideas to write about (Berninger et al., 2006). Men had more significant problems in writing and spelling, compared to women (Berninger et al., 2008a). In addition, males had more difficulty with composition and handwriting although they did not differ in motor ability.

Neuropsychological Correlates of Written Language Disorders

The extent to which written language disorders result from right- or left-hemisphere lesions or dysfunction is still not resolved. The two hemispheres appear to play complementary roles in writing, with the right hemisphere (anterior, central, and posterior regions) involved in the visual-spatial, emotional, and affective components of language skills, while the left hemisphere (temporalparietal and anterior regions) is involved in linguistic, speech, and reading processes. Studies have found that the processing of graphics requires quick recognition of the spatial features (Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001) with teaching of handwriting contributing the visual recognition of letters (Longcamp et al., 2008). Areas found through fMRI to be involved in writing include the left Broca's area and bilateral inferior parietal lobe. In addition the fusiform gyrus in the temporal lobe appears to have an area that is dedicated to word forms which is important for spelling as well as for writing (Xue & Poldrack, 2007). This region has been implicated in processing of letter patterns, a skill important for handwriting and spelling (McCandliss, Cohen, & Dehaene, 2003).

The neuropsychological substrates of WLD have not been researched as thoroughly as reading and speech-language disorders. Written language deficits have been found to be associated with right hemispheric lesions (Aram & Ekelman, 1988). Orthographic mapping, a skill important for spelling and writing, has been found to be present in the right frontal gyrus and right posterior parietal gyrus (Cohen et al., 2002). Direct intervention in spelling and writing with dyslexic children found normalization in this region following intensive treatment using fMRI (Richards et al., 2005). These changes were related to improvement in spelling of real and nonwords.

Cognitive Correlates of Written Language

Writing requires motor skills as well as visual-spatial ability. The child begins learning to write by copying and tracing figures, and moves to independent production of these figures as the motor strokes become more automatized. Teaching generally moves from single letters to connecting letters to making words through practice and repetition. Studies have suggested that children respond very well to visual models paired with practice rather than through practice alone (Berninger & Amtmann, 2003).

Hayes (1996) has revised his previous model developed with Flower (Hayes & Flower, 1986) which includes planning, translating and reviewing

as key issues in writing. Problem solving and executive functioning skills have also been implicated in writing. Children with writing difficulties may experience problems with selective attention which impacts the ability to plan and write coherently. In addition, there may be problems with organization and spelling that further impede the writing process. Handwriting or keyboarding difficulties arising from motor or visual-spatial challenges can also impede writing progress and interfere with conveying main ideas. Memory problems affect word retrieval; spelling; memory for rules of grammar, punctuation and capitalization, and dysfluent writing. Language problems may result in impoverished vocabulary, decreased written expression, dysphonetic (phoneme–grapheme irregularities), spelling patterns, and poor narration. Working memory is also important for writing because it allows ideas to be utilized as the child/adolescent is writing. It is also important for recalling vocabulary, spelling, and grammar as the writing process continues (Hooper, Swartz, Wakely, de Kruif, & Montgomery, 2002).

An important area for intact writing ability is planning and self-regulation (Harder et al., 2006). Planning is closely related to working memory and the two skills interact. As one writes the ability to plan what is to be said next and to link it to what has been said requires working memory (Gregg & Mather, 2002). These skills have been found to be problematic for children with writing difficulties and have also been the target for interventions.

Assessment of Written Language Disorders

Written language disorders can be measured using writing samples taken from the child's academic work or structured tests. Portfolio or authentic assessment procedures typically include an analysis of writing samples generated by the child. See Table 6.1 for a list of commonly utilized standardized measures.

Informal measures of writing are very helpful in understanding the difficulties a particular child has in writing. Task analysis, error pattern analysis, application of the academic skill, dynamic assessment

(e.g., learning efficiency), and process assessment using the child's curriculum to determine the learning processes used by the child are several alternative measures that can be used informally to evaluate the child's writing skills (Berninger, 2001).

Interventions for Written Language Disorders

Berninger and colleagues have published extensively on interventions for handwriting and spelling as well as for writing composition. A review of the literature as to interventions for WLD has indicated that a tiered model of instruction provides the best results for both children with and without learning disabilities who experience written language deficits (Graham, Olinghouse, & Harris, in press). Particular areas that are important to target for intervention at Tier 1 include direct teaching of the ability to plan, revise, and edit a writing sample. In addition, the ability to set clear goals and develop an outline, as well as understand how to use the outline to write a preliminary draft of the writing sample is important, as is teaching the students how to develop an idea and link it throughout the writing sample are all crucial to developing appropriate writing skills (Mason & Graham, 2008).

The second tier includes teaching the student self-regulation which includes self-monitoring, self-reward, and instructions as the writing process continues. During this period of time it was also suggested to utilize student-teacher conferencing and peer conferencing to discuss progress and any areas of difficulty that were encountered (Mason & Graham, 2008). Reading and writing need to be taught together as they are complementary, and writing cannot be done without also utilizing reading skills (Graves, Valles, & Rueda, 2000).

Using computers, technology, and web-based instruction can support basic writing skills and direct teaching, but cannot be used in isolation (Feretti, MacArthur, & Dowdy, 2000). The use of this technology in isolation is often recommended for working with children with written language disabilities (Freeman, MacKinnon, & Miller, 2004). It is important, however, to emphasize that

using computers and technology have not been empirically validated for WLD (Berninger & Hooper, 2006).

Summary

The emerging evidence in WLD is providing support to improve our diagnostic and interventional capacity to assist children in learning how to write. These skills are becoming more and more crucial for functioning in many positions and for success in college. WLD often goes hand in hand with RD and needs to be treated accordingly. There is evidence that utilizing small groups and providing intensive intervention can assist children with the process of writing. Difficulties remain for adolescents and college students with WLD, particularly as writing demands increase (Harder & Semrud-Clikeman, submitted). More work is needed to understand early writing difficulties as well as appropriate interventions for high school and college students.

Learning Disabilities in Mathematics

A sole learning disability in mathematics is unusual and often found in children with nonverbal learning disabilities (NVLD). NVLD will be discussed in the next section of this chapter. The prevalence of mathematics learning disability (MLD) is approximately 5 percent to 8 percent of school-aged children (Geary, 2004). It is unclear from these percentages what proportion of these children also has a learning disability in reading and/or ADHD. It is also not clear how MLD and RD differ and whether they arise from two separate substrates (Mazzocco & Myers, 2003). MLD is similar to RD in that many processes are involved in mathematics knowledge and a definition that encompasses all of the complexity of mathematics is not established at this time. Consequently, the research findings are varied due to differing definitions, cut-offs, and conceptualization of what a MLD is.

Geary (2004) suggests there are three subtypes of MLD. The first is the procedural subtype. These children's performance skills are similar to a

developmental delay and their skills often improve with age and grade. They show frequent careless errors, use their fingers to count, and do not fully understand the basic processes behind the task. The second subtype is the semantic memory which continues throughout school. These children frequently also have a RD, show problems with memory and retrieval of math facts. This subtype is hypothesized to be associated with a left hemispheric dysfunction due to problems with retrieval of information. The final subtype is called the visuospatial subtype. These children experience problems with spatial representation, aligning columns, understanding the relationships between number and quantity, and experiencing problems with misperception. These children do not show a RD. The deficit in this subtype is hypothesized to be a right hemispheric dysfunction. It should be cautioned that there is no empirical evidence to support this; therefore these are basically theoretical at this time. The final subtype is reminiscent of the nonverbal learning disability disorder which is discussed later in this chapter.

Development of Mathematics Ability

For the typically developing child counting is an important ability in learning mathematics. Skills such as one-to-one correspondent counting, correct order of numbers, and understanding how objects can be sorted and categorized are important pre-math skills that underlie development. Findings with MLD children indicate that they do not understand the counting process that underlies mathematical skills (Hoard, Geary, & Hamson, 1999).

Arithmetic skills begin with addition which is based on counting ability. Arithmetic facts become memorized and then automatized with practice and exposure. As the child becomes more adept at the calculations, the problems are solved more efficiently and more quickly with fewer errors (Geary, 2004). Children with MLD experience significant problems in solving arithmetic calculation problems. Younger children generally use their fingers to count to solve the problems; a strategy that becomes less useful as the facts are automatized. Children with MLD do not move from the finger counting strategy to automatic processing until the

late elementary years (Geary & Hoard, 2002). In addition, problem solving strategies and memory retrieval deficits for number facts are not well established until the MLD child is much older than his/her peers (Hanich, Jordan, Kaplan, & Dick, 2001; Ostad, 2000). These difficulties may be related to problems with storing facts and then retrieving them in an efficient manner (Geary, 2004).

Neuropsychological Correlates of MLD

A review of the literature found that 231 articles were published between 1985 and 2006 studying MLD, compared to 1,077 for RD in the same time period. Thus, the study of MLD is in its infancy compared to that of RD or possibly WLD. Also complicating the situation is the dearth of standardized measures that are specifically designed to evaluate a mathematics-based learning disability. This consideration is important because standardized tests often measure overall calculation and reasoning skills, but do not evaluate number sense, counting skill and other components important for mathematical reasoning (Murphy, Mazzocco, Hanich, & Early, 2008).

Murphy et al. (2008) evaluated three groups of children using varying definitions of MLD. One group had mathematics ability in kindergarten measured at or below the 10th percentile, one group had scores between the 11th and 25th percentile, and the final group had scores above the 25th percentile on the Test of Early Math Ability (TEMA-2) (Ginsberg & Baroody, 1990). These children were evaluated in kindergarten and again in third grade. Measures included reading cluster from the WJ R, visual-spatial ability, rapid automatized naming tasks, and the Contingency Naming Test as a measure of working memory (Anderson, Anderson, Northam, & Taylor, 2000). It was found that the mathematics skills of the two highest scoring groups increased at a faster rate than for the children in the lowest performing group. The middle group did show a lag that continued into third grade, compared to the typically achieving group. These differences continued at the same rate indicating that, while not as severe as the low performing group, the middle group continued to lag in mathematics

ability. In addition, the low achieving group appeared to reach a plateau that wasn't seen in the two higher achieving groups, suggesting that further improvement was unlikely without intensive intervention. All groups differed on the counting task particularly in identifying errors that were made.

An assessment of related neuropsychological factors found that IQ, visual-spatial ability, and rapid number naming predicted group membership at the entry level. IQ and visual-spatial ability were not predictive of growth rates while rapid naming of numbers was particularly for the lowest achieving group. Reading ability was related most strongly to progress for the lowest achieving group and was also present as a predictor for the middle achieving group, albeit in a weaker manner. Working memory skills were related to mathematics difficulty as well as progress for all groups. Poorer working memory ability was related to efficiency in solving mathematical problems.

Executive functioning appears to be a problematic area for children with MLD. In order to solve a mathematical problem one not only needs the basic facts and operations readily at hand, but must also focus attention to the task at hand and inhibit responding to irrelevant material (Blair, Knipe, & Gamson, 2008; Geary, 2004). These skills, plus working memory, are important for success in mathematics, but children with MLD appear to have problems with these skills. Children with MLD show concurrent difficulties on tasks that measure executive functioning, particularly in the areas of working memory and inhibition (Mazzocco & Kover, 2007).

Children with MLD are less accurate, compared to their peers, in evaluating whether answers to specific arithmetic problems are correct or not. This difficulty is related to the MLD child's ability to monitor what is being asked of him/her and evaluating whether the correct response has been provided. Such self-checking is an important aspect of mastering arithmetic facts and processes (Garrett, Mazzocco, & Baker, 2006).

Neurological Contributions to Mathematics Skills

Mathematicians have increased parietal gray matter bilaterally and increased volume of the

bilateral inferior frontal lobes. These regions have been implicated in arithmetic calculation and visuospatial processing. Morphometric differences have been found in the brains of accomplished mathematicians, musicians, and scientists in the parietal lobes. Larger parietal regions and more gyral formations have been linked to stronger mathematical skills in adults (Spitzka, 1907; Witelson, Kigar, & Harvey, 1999). Brain differences may be due to experience and/or genetic disposition. Studies have found that brain differences can be associated with intense learning. Studies of children with early and intense musical training have found morphological differences in these children compared to controls (Gaser & Schlaug, 2003; Hutchinson, Lee, & Gaab, 2003; Munte, Altenmuller, & Jancke, 2002). Brain structural changes have also been linked to intensive training in undergraduate and graduate students in medicine, with increases in the bilateral parietal cortex as well and hippocampus in post-versus pre-testing (Dragnanski et al., 2006). These increases were associated with learning abstract material. Whether increased volume in the parietal and hippocampal regions are present at earlier ages has not been studied. What differences may be present at an earlier age in students who are mathematically and scientifically disposed, and how these differences change with exposure and training, are important questions for further study. Long-term training in a mathematical discipline may lead to brain changes that support mathematical ability.

There are studies that link brain changes to practice and experience with mathematical concepts. These studies have generally utilized structural (anatomical) data. While high ability has been linked to expertise in a field, differences in brain structure may be due to more than solely intelligence, and are specific to mathematics-based talent (Rickard et al., 2000). Very few studies have been conducted that involve brain activation in adults with mathematics-based interests, and no studies have linked developmental brain activation and structural changes in participants with math-based skills and interests. No studies were found that evaluate neuroimaging in children with mathematical disabilities.

Implications for Assessment

As described in Chapter 6, there are several standardized measures that evaluate reading, mathematics and written language. There are very few specially developed tests just for mathematics. To evaluate mathematical skills standardized tests need to be supplemented with curriculum-based materials. These materials need to evaluate the child's counting ability, understanding of quantity, knowledge of concepts, and ability to check one's work. One of the main tests used to evaluate mathematics directly include the Key Math Diagnostic Arithmetic Test-3 (Connolly, 2007). The test is designed for students aged four years, six months to 21 years and meets the criteria established by the National Council of Teachers of Mathematics in 2000. Its measures evaluate numeration, algebra, geometry, measurement, probability, mental computation, basic fact knowledge, problem solving, and estimation.

For younger children, the Test of Early Mathematics Ability-3 (Ginsburg & Baroody, 2002) measures basic number understanding as well as beginning comprehension of quantity and mathematical facts. Evaluating the child's ability to count, to understand quantity through a number line, and having the child rapidly name numbers are other methods for understanding a child who is at risk for learning problems in mathematics. There is emerging evidence that children who experience difficulty with phoneme-grapheme correspondence may also have problems associating numbers and symbols (Wills, 2007).

Implications for Interventions

As stated above, drilling on mathematical facts is helpful only up to a point. Using visual cues as well as experiential materials may be very helpful for a child who has not mastered the concepts of basic math (numerosity, quantity, etc.). Cuisenaire rods are a series of color-segmented rods with different colors representing numbers from 1 to 10. Children are able to mix and match the colors to understand adding (2 red rods each equal to

5 make 10) or subtracting rods as desired. Other visual aids such as number lines can also help children understand how numbers relate to each other.

Word problems can be problematic for children who have difficulty understanding the words as well as the processes that are required. Fuchs et al. (2004) evaluated third-grade students to evaluate how word problems are solved. The children were provided with intervention to assist with understanding word problems and developing strategies to solve future problems. This intervention improved functioning in typically developing children apart from knowledge that they would have gained from practice (aligning columns, understanding particular words and symbols, etc.). When these interventions were applied to children who were below grade level in mathematics, they also made improvement following intervention (Fuchs et al., 2003a). When these strategies and self-monitoring strategies were further evaluated in low achieving samples of children in mathematics, these children had more difficulty, particularly in setting realistic goals based on their performance (Fuchs et al., 2003b). Thus, teaching basic executive functions may assist in helping children with MLD to improve.

Summary

Based on this brief review of the literature on MLD, there are many areas of inquiry that are incomplete in our understanding of mathematically based learning disability. Neuroimaging of children with MLD has not been published at this point in time and it is not clear what the neurological contributions to mathematical difficulty are. While there is evidence that excellence in mathematical ability may be related to enhanced parietal lobe functioning, neuroanatomical and neurofunctional differences in children with MLD and those without have not been demonstrated. As the research continues to produce results, findings as to best practices for assessment and intervention will assist in our understanding of this disorder both with and without co-occurring reading disability.

Nonverbal Learning Disabilities

In a series of studies (Rourke, 1989, 1995; Rourke & Tsatsanis, 1996), Rourke and colleagues introduced the concept of a syndrome, nonverbal learning disability (NVLD), based on the presence of an intact left hemisphere with dysfunctional right-hemisphere systems. The interplay between basic neuropsychological deficits and assets result in complex social-emotional and academic difficulties.

The definition of a nonverbal learning disability is problematic and varies among researchers and clinicians. Children with NVLD generally show a different pattern of strengths and weaknesses compared to children with LD. In contrast to children with LD who show difficulties in phonological processing, children with NVLD frequently do fairly well in single word reading and in spelling. Children with NVLD have significant problems with mathematics calculation, frequently misalign the columns in the computations, and have problems learning basic mathematics facts. They have particular difficulty in recalling information that is complex or novel, but do very well with rote memory or information that can be recalled by verbal means (Rourke, 1995). Many children with NVLD have difficulty with fine and gross motor development and experience problems in learning to skip, tie shoes, and to write legibly.

Children with NVLD also have difficulties understanding nonverbal input in social situations and, subsequently, are socially isolated. They are infrequently chosen in games and often socially isolated. Significant problems are described in the child's ability to correctly perceive social relationships and with social judgment. In several instances the child experiences difficulty with relating to peers. Many children with NVLD relate better to adults and may cling to teachers and parents as a way of adapting to a confusing social situation. Many children with NVLD also have a tendency to show attentional difficulties and may qualify for an additional diagnosis of ADHD: predominately inattentive. An increased incidence of mood disorders has been found in older children with NVLD.

Children with NVLD have particular difficulties understanding situations that are novel and complex (Rourke & Fuerst, 1991). Particular difficulty is present in understanding situations that involve

cause-effect reasoning and with generating solutions to problems (Semrud-Clikeman, 2001). Language skills are generally well developed for basic skills, but problems are also present with more complex language, understanding figurative language and idioms, and with incongruities frequently seen with the understanding of humor (Semrud-Clikeman & Glass, 2008). Difficulties with social conversation as well as reciprocity in relating to others can significantly affect the NVLD child's ability to enter into peer relations, a skill that becomes more important with adolescence.

Rourke and colleagues (2002) characterize the NVLD disorder as having several principal features, including:

- bilateral tactile-perceptual deficits more pronounced on the left side of the body than the right,
- bilateral coordination problems—again more on the left than right,
- problems with visual, spatial, and organizational abilities,
- problems adapting to novel and complex situations—use of rote or literal interpretation of behaviors that frequently result in inappropriate behavior,
- difficulty with problem solving—more evident with nonverbal than verbal materials and situations,
- problems with benefiting from positive and negative feedback,
- a distorted sense of time,
- well developed rote verbal memory,
- highly verbose with much repetition of previously stated ideas,
- poor speech intonation (prosody),
- problems with mathematics calculation with relative strengths in reading and spelling, and
- problems with social judgment, social perception, and social interaction skills.

Some studies have not supported this conceptualization, particularly in regard to the difficulty in motor and perception skills (Wilkinson & Semrud-Clikeman, 2008). Areas that have received support in research include prosody, attention, mathematics problems, social judgment difficulty, and challenges with problem solving (Semrud-Clikeman & Fine, 2008). Many clinicians and researchers utilize diagnoses that include 3–5 of the symptoms listed above.

There is little empirical evaluation of this process and further study is needed. It is not clear which of the symptoms are required for a diagnosis and which are correlated. For example, some children may show visual-spatial and mathematics problems, but do not have difficulty with social understanding. Others do not show verbal performance differences and yet have social difficulty, visual-spatial problems, and mathematics difficulty. A discriminant analysis of a large database of children with NVLD, ADHD, LD, and ASD found that the single most salient predictor of group membership for NVLD was social functioning (Fine, Semrud-Clikeman, Reynolds, & Smith, submitted). Similar studies need to evaluate which of the symptoms in this disorder are primary and which are correlated in order for a better understanding of what NVLD is and how to diagnose the disorder. See Table 12.2 for a summary of research investigating the neuropsychological, cognitive, academic, and psychosocial features of the NVLD syndrome.

The NVLD model is a culmination of 20 years of research investigating the neurocognitive basis of learning and social-emotional functioning in children (Rourke & Tsatsanis, 2000), and is an extension of the Goldberg and Costa model (Goldberg & Costa, 1981). Rourke (1989) summarizes two major functional-anatomical differences between the hemispheres:

1. The left hemisphere has greater cortical representation in specific sensory modalities (in temporal, occipital, and parietal areas) and in the motor cortex, whereas the right hemisphere has more association cortex (temporoparietal and prefrontal areas) than the left.
2. The left hemisphere has more intraregional connections, while the right has more interregional connections.

These basic differences led Goldberg and Costa (1981) to conclude that the right hemisphere has a greater capacity for dealing with "informational complexity." Rourke (1989) further incorporates neurodevelopmental theory and discusses the role of the right hemisphere cognitive and emotional adjustment in children. Rourke proposes that the right hemisphere is more important than the left for activating the entire cortex, processing novel information, developing new descriptive systems,

Table 12.2 A summary of specific deficits associated with Nonverbal Learning Disabilities (NLD)

Biogenetic Factors		*Environmental Factors/Prenatal/Postnatal*	
– No known correlates		– NLD appear at or soon after birth	
		– Neurodevelopmental disorder or may be caused by traumatic injury	
		– Few details on environmental impact	
Temperament		*Birth Complications*	
– No known correlates		– No known correlates	
		CNS Factors	
		– White matter dysfunction	
		– Intermodal integration (callosal fibers)	
		– Right-hemisphere involvement	
		Neuropsychological Factors	
		– Bilateral tactile deficits (pronounced on left side)	
		– Visual-spatial-organizational deficits	
		– Complex psychomotor deficits	
		– Oral-motor apraxia	
		– Concept formation and problem-solving deficits	

Intellectual	*Perceptual Memory*	*Memory*	*Attentional*
– Concept formation	– Visual discrimination	– Tactile	– Tactile
– Strategy generation	– Visual detail	– Nonverbal	– Visual attention
– Hypothesis testing	– Visual relation	– Complex information	– Attends to simple, repetitive verbal material
– Cause-effect relations			
– Little speech prosody			
– Formal operational thought			
Academic/Behavioral	*Psychosocial*		*Family*
– Graphomotor	– Adapting		– Research is sparse
– Reading comprehension	– Overreliance on rote behaviors		– Social interaction skills
– Mechanical arithmetic	– Externalized disorders (conduct, acting out)		
– Mathematical reasoning	– Social perception and judgment		
– Science	– Social withdrawal or isolation		
	– May develop internalized disorders (e.g., depression, anxiety)		

and processing complex information. The left hemisphere is more adept than the right at applying already learned descriptive systems that use discrete units of information (like language), and for storing compact codes (Rourke, 1989).

Genetic Factors

To date there are no studies addressing the genetic basis for the NVLD syndrome. The extent to which genetic factors play a role in this neuropsychologically based learning disorder certainly warrants investigation. There are indications that some genetic syndromes may have profiles that are similar to those described for nonverbal learning disabilities, including Turner syndrome and Velo-cardiofacial syndrome.

Turner Syndrome

Turner Syndrome (TS) is the loss of some or all of the X chromosome. It is rarely seen in males and has an incidence of 1 in 3,000–5,000 live births in females (Rovet, 2004). Females with TS lack estrogen and often have ovarian dysgeneration and infertility. The neuropsychological profile present in TS includes significant problems processing social information, visuospatial information, and severe mathematics disabilities. Performance IQ is generally 15 points lower than verbal IQ, which is generally in the average range (Rovet, 2004). Other

areas that are frequently affected include working memory, face processing (Lawrence et al., 2003), mental rotation, spatial reasoning, and difficulty processing emotions (Elgar, Campbell, & Skuse, 2002; Lawrence, Kuntsi, Coleman, Campbell, & Skuse, 2003). The mathematics, working memory, and visuo-spatial difficulties have been found to be present developmentally and continue throughout a child's life (Murphy & Mazzocco, 2008; Murphy, Mazzocco, Gerner, & Hendry, 2006).

Structural imaging has found differences in children and adults with TS in smaller volumes in the areas of the occipital and parietal lobe and reduced volume in the caudate, thalamus, and hippocampus (Reiss, Eliez, Schmitt, Patwardhan, & Haberecht, 2000). Larger volumes compared to controls have been found in patients with TS in the temporal lobes, amygdala, and orbitofrontal gray matter (Brown et al., 2002; Good et al., 2003).

The finding of anamolous development in the amygdala is similar to research in autism (see Chapter 10 for further information. Patients with TS have abnormal responses to fear recognition and other types of negative facial expressions which may be related to the anomalous amygdaloid and orbitofrontal regions. These structural differences, coupled with the neuropsychological correlates of NVLD, have lead some to speculate that there may be similar underlying neurological differences between these disorders. Further study is needed to determine whether there is a commonality in connectivity, functionality, and neuropsychological findings that underlie both TS and NVLD.

Velocardiofacial Syndrome

Velocardiofacial syndrome can also exhibit deficits in visual-spatial skills, social processing, and mathematics reasoning (Swillen et al., 1999). Velocardiofacial syndrome occurs with a deletion on chromosome 22 and many of these patients show neurological, cognitive, and behavioral deficits (Murphy, Jones, & Owen, 1999). Imaging has found differences in the white matter, particularly in the parietal regions of the brain (Amelsvoort et al., 2001; Eliez, Schmitt, White, Hu, & Reiss, 2002). Diffusion Tensor Imaging (DTI) has found alterations in the white matter tracts in the parietal

lobes as well as in the frontotemporal regions bilaterally (Barnea-Gorly et al., 2003).

Agenesis of the Corpus Callosum

While not a genetic disorder per se, agenesis of the corpus callosum (AC) occurs at some point during gestation when the corpus callosum (a large bundle of fibers that connect the two hemispheres) either forms incompletely or not at all. Children with AC range in ability from mentally retarded to having average ability. For those children with average ability difficulty appears to be present for novel problem solving, as well as social understanding (Brown & Paul, 2000; Paul, Schieffer, & Brown, 2004). In addition, children with AC also have trouble understanding figurative language as well as affect as expressed by speech intonation (Brown, Symingtion, Van Lancker-Sidtis, Dietrich, & Paul, 2005; Paul, Van Lancker-Sidtis, Schieffer, Dietrich, & Brown, 2003).

These findings certainly suggest a similarity to NVLD. Studies that compare children with AC, children with NVLD, and children with other genetic syndromes that have similar features would be informative as to what these disorders have in common and whether there are discriminating aspects of these issues. If there are similar behaviors that arise from similar neurological underpinnings but different causes, it may well be that the disruption of connectivity in particular regions of the brain relates to social, visual-spatial, and mathematical difficulties. Some studies of children with TS have contrasted their functioning in mathematics to that of children with Fragile X and found similarities (Murphy & Mazzocco, 2008). Unfortunately, social functioning measures were not also obtained in these studies. This area of research is ripe for further investigation.

Prenatal/Postnatal Factors

The NVLD syndrome is described as a neurodevelopmental disorder; that is, one that is present at or soon after birth (Rourke, 1989). While Rourke (1989) does assume that the neuropsychological patterns of assets and deficits are developmental in

nature, appearing at birth, he does acknowledge that traumatic injury or trauma may result in a similar pattern. Few other details are available describing prenatal and postnatal factors associated with the NLD syndrome.

One of the theories about NVLD is that it involves right hemispheric dysfunction. It has been suggested that development of the right hemisphere can be affected by many issues including hormones during gestation, prematurity, pregnancy and delivery complications, among others (Forrest, 2007). During development the right hemisphere is believed to grow first, followed by the left hemisphere and finally connectivity between the two hemispheres and hemispheric specialization (Thatcher, 1996). Similarly, Luria suggests that within the lobes hierarchical development occurs, moving from primary centers (hardwired centers) to more associative and highly complex areas that are important for problem solving and insight into behavior (Luria, 1980).

Neuropsychological Correlates

Rourke (1989) lists the neuropsychological assets of the child with NVLD as auditory perception, simple motor skills, rote memory, verbal and auditory memory, attention to verbal and auditory information, and verbal reception, storage, and associations. Neuropsychological deficits associated with the right hemisphere NLD syndrome include tactile and visual imperception, impaired complex psychomotor skills, inattention to tactile and visual information, poor memory for tactile and visual information, and some verbal skill deficits (i.e., prosody, semantics, content). Scores are also below average on subtests of the Performance Scale of the WISC-R (Block Design, Picture Arrangement, and Object Assembly): the Tactual Performance Test, left hand; the Pegboard Test, both right and left hands, and the Category test (Rourke, 2000).

Academic and School Factors

The interaction between right hemisphere weaknesses and left hemisphere assets is manifested in good graphomotor skills for right-handed children (usually later in life), word decoding skills, spelling skills, and "verbatim memory" (Rourke, 1989). Because children with NVLD rely heavily on intact left hemisphere functions, they often develop excellent reading, decoding, and spelling skills (Semrud-Clikeman, 2007). Children with NVLD tend to perform well on academic tasks that rely on rote verbal memory.

Academic deficits include poor academic achievement in mathematical reasoning and computation. Initially the child with NVLD shows good reading recognition, but in later grades as reading for meaning becomes more important, the child experiences significant problems with reading comprehension. These academic areas are particularly compromised by difficulties with abstract reasoning and deduction. Children with NVLD fail to develop complex concept formation and problem solving abilities needed for advanced subject matter such as physics (Semrud-Clikeman, 2003).

Although children with NVLD start out with slow development of early graphomotor skills, these abilities improve with age. Academically, children with NVLD appear to be compromised by their extreme difficulties with understanding cause-and-effect relationships, and problems generating age-appropriate problem solving skills. These deficits are particularly evident during novel tasks, and subsequent learning is negatively affected (Semrud-Clikeman, 2007).

Visual-Spatial Ability

Visuospatial skills, visual working memory, and imagery in children with NVLD are areas of significant difficulty (Cornoldi, 1999). Visual imagery and working memory have been linked to the ability to process social information, an area that is difficult for children with NVLD (Logie, 1995). Children with NVLD have trouble recalling visual and spatial information as well as imagery for both verbal and visual information. Thus, difficulty is present on tasks that require the child to learn new information by associating it with previously learned material. It is suggested that visual working memory is an area of particular difficulty and support is required to assist with these abilities.

The ability to integrate information presented visually may be a primary difficulty for children with NVLD who have more difficulty on measures of visual-motor integration and visual-spatial skills, compared to children with ADHD or typically developing children (Wilkinson, & Semrud-Clikeman, 2008). When the performance of children with verbal LD, NVLD and typically developing children were compared on measures of visual motor integration (Foss, 1991; Meyers & Meyers, 1995), the children with learning disabilities performed more poorly than typically developing children. The children with NVLD, however, performed the most poorly. Qualitative analysis of the findings indicated that children with verbal LD were generally able to copy the picture adequately, but missed many details. The children with NVLD copied the picture in a piecemeal fashion with disconnected details. This disjointed understanding of the whole from the parts likely interacts with difficulties with social perception.

An evaluation of the perception of children with NVLD using projective measures found that they had significant difficulties in perceiving the inkblots in a typical manner compared to controls and children with ADHD: PI (Corlett, 2002). The difficulty that was present was characterized by problems with integration. No differences were found between the ADHD: PI and control groups, thus attentional deficits were not at the core of the problems with visual integration. Thus, it is likely that children with NVLD will have difficulties integrating visual input accurately and may react inappropriately. Although children with NVLD scored on indices indicating interest in others, their responses indicated they are likely to react inflexibly to a social situation.

These studies indicate that children with NVLD have difficulty with visual-spatial integration that may relate to the frequently encountered problems with social processing. These difficulties in understanding novel events, processing materials quickly, and putting together parts of a scenario to understand the underlying meaning likely interfere with social processing. In addition, if the infant has difficulty deciphering faces and understanding facial expressions, it is likely that the early building blocks of social understanding are not well established and carry over into later childhood (Semrud-Clikeman & Hynd, 1990).

Attention

Attentional skills are problematic for children with NVLD and many are diagnosed with ADHD: predominately inattentive type (Semrud-Clikeman, Walkowiak, Wilkinson, & Christopher, submitted). Attention to complex, novel information is particularly difficult, and children with NVLD are more attentive to simple, repetitive tasks than to tasks that are verbal or auditory in nature. This attentional bias makes new learning particularly difficult, and becomes more prominent with age. Children with NVLD often appear overactive initially, but this apparent hyperactivity does not persist.

Executive Functioning

The skills of working memory, processing of complex and novel material, and understanding of other's motives and feelings is related to difficulty with executive functioning for these children. Executive functions are those that allow a person to view their behavior, assess its appropriateness, and make changes if required. They differ from cognitive functions somewhat; cognitive functions look at what a person knows while executive functions evaluate the person's ability to carry through with a plan of action (Damasio, Tranel, & Rizzo, 2000). Thus, a child or adolescent can know the appropriate plan of action in a social situation, but be unable to carry through with it in an efficient manner. Often fluid social interaction require the child to process information quickly and efficiently generally using simultaneous evaluation of many aspects of the difficulty.

Children with NVLD perform better skills on measures of sequential processing than those of simultaneous processing. Simultaneous and sequential processing are based on Luria's (1980) model of brain function that conceptualizes the brain function into three networks that function independently and are integrated at higher levels. The three networks are planning, arousal, and processing (simultaneous as well as sequential). Sequential

processing is the ability to process information in a step-by-step manner and is primarily based on left hemispheric processing. Simultaneous processing is a right hemispheric function and allows the individual to process information with many facets and form an integrated whole. The individual uses either style depending on the task at hand. Chow and Skuy (1999) evaluated children with NVLD and those with verbal LD on measures of sequential and simultaneous processing. Children with verbal LD were more likely to use the simultaneous processing style while children with NVLD favored the successive processing mode.

This difficulty in understanding the gestalt of a task, or social exchange, likely interferes with the ease of social interactions. If the child with NVLD is attempting to understand a perceptual task using an inefficient method (such as sequential, language-based processing), the behaviors are likely to feel flat and inappropriate to the fellow person in the interaction. Difficulties with fluid reasoning, concept formation, and problem solving have been identified in children with NVLD (Schnoebelen, Semrud-Clikeman, Guli, & Corlett, 2002). These difficulties interact with the problems in processing perceptual information, particularly when it requires the processing of novel and complex social information. The problem that children with NVLD have in social interactions may be a combination of difficulty with attention, executive functioning, and perception (Semrud-Clikeman & Schaefer, 2000).

Social-Psychological Functioning

The difficulty children with NVLD have understanding complex pictures underscores the challenges present in comprehending dynamic social exchanges. These difficulties with integration make it problematic for the child with NVLD to understand facial expressions and pair them with gestures and language. When asked to interpret a scene where the verbal portion of the communication does not match the nonverbal portion, children with NVLD inevitably use the verbal portion to translate meaning. Thus, sarcasm or humor is not understood by children with NVLD and they often

translate this type of communication literally (Semrud-Clikeman & Glass, 2008). Moreover, children with NVLD often make inferences based on language and interpret a situation using details without reference to the context (Worling, Humphries, & Tannock, 1999). Thus, the child's interpretation may not be accurate for the context in which the information is given and, subsequently, his/her behavior is often inappropriate based on misperceptions.

Borod, Andelman, Obler, Tweedy, and Welkowitz (1992) suggest that interpretation of emotion requires the ability to understand the relationship between emotions which in turn requires spatial organization—a right hemispheric integrative function. Working memory deficits present in NVLD also limit the child's ability to apply appropriate emotional inferences to the situation at hand. It is likely that this system becomes overloaded attempting to process the details involved in any social exchange, thus resulting in difficulty with social interacting that is fluid and reciprocal.

To more fully understand the prevalence of psychopathology in children with NVLD compared to those with RD, a study contrasted typically developing children, children with NVLD, RD, a psychiatric control group, and a group of children with velocardiofacial syndrome (VCFS) to determine what differences may be in the prevalence rate of psychiatric disorders (Antshell & Khan, 2008). Each parent was interviewed to determine the presence of psychopathology. The NVLD, RD, and psychiatric control groups were found to show a higher incidence of ADHD and substance abuse/dependence. The psychiatric controls and children with NVLD were also found to have a higher prevalence rate of familial bipolar disorder. This finding was not true for the velocardiofacial group who also had NVLD. It was concluded that the children with VCFS and NVLD were different genetically compared to the NVLD without VCFS. The conclusions from this study are interesting in that the authors related NVLD to bipolar disorder. This conclusion of increased bipolar disorder in the families of children with NVLD has not been replicated (McDonough-Ryan et al., 2002). Further study is needed in these areas to more fully understand the link that may exist between NVLD and other psychiatric disorders.

The areas of attention, executive functioning, social understanding, and academic functioning are domains that need to be evaluated by a neuropsychologist. Each of these regions requires varying types of measures. The following section discusses what measures may be most helpful in this evaluation.

Neuroimaging in NVLD

The only studies completed on neuroimaging in NVLD are case studies. In one case two adolescents with NVLD and two controls were asked to utilize self-talk to complete a task and then to use solely tactile information (Tuller, Jantzen, Olvera, Steinberg, & Kelso, 2007). Each adolescent was asked to touch his thumb to each of his fingertips in the same hand. Results from the fMRI found that the two subjects with NVLD showed a widely distributed network when completing this task, compared to the controls. One of the difficulties with this study is the low number of subjects and the difficulty in knowing whether these results truly represent the functioning of children with NVLD or whether they solely represent normal fluctuation among individuals.

One study evaluated a 14-year-old boy with cerebral palsy who was diagnosed with nonverbal learning disabilities as well as executive function deficits and visual-spatial delays (Gross-Tur, Ben-Bashat, Shalev, Levav, & Sira, 2006). He had a developmental hypoplastic left cerebellum. A reduction in right hemispheric white matter in the cerebrum as well as in the cerebellum was found via DTI. The conclusion from this study was that the disruption of the right hemispheric circuits negatively influenced the child's ability to relate to others, complete visual-spatial tasks, or plan and organize information. There were no other specific studies that evaluated NVLD using neuroimaging in our recent literature review.

Implications for Assessment

Comprehensive neuropsychological assessment is necessary to identify the NVLD syndrome in children. A developmental model of assessment, where evaluations are repeated over time and form the basis for remedial programs, has been recommended (Rourke, 1994). Based on the above descriptions of difficulties children with NVLD experience it would be recommended to include measures of attention, executive functioning, and academic performance. Many of the measures listed in Chapter 6 are appropriate for this evaluation. Particular recommendations would be for the sorting, Stroop, and Tower tests from the Delis-Kaplan Test of Executive Functioning, the Rey-Osterreith, the TOVA, the WJ III Tests of fluid reasoning, and a full evaluation of the child's mathematical and reading abilities.

In addition to these measures, it is also imperative to evaluate the child's social abilities. There are few good direct measures of social functioning. One measure that has been helpful in our work is the Child and Adolescent Social Perception Test (CASP (Magill-Evans, Koning, Cameron-Sadava, & Manyk, 1996). This measure is a series of videotaped vignettes of children, adolescents and adults interacting. The videotape shows the action with the words masked so that what the child hears is the intonation, but not the words. After each of 10 vignettes, the child is asked questions about what happened and what the people were feeling. Two standard scores are provided, one for nonverbal cues and one for emotion recognition. The psychometric properties of the measure are acceptable, but further research is needed to determine whether the scores can discriminate among groups of children with disabilities.

Fine, Semrud-Clikeman, Butcher, and Walkowiak (2008) evaluated the use of the CASP with children with attention problems and those with social competence problems with and without attentional issues. While attention played a part in the performance on this measure, the CASP identified children with social difficulties even with attentional aspects removed. While the CASP is helpful and one of the few things available, the vignettes are a bit dated and its use for younger children may be questionable. It can be ordered by contacting Dr. Magill-Evans at the University of Alberta in Edmonton, Canada.

Other measures that have recently become available include the Social Communication Questionnaire (SCQ) (Rutter, Bailey, Berument, Lord, &

Pickeles, 2003). The SCQ is completed by the parent and provides a total score that indicates the child's likelihood for autism. While it is a screener for autism and shows severity of difficulty, it is a measure that can also be used with children with NVLD to pinpoint problem areas. The authors report that the SCQ is not affected by age, gender, language skills or performance ability. The utility of the SCQ for diagnosis of autism has been established; its use with NVLD would be to assist with understanding the social areas for which the child has difficulty.

The Social Responsiveness Scale (Constantino & Gruber, 2006) is a parent report for children aged 4–18 years. It can be completed by a parent or teacher and evaluates the child's functioning within a natural social setting. The areas of reciprocal social communication, social anxiety/avoidance, preoccupations, social awareness and social impairments are evaluated. It provides information about the level of difficulty in each of the areas of concern. There are five treatment subscales in addition to the total score. These subscales are receptive, cognitive, expression, and motivational aspects of social behavior and autistic preoccupations. It differs from the SCQ in that it doesn't use a cutoff score, but rather utilizes a scale that provides a measure of severity for each of the subscales. This instrument is fairly new and further research is needed to determine how useful it will be for evaluating children with NVLD. It is, however, a measure that can be helpful in evaluating the child's social performance in school and home.

Evaluating the child's functioning in all of these domains should also provide ideas as to appropriate interventions. The interventions often need to be tailored to the individual child and empirical validation of these methods is not as strongly established as for other types of learning disorders. The following section briefly reviews one particular type of intervention that has provided some empirical validation.

Implications for Intervention

According to Rourke, when systems of the right hemisphere are dysfunctional and systems of the left hemisphere are relatively intact, the child tends to engage in perseverative or stereotypic responses because of the over-reliance on information that has already been learned. This often results in difficulties in developing problem solving strategies and generating alternative solutions. Children begin to develop compensatory skills that are primarily verbal in nature, and they begin to avoid novel situations. Because of tactile deficits and slow maturation of early psychomotor skills, children with NVLD have a tendency to avoid active exploration of the environment.

Intervention programs that incorporate early teaching in sensory-motor integration as well as interventions that are implemented across all domains (i.e., academic and psychosocial) include the child as well as the parent. Methods that increase social awareness, teach problem solving strategies, encourage generalization of strategies, and improve verbal skills should be part of the intervention plan. Methods for strengthening areas of weakness in visual-spatial areas, interpreting competing stimuli, teaching nonverbal behaviors, providing structure for exploration, using concrete aids, teaching self-evaluation, and developing life skills are important aims for any intervention.

The social skills curriculum developed for other children has proven to be a successful intervention without tailoring the skills to the child with NVLD (Palombo, 2006; Semrud-Clikeman & Schaefer, 2000). Most social skill programs begin at a level that is likely too advanced for children with NVLD as these programs generally assume that the child is able to accurately interpret facial expressions and body language. For many children with NVLD (and for those with HFA and AS) the interventions need to begin with labeling of emotions and understanding emotional labels to be effective. In addition, interventions need to be based on teaching social perception through the use of practice, modeling, and role-playing. Breaking social perception down into discrete steps and teaching rules to allow the child with NVLD to process the information verbally plays on the strengths that these children bring to the program. Pairing auditory and visual stimuli together may also provide the type of support that is necessary for the child to fully understand the complex nonverbal social communication that is problematic for his/her interpretation (Semrud-Clikeman, 2007).

In order for these interventions to be helpful to children with NVLD it is likely important that the program begin slowly and with a great deal of structure, and then gradually move to the more complex activities that require the building of trust in order to attempt them. Practicing the skills as well as overlearning key social abilities and perceptions is crucial not only for mastering these abilities, but for later generalization. To encourage generalization of the skills, it is important to involve the parents so they can help practice the newly learned skills at home and in school, and teach these children how to apply the social skills appropriately.

Generally the interventions fall into one of three types: parent interventions, social skills curriculum (including coaching and friendship groups), and a group-based intervention based on learning about emotions and social applications. Parents can be very helpful in working with NVLD children as long as additional support is provided. Another method that has been helpful is that of peer or adult coaching. These interventions will be briefly discussed below.

Parent Interventions

Parent Effectiveness Training (PET) (Gordan, 2006) is a program that assists a child to manage his/her relations with others. PET encourages parents to invite children over to play with their child in a structured environment as well as join groups such as 4-H, Cub/Boy Scouts or Brownies/Girl Scouts. The structure of these programs and the emphasis on working together can assist a child with NVLD to enter into more structured, safe settings for social experiences. For parents who also experience social difficulties, family therapy may be the most appropriate mechanism to support the child with similar social difficulties. A frequent clinical observation is that parents with children with NVLD (or ASD) may also experience difficulties with social interactions. Thus, an intervention that expects them to teach the child such skills is problematic.

While parents may not be the best vehicle for teaching social skills, they are very helpful in providing appropriate information about development, new programs, and the child's progress (Semrud-Clikeman & Schaefer, 2000). Parents supplied with

suggestions and support can provide additional experiences for their child that is more helpful. Children with NVLD often experience rejection and isolation in school and in unstructured activities. A parent who can provide support through organized activities, a calm demeanor, and a place to decompress is likely giving the best support to the child. Setting up situations where the child is paired with one other child who may be more tolerant of the child's behaviors can also help. Trips to the museum, movies, or a structured activity are proactive for appropriate social exchanges. Situations that don't provide such structure are likely to be more anxiety-producing and possibly less constructive as the child seeks to entertain his/her "friend" (Glass, Guli, & Semrud-Clikeman, 2000; Semrud-Clikeman & Schaefer, 2000).

Coaching

Matching the child with NVLD to a child who is more tolerant for socialization can be helpful. While this type of "friend making" can be somewhat artificial and requires a very special child to support the child with NVLD, it can provide a safe environment in which the child is able to perform skills that have been taught in the clinic or in small groups. The advantages of peer matching are that it occurs in a naturalistic setting and the child learns from a same-aged child. However, it is time consuming and requires a great deal of adult support for success both from the parent and teacher. It may be most successful for children who are in special education programs where there are additional paraprofessionals and support rather than in a larger classroom.

Suggestions in the field have been made for coaching interventions. These interventions occur in the child's environment and the adult observes the child. Following the observation, the child meets with his/her coach and discusses the behaviors seen and the situations. Corrective exercises are provided. It is likely that this method could be quite useful in assisting the child to learn appropriate behaviors in a naturalistic setting. This type of intervention does not have empirical validation and can be costly. However, it may also be helpful for children who are really struggling to relate to other children.

Social Competence Intervention Program

A social competence intervention program (SCIP) designed to work with children with NVLD and Asperger's Disorder has been developed (Guli, Wilkinson, & Semrud-Clikeman, 2008). SCIP is an intervention that is multisensory in nature and targets underlying difficulties in social perception as well as provide exercises to improve the generation of strategies for problem solving. Figure 12.1 illustrates the basic tenet behind this intervention.

Fig. 12.1 Model for Social Perception

PERCEPTION

visual
auditory
tactile
kinesthetic

INTERPRETATION

facial expression
body language
vocal cues

RESPONSE

social interaction
contextual understanding

In SCIP, exercises were adapted from children's creative drama and theater classes to practice the processes fundamental to social competence. These activities were originally designed to help actors develop accurate perception and response to cues, and address various aspects of social perception (Guli et al., 2008). These activities fall into the following categories: sensory games, space/movement games, mirroring activities, communication with sounds, physical control, "part of a whole" and multiple-stimulus games.

The exercises are designed to move from learning how to perceive various emotions to appropriate interpretation of these emotions and then to assisting with choosing the best response to the situation

at hand. In each case the training begins with easily recognized emotions such as happy and sad, and moves to more abstract emotions such as embarrassment, confusion, and frustration. The initial session includes direct teaching of facial expression recognition as well as voice intonation, intent of the speaker, and interpreting body language. As the child moves through the program, role-playing is introduced and the child is exposed to more and more complex situations with significant amounts of adult guidance. The SCIP program provides new experiences that change with time, but are built on situations that are familiar and thus not as anxiety-producing as fully novel experiences would be. The work is constantly reviewed and supported throughout the intervention, thus reviewing and refreshing skills.

One of the difficulties that children with NVLD face is limited exposure to other children to practice skills. They are often isolated and ignored. The intensity of the SCIP program allows the child to experience being with other children as they work toward a common goal; namely, understanding social interactions. The experience of children with SCIP has been a joining together and enjoyment of one another within a safe environment. Activities and role-plays are in a setting which allows the child to experiment, laugh when something goes wrong, and find out that he/she is not the only one struggling with some issues.

Guli et al., (2008) evaluated the efficacy of the SCIP program. A treatment group and a clinical control group with deficits in social perception were compared using several outcome measures before and after participation in the SCIP program. The outcome measures included a test of recognizing facial expressions and voice cues, parent ratings on behavioral checklists of withdrawal and social skills, and direct behavioral observations of peer interactions. Following the intervention, parents and children in the treatment group were interviewed about their experiences.

Quantitative and qualitative support was found. Improvement was found in the child's ability to correctly recognize facial expressions, vocal cues, and social behavior. Approximately three-fourths of the parents reported positive changes in one aspect of their child's social functioning, while 82 percent reported several aspects

showed improvement. Moreover, these findings strongly support research that stresses training in perception and integration of nonverbal cues for children with nonverbal learning disabilities (Barnhill, Tapscott, Tebbgenkamp, & Smith, 2002; Bauminger, 2002).

Summary and Comments about NVLD

Emerging research underscores the need to understand the dynamic interaction between psychological and emotional problems in light of neuropsychological assets/deficits in children with learning disabilities. Although further research is necessary to verify these relationships and to determine how learning disabilities change over the ages, an integrated neurodevelopmental model provides the framework for such study. Although Rourke has developed a model based on a series of related studies spanning two decades, sub-typology research has been criticized. Reynolds (2003) asserts that models relying on profile analysis must take into account the reliability (i.e., stability) of profiles. The extent to which profiles change over time and how these changes might affect the original clinical decision need further study. Others have pointed out weaknesses in using correlational methods to imply similarity among subjects (Keith, 2006). Correlational methods are also inappropriate for studies when the linearity of variables is questionable.

Despite criticisms of subtype research, Rourke's NVLD model provides a foundation for further research and contributes to our preliminary understanding of how neuropsychological, cognitive, and social-emotional functioning interacts with and influences the development of children. This model describes a complex interaction among deficient and intact neuropsychological systems, early experiences, and learning that is associated with social-emotional functioning. Rourke does provide a viable model for a "right-hemisphere syndrome" that can be tested empirically with children experiencing academic disabilities (primarily in math) and psychosocial adjustment difficulties using standard neuropsychological and psychological tests.

Recent research indicates that the original belief that motor and tactile issues were primary in NVLD have not been supported and that attention and social-emotional functioning may be important aspects of this disorder. The research does not clarify the main aspects of NVLD or the neural underlays for the difficulty these children have in relating to others in visual-spatial skills and in executive functioning. In addition, when the diagnosis is not clearly defined, it is difficult to compare results across studies. Further validation of the disorder, as well as additional study of the possible causes and interventions, would be increase our understanding of this disorder.

Case Study of a Child with Severe Developmental Dyslexia

The following case describes an assessment of a 10-year-old boy who had received excellent special education services for several years, but who continued to be unable to read beyond a primer level. The case demonstrates the need to evaluate reading difficulties comprehensively, and obtain a family history. Allen is a fourth-grade boy who was referred to the clinic for ongoing reading difficulties despite having had three years of special education services. He had been diagnosed with ADHD and responded favorably to Ritalin. In kindergarten, Allen was first identified as experiencing difficulty with readiness skills. He was very active and had great difficulty staying in a group and participating in activities. He started taking Ritalin in first grade and was kept in first grade an additional year because of significant delays in academics. Allen was evaluated in second grade and placed in a learning disability program. Behaviorally and socially he was reported not to experience any difficulties, and was well accepted by his peers. He was also reported to be hard working and motivated.

Allen was the product of a normal full-term birth, labor, and delivery. Developmental milestones were generally attained within normal limits for age. At an early age Allen was noted to display an extreme level of overactivity and inattention. He was diagnosed with ADHD in first grade. His

Ritalin dosage has gradually increased from 5 milligrams (mg) twice per day to a current dose of 20 mg in the morning, 20 mg at noon, and 15 mg at 3:00 P.M. His paternal history is remarkable for reading difficulties. His father, his stepsister, a paternal uncle, and a grandfather have all experienced significant reading difficulties, which continued throughout school and into adulthood. Although Allen's father's intelligence is above average, he is unable to read and is currently employed as a grocery stocker. Allen's neurological examination and MRI were normal. He has not had any head injuries, seizures, or serious illnesses.

Cognitive Ability

Allen's evaluation indicated an average ability with strengths in vocabulary, social comprehension, perceptual organization and nonverbal reasoning. Significant weakness was present in working memory as well as in memory for previously learned material, abstract language ability, motor speed, and arithmetic reasoning. The following results were obtained on the WISC IV.

Verbal Comprehension	82
Perceptual Reasoning	99
Full Scale IQ	94
Working Memory	78
Processing Speed	75

Information	5	Picture Completion	10
Similarities	6	Coding	4
Arithmetic	5	Matrix Reasoning	10
Vocabulary	9	Block Design	8
Comprehension	10	Object Assembly	9
Digit Span	4	Symbol Search	6

Achievement Testing

Achievement testing indicated severe deficits in all areas of reading, with math skills also depressed, particularly in applied problems. The Woodcock

Johnson Achievement Battery-III was administered and the following scores obtained:

Letter-Word ID	46
Reading Comprehension	64
Reading Fluency	50
Word Attack	51
Applied Problems	75
Arithmetic Calculation	83
Math Fluency	80
Spelling	50
Written Expression	65
Writing Fluency	60

Allen is a choppy and dysfluent reader. He appeared unsure of vowel and consonant sounds and consequently relied on a "best guess" strategy for reading (e.g., using a word's visual characteristics as an aid to decoding). The Lindamood Auditory Concepts test was also administered to further evaluate Allen's word attack skills. Allen performed at the mid-first grade level on this test, with significant difficulties with sound-symbol relationships even at the individual phoneme levels. Blending and the ability to combine sounds were delayed. Allen experienced difficulty at the primary level for distinguishing similar, but different sounds at the beginning and ending of words.

Memory

Allen's memory skills were evaluated using the Children's Version of the California Verbal Learning Test.

Allen's learning of List A fell significantly below average over the five trials. Although the learning curve rose steadily over the five trials, suggesting that Allen benefited from repetition of the words, the number of items recalled after each trial fell below expectations compared to same-aged peers. Allen's recall of List B also fell below average. Both short-term free recall and cued recall fell within average levels for his age. These findings indicate that Allen is able to retain information that he has

learned. His memory skills are problematic in that Allen has difficulty encoding new information. In addition, he was unable to utilize memory strategies that would assist him in encoding information; rather he tried to recall the words using rote memory rather than grouping them into categories.

Total Recalled	85
Trial 1 Recall	60
Trial 5 Recall	80
List B	75
Short-term Free Recall	100
Short-term Cued Recall	98
Long-term Free Recall	102
Long-term Cued Recall	103
Learning slope	88

Language Ability

Language assessment indicated that Allen has difficulty in both receptive and expressive language skills. The Clinical Evaluation of Language Fundamentals-3 was administered, and the following results were obtained:

Receptive Language		Expressive Language	
Concepts and Directions	4	Formulated Sentences	5
Word Classes	9	Recalling Sentences	7
Semantic Relationships	3	Sentence Assembly	6

This assessment indicated pervasive language problems in Allen's ability to understand and use language. On receptive language tasks, Allen's ability to follow directions using visual cues that increase in complexity was quite poor, and likely a reflection of his previously identified difficulty with adequately encoding verbally based information. Allen's performance on a task that tapped his understanding of comparative, temporal, quantitative, and spatial concepts in language also fell significantly below average. Allen's ability to see relationships between words was within age expectations.

On the expressive language measures, Allen demonstrated significant weakness on a series of structured tasks that required him to create sentences about pictures using stimulus words. He had difficulty integrating words into a relevant sentence while maintaining appropriate grammatical structure. Consistent with his difficulties with encoding verbally mediated information, Allen evidenced a significant weakness in his ability to repeat progressively longer and syntactically complex sentences.

Attention

The Test of Variables of Attention (TOVA) was used to measure attentional functioning. Testing was done off Ritalin, on 15 mg of Ritalin, and on 20 mg of Ritalin. Measures of vigilance (omissions), impulsivity and inhibition of responding (commission), speed of information processing (reaction times), and variability of reaction time (variability) were obtained with the following results:

Measure	20 mg	15 mg	Off Ritalin
Omissions	98	98	66
Commissions	90	90	98
Response Time	67	54	34
Variability	63	26	< 25

Results indicated that on his current 20 mg dose, Allen demonstrated age-appropriate gross attention to task and impulse control. In contrast, reaction time and sustained attention fell significantly below expected limits for age. On a 15 mg dose of Ritalin, Allen's gross attention and impulse control were identical to that observed on the higher dose. However, his reaction time and sustained attention were much poorer on the lower dose of Ritalin. With the exception of his impulse control, Allen's performance on the TOVA off medication fell significantly below average on all attentional parameters. Overall results indicated that Allen exhibits a beneficial response to his current Ritalin dose of 20 mg. Even with the higher dose, however, his response time and ability to sustain and deploy attention consistently fell significantly below average.

Executive Functioning

Allen completed subtests from the Delis Kaplan Test of Executive Functioning (D-KEFS). The D-KEFS found that Allen's executive functioning ability fell within the average to far below average range. Allen's visual-spatial-motor skills consistently fell in the average range. For example, on a measure that required Allen to connect a series of letters as quickly as possible, his performance fell in the average range. On a similar task, his ability to connect a series of numbers also fell in the average range. He also performed in the average range when asked to sequence between a number and a letter in succession (1-A, 2-B, 3-C, etc). On a measure of verbal fluency, Allen's ability to rapidly name as many words that began with a certain letter, name as many animals, and as many male names as he could in 60 seconds fell within the average range. His ability to repeat a sequence of numbers presented orally fell within the low average range and his ability to repeat a series of numbers and letters was also within the low average range. Allen struggled in a task that required him to rapidly name colors and color word names. His ability to name colors and read color words fell in the average range. However, as the task became more difficult, he struggled when he was asked to name the color of a color word printed in an opposing color (Saying "green" when looking at the word blue printed in green ink). His performance in this response interference task fell in the far below average range. Allen performed in the far below average range on a planning task that required him to plan a set of sequential moves using up to five rings in a predetermined starting point after being shown the correct ending position of the rings.

Taken together these findings indicate that Allen shows relatively better performance on visual-spatial-motor tasks than tasks that require cognitive response interference, set switching, and planning. This finding may mean that since he performed in the average range on visual-motor tasks but not purely cognitive executive measures, Allen may be experiencing specific difficulty with tasks that require him to hold a cognitive task "online" while ignoring distracters. In addition he experiences problems in his ability to successfully plan and execute a set of moves while remembering the directions necessary to complete the task.

Visual-Spatial Skills

Allen's visual-motor integration skills were assessed using the Developmental Test of Visual-Motor Integration. Consistent with teacher reports regarding illegible writing and poor copying skills, Allen's reproductions on this task fell moderately below age expectations (standard scores = 76). On the Judgement of Line Orientation, Allen showed below age level functioning. His finger dexterity as measured by the Purdue Pegboard was within age expectations for either hand and for both hands together. These findings indicate some difficulty with visual-spatial integration, but not with motor skills.

Behavioral/Emotional Functioning

Personality and behavioral assessment indicated no areas of concern. He did not score in the significant range on any portion of the Behavior Assessment Scale for Children II. Teacher reports indicated concerns only in the area of academic progress. These profiles indicated that Allen is perceived as well adjusted, without any behavioral problems.

Summary and Recommendations

Allen is a 10-year-old boy with speech and language problems as well as difficulty with acquiring reading skills. He also has a history of ADHD and is currently being treated with Ritalin. This evaluation was requested by his mother to determine current reading skills and to offer treatment recommendations. Assessment of Allen's academic achievement confirms school and parental reports that he is experiencing persistent and severe difficulties in acquisition of beginning reading skills. Evaluation revealed that his reading skills fell significantly below average, and well below what was to be expected on the basis of his intellectual profile.

Allen's reading skills fall approximately at a mid-first grade level and are limited to inconsistent identification of high frequency sight words. He shows little in the way of word attack skills and is deficient in other phonological coding skills that have been found to be highly related to the normal acquisition of reading. Relative to an assessment completed more than two years ago, Allen shows little progress. Overall, results from the present testing indicate the presence of a verbally based learning disability. Testing of language functions revealed striking weaknesses in both receptive and expressive language skills. Although parental reports indicated that Allen has made a stable pattern of gains since speech therapy was initiated this year; his language problems are of such severity that they are continuing to have an impact on his ability to use and understand language effectively. Testing of memory and learning indicated that Allen experienced difficulties in encoding and memorizing verbal information, such as stories and lists of words. Allen's ability to remember verbal information is constrained by problems with encoding and inputting. He does not have difficulty in retrieving and outputting information from memory; that is, once information is encoded into memory, he can retain it for relatively long periods of time. His encoding problems also affect his ability to process verbal material, such as instructions, adequately. It is important to emphasize that despite his encoding difficulties, Allen has the potential to learn and memorize new information, but he will do so at a rate that is significantly slower than his same-aged peers, and he will require more than the usual amount of repetition. Allen does not appear to have significant difficulty memorizing material that is visual in nature, such as designs and pictures. Recommendations include an intensive learning disabilities program to work on his phonological coding difficulties while simultaneously strengthening his sight word vocabulary. Given Allen's good visual-perceptual and visual-memory abilities, it is recommended that teaching strategies focus on a sight word approach with the high frequency words he encounters. For Allen to become a fully functional reader, it is crucial that he become adept at decoding unknown words. Teaching Allen how to decode words will not be an easy task, given that he lacks a number of the essential phonological processing skills necessary for effective decoding. To help Allen develop the phonological processing skills that are critical to becoming an effective reader, the Linda-mood Auditory Discrimination In Depth Program is recommended. This program, multisensory in nature, recognizes that some children have great difficulty in recognizing and perceiving the association between sequences of sounds in spoken words and sequences of letters in written words. It provides experience at a level prior to that of most beginning phonic programs by teaching sound-symbol correspondences through activities that allow students to hear, see, and feel sound units of language. The program starts with oral motor activities (e.g., noting the position of the mouth and tongue when a certain sound is produced), and gradually builds up to working with words. For the program to be effective for Allen, it should be intensively incorporated into his reading program. For many children with phonological processing difficulties, this program has been helpful in diminishing their decoding difficulties. The Lindamood Program, including the associated manual and step-by-step program instructions, can be obtained through Riverside Press.

It is further recommended that Allen be provided with a computer for rehearsing reading skills. Moreover, a language experience approach should be incorporated into Allen's classroom program. This method, which will encourage Allen to use his own words, includes writing his own book by dictating a story to a teacher or aide who provides him with a written transcript. Allen would then read the story back and accumulate flashcards of unknown words that he encounters. Taped books should also be available for Allen. The benefits of taped books are two-fold. They will assist with the acquisition of information that would ordinarily be available only through written text, and provide a way to enhance Allen's reading skills by allowing him to listen to a tape as he follows along in a book. Language therapy is also required to assist with his skill development. Intervention that focuses on his organization of language output, pragmatics, and repair strategies (e.g., using an alternative word or phrase to accommodate his word finding difficulty), will be especially helpful to him at this point. These recommendations have been put into place. Allen will return to the clinic in approximately six months to assess his progress.

Chapter Summary

The purpose of this chapter was to describe the neuropsychology of language disorders and learning disabilities in children. In all these disorders, the child's genetic inheritance and neurological makeup interact with the environment. A child with language and learning disorders is born with neurological constraints that make up the beginning points of the child's interaction with the world. In these disorders, early interventions that combine phonological awareness training and direct instruction of the child in the context of reading have been most successful. The neurobiological constraints are the backdrop for what develops and, although they are limiting in some manner, they are also malleable through environmental interventions.

A transactional approach allows for a simultaneous understanding of the biology, neuropsychology, and family systems of children with neurodevelopmental disorders. Such an understanding is imperative in order to work effectively with children with neurobiological vulnerabilities. As one parent of a learning disabled child reminded the first author: "You professionals give us [the mother and father] lots of suggestions-do you not recognize that we also have learning disabilities? How do you expect us to follow through when we have the same problem?" The wisdom of this father's statement cannot be lost on us as we work with families of children with neurodevelopmental disorders. Families frequently share, to some degree at least, the problems of their child. Even when they do not, the stress, concern, frustration, and disappointment families routinely feel is often ignored when developing treatment plans for children and adolescents with disorders. These contextual variables also need to be assessed and planned for in effective interventions.

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