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# Luria and Learning: How Neuropsychological Theory Translates into Educational Practice

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*Deconstructing Historical Precedents in Psychological Assessment*

Rooted in the philosophical writings of structuralists like Rene Descartes and functionalists like John Locke, the field of psychology turned to measurement to answer long-held observations and beliefs about constructs such as intelligence and personality as early as the 1800's. It was believed that psychological constructs such as sensation, perception, or affect could be quantified and measured with mathematical precision. With the advent of Galton's psychometrics, Terman's Intelligence Quotient, and Spearman's factor analyses revealing *g*, Western psychology increasingly used nomothetic and quantitative approaches to understand the human experience. As we will argue here, this measurement obsession has undermined the utility of psychological assessment, and assumptions underlying psychological test interpretation need to be reconsidered, or even deconstructed altogether.

As psychological practice evolved, the underlying abilities and skills that comprise the *g* factor were modified, refined, generalized, and ultimately challenged, but it was quantitative psychology that dominated Western psychology for the next 100 years. Until recent times, few challenged this dominant orientation. However, with the advent of brain imaging technology a new ideology and theoretically sound approach to psychological assessment has emerged. This process-oriented approach, while new to Western psychology, was the mainstay of Eastern neuropsychology nearly 50 years ago, with the iconic A. R. Luria prophetically extolling how interpretation of psychological processes, not overt or measurable outcomes, was the key to understanding human brain-behavior relationships.

While "g" is often interpreted as general mental energy or ability, Spearman correctly noted that it was merely a mathematical not a psychological phenomenon. Unfortunately, this quantitative approach is not sensitive to the underlying psychological processes and patterns of performance that have clinical utility (Luria, 1973). Many tasks used to assess global "ability" share little variance among them in the prediction of meaningful outcomes, and are contaminated by prior experience and education (i.e., achievement), so are in part dependent on individual prior learning experiences, sociocultural expectations, and acquired knowledge.

Normative data required for nomothetic interpretation of intelligence measures requires collapsing potentially meaningful individual differences into large heterogeneous samples. Assuming universality rather than individuality of cognitive function, these interpretive approaches persist despite empirical findings attesting to substantial (80-85% of sample) cognitive variability within these large populations, which undermines the predictive validity of global scores (Hale, Fiorello, Kavanagh, Holdnack, & Aloe, 2007). Nomothetic approaches can help determine only if a problem exists – they do little to inform diagnosis or intervention. In other words, nomothetic interpretation approaches may have sensitivity for detecting the existence of a problem, but they lack diagnostic and intervention specificity. Thus, nomothetic assessment approaches to intellectual test interpretation do little to inform educational instruction – they don't tell teachers what to teach, or how to teach, struggling learners in the classroom (Fuchs, Hale, & Kearns, 2011).

Unlike Spearman's global approach which focuses on a child's *level* of performance, idiographic interpretation approaches championed by A. R. Luria focus on *patterns* of processing strengths and weaknesses from a neuropsychological perspective. Fostered by advances in neuroimaging, idiographic assessment advocates note that interpretive accuracy can only come from inferences regarding *psychological processes*, and greater specificity than stimulus *input* and response *output* traditionally recognized by nomethically-driven psychometric approaches to interpretation. When assessing children who manifest atypical behavior and cognition, it is crucial to examine the unique processing demands that explain performance variations demonstrated across different measures (Fiorello, Hale, Snyder, & Teodori, 2008; Hale, Wycoff, & Fiorello, 2010).

As any teacher knows, there are multiple ways to approach any given cognitive or academic task, leading to tremendous variability in interpretive outcomes across children. When looking at a "problematic" subtest score, practitioners must not only focus on the affected cognitive processes, but they must also examine processes allowing compensation for these deficits, a finding now regularly supported by neuroimaging studies of children with disabilities (Fiorello, Hale, Decker, & Coleman, 2009). As A. R. Luria (1973) suggests, considering *how* a child approaches a task, and adapts to task demands within and across measures, we need to think about *dynamic* interpretation of a child's unique cognitive processing *states* within a developmental context, and not make the mistake of thinking we are measuring static underlying *traits* that will remain stable. This is why repeated measurement across time is essential practice when conducting psychological evaluations, to ensure accurate interpretation of both psychological process and product. This deconstruction of traditional nomothetic, quantitative approaches to test interpretation is critical if our results are to have diagnostic specificity and treatment validity for children struggling in classrooms.

### *Specific Learning Disabilities: Rethinking Paradigms and the "Third Method"*

Vague educational definitions of childhood disorders such as specific learning disabilities (SLD) essentially require practitioners to make dichotomous level of performance interpretations of data (e.g., disabled/non-disabled). This explains why psychologists' roles have traditionally focused on identification purposes, and their assessments do little to inform intervention. Not only does this ineffectual practice undermine practitioner efforts at idiographic interpretation of assessment results, it also leads to vague classification categories that lack specificity for diagnosis and intervention.

The dramatic increase in the SLD prevalence in the last quarter century is thought to be partially due to great variability in SLD definition and identification practices (Hale, Wycoff, & Fiorello, 2010). The ability-achievement discrepancy model has been the dominant method for legally classifying children as having a SLD for over 30 years. A growing body of evidence suggests that the discrepancy model is neither a useful nor valid tool in SLD identification (Fletcher et al., 2002; Hale et al., 2010). Applying a uniform discrepancy approach to all children struggling in school fails to account for developmental differences in cognition and achievement, and does little to discriminate between children with SLD and low achievement. Using global intellectual/cognitive scores for discrepancy criteria essentially ignores the profile variability inherent in children with SLD. Not only does this variability potentially explain the *processing deficit* that is causing the SLD, but it also explains why subtests account for more achievement variance than factor scores, with the least amount of variance explained by global IQ (Hale et al., 2008; Hale et al., 2010b). Thus, the ability-achievement discrepancy model fails to provide a direct link between eligibility criteria, assessment results, and subsequent individualized interventions, resulting in lifelong achievement deficits with minimal documented improvement (Hale et al., 2010b).

An alternative model for identifying and serving children with learning problems, called response-to-intervention or instruction (RTI) views learning problems as socially-constructed phenomena external to the child (Ysseldyke, 2009). Rather than focusing on summative intelligence test scores for identification of SLD, RTI adopts a more outcome-based approach, executed through ongoing formative assessments of academic achievement and regular progress monitoring of response. The RTI approach suggests that struggling students who are unresponsive to empirically validated interventions should be considered eligible for special education services under the SLD category (Burns & Vanderheyden, 2006). Although RTI is useful in providing early intervention services in an attempt to prevent disability, determining reliable responsiveness has not been achieved (e.g. Barth et al., 2005; Brown-Waesche, Schnatschneidedr, Maner, Ahmed, & Wagner, 2011; Fuchs, Fuchs, & Compton, 2004; Speece, 2005) because there is no *true positive* in an RTI model – you don't know what the child has, only that they didn't respond (Hale et al., 2010b). Therefore, inferring SLD from a failure to respond to intervention is not a clinically or scientifically valid method for identification (Hale et al., 2010).

More individualized and comprehensive evaluations using cognitive and neuropsychological measures should be taken for children who do not respond to RTI, according to both the Individuals with Disabilities Education Act (IDEA) and U. S. Supreme Court rulings (Dixon, Eusebio, Turton, Wright, & Hale, 2011). This will ensure accurate differential diagnosis of SLD, and ultimately information to help educators develop more effective classroom interventions (Hale et al., 2008; Hale et al., 2010b). Reflecting this growing concern for using discrepancy and RTI for SLD identification, a panel of 58 experts in education, psychology, medicine, and law commissioned by the Learning Disabilities Association of America produced a white paper that affirmed that children with SLD have a disorder in the *basic psychological processes* that adversely affects academic achievement, and that comprehensive evaluations using cognitive and neuropsychological measures were necessary to identify these processes and guide academic intervention (Hale et al., 2010a).

Given the limitations of the traditional ability-achievement discrepancy and RTI models for SLD identification, the Office of Special Education and Rehabilitative Services (OSERS) incorporated what has been called the "third method" or "processing strengths and weaknesses" approach for determining SLD in their final IDEA regulations (Hale et al., 2010b). Unlike discrepancy and RTI models, the third method approach addresses regulatory and statutory SLD identification requirements through identification of academic achievement deficits associated with cognitive and/or neuropsychological processing patterns (Hale, Flanagan, & Naglieri, 2008; Hale et al., 2010a). To adopt a third method approach, however, practitioners must understand *psychological processes*. However, to understand psychological processes, we argue here that neuropsychological theory and practices provide the foundation for interpretation, with arguments based primarily based on the works of A. R. Luria (1973), E. Goldberg (2001), and J. B. Hale and C. A. Fiorello (2004).

### *School Neuropsychology in Assessment and Intervention*

Nomothetic approaches to interpretation are limited because most children have cognitive processing strengths and weaknesses, suggesting cognitive diversity is the norm rather than the exception, and that profile variability in and of itself is not diagnostic (Hale et al., 2007). However, some children with variable test profiles have disabilities requiring individualized intervention. While psychometric theories such as Cattell-Horn-Carroll Theory provide a strong foundation for understanding the cognitive processing components involved in learning and identification of SLD (see Flanagan, Fiorello, & Ortiz, 2010), a neuropsychological approach recognizes and investigates individual differences found on subcomponent measures, and is thus an essential part of assessment in children (Fiorello et al., 2008; Hale et al., 2010b).

Neuropsychological approaches to interpretation examine the relationship between the brain and behavior from an idiographic perspective in a data-driven, empirically-supported, and clinically sensitive manner. Unlike psychometric approaches, the focus is on the child's unique processing characteristics inferred from patterns of performance within and across cognitive and neuropsychological tests. This approach not only identifies whether there is a problem (i.e., sensitivity), but it also promotes *specificity* for differential diagnosis. Not only does this help recognize the unique characteristics of identified children, but it also fosters teacher insight into individual differences among children and provides useful information to guide targeted interventions for affected children.

*Neuropsychological Approaches to Cognitive Processing*

Considered by many to be the founder of modern Neuropsychology, A.R. Luria provided the foundation for conceptualizing the processes underlying cognitive strengths and weaknesses. Luria (1973) argued in his three Laws of Functional Organization that:

1. The brain is hierarchically organized from basic input (primary cortical) areas to increasingly complex regions (secondary and tertiary cortical) areas, with the tertiary areas being most complex;
2. The specificity of neural tissue diminishes from simple input in the basic zones (very specific and one mode of processing) to increasingly complex integration of information in the tertiary zones (not specific and multimodal processing); and
3. The lateralization (left/right hemisphere) of specific processing demands becomes increasingly differentiated as one goes up the hierarchy, from basic and specific cell functions to complex hemisphere-specific systems.

Luria proposed the brain be conceptually separated into three different functional units. The first unit, composed of reticular and other subcortical structures, regulates states of cortical alertness, and allows the brain to be ready to process incoming information and act on the environment. The second unit receives, stores, and analyzes information, and includes the posterior occipital, parietal, and temporal areas which process visual, somatosensory, and auditory information respectively. Information is interpreted in the second unit in the occipital-temporal-parietal convergence zone. Aptly named the "zones of overlapping", information from different sensory modalities is integrated here, allowing the highest levels of understanding to take place. Luria's third functional unit acts upon information, governs all brain activity, and monitors higher-level mental functions. This "superstructure" unit involves the anterior frontal cortex and supporting structures (e.g. frontal-subcortical circuits), where top-down executive control of all brain functions takes place.

Building upon Luria's theories, Hale and Fiorello (2004) provided the Cognitive Hypothesis Testing Model (CHT) using neuropsychological theory to guide interpretation of cognitive and neuropsychological test results. Expanded upon by Hale et al. (2009), this model posits three *axes* of clinical interpretation to aid in the integration of cognitive and neuropsychological data for both assessment and intervention purposes (see Figure 1). They are called "axes" of interpretation because they are interrelated systems that influence each other. As Goldberg (2001) notes, it isn't important to localize function, but instead think of a continuum or gradiential approach for interpretation. The question therefore isn't about which structures are involved, but instead *how much* one structure is involved over another.

The *posterior-anterior axis* receives, analyzes and stores information in the posterior of the brain, and then acts on this information using the prefrontal and motor regions. Incoming information is integrated in the highly interconnected association cortex (Luria's *Zones of Overlapping*) where the highest forms of comprehension take place. Information is forwarded to the anterior prefrontal brain regions (Luria's *Superstructure*) where it is coordinated, managed, and used to inform action. A useful and typical pattern is the finding that most SLDs are related to the second functional unit (i.e., Zones of Overlapping), while most psychopathologies are related to the third functional unit (i.e., Superstructure).

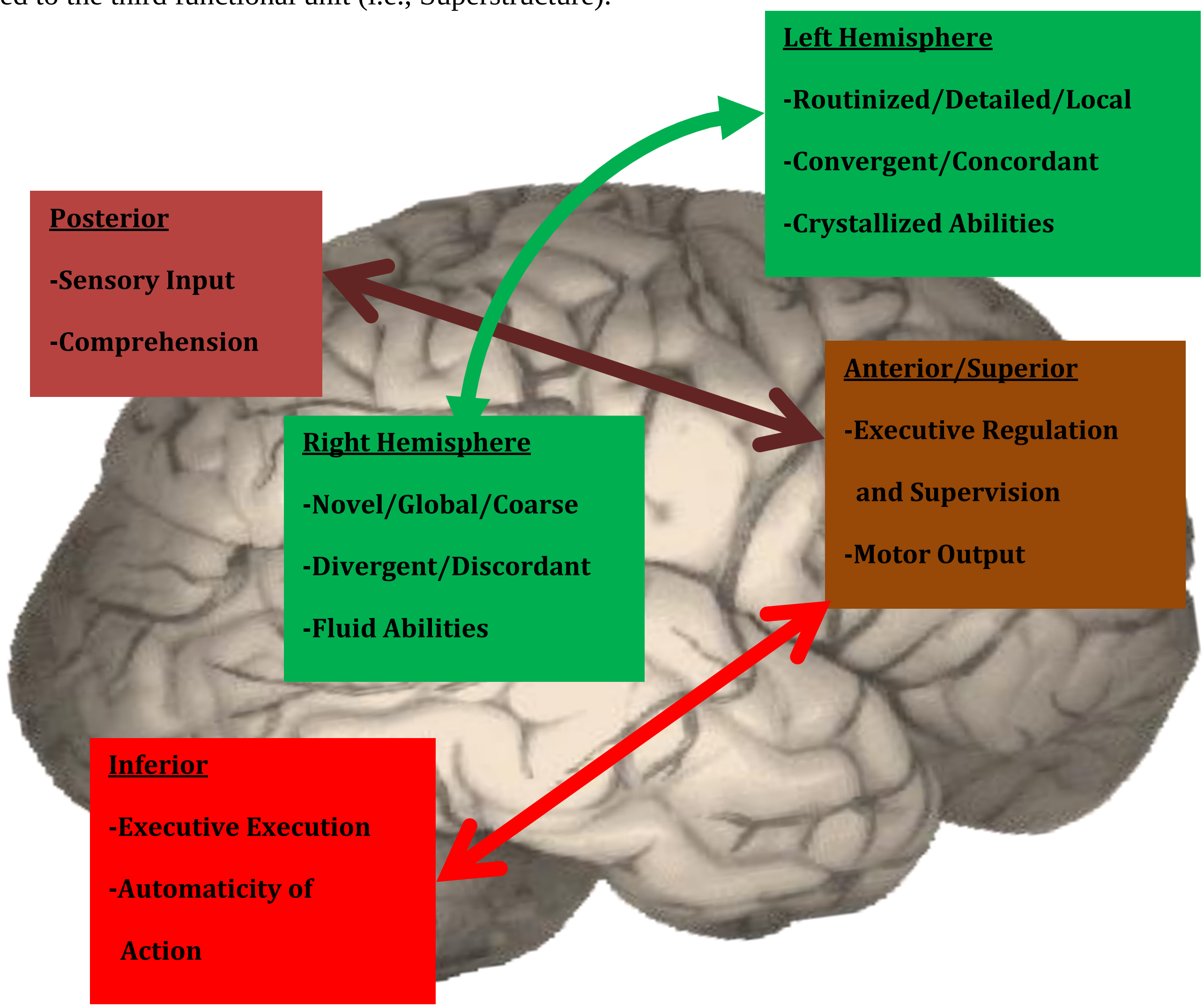


*Figure 1.* The Hale and Fiorello three axes approach to neuropsychological interpretation.

The *left-right axis* represents the functions of the left and right hemispheres. The traditional dichotomy of hemispheric specialization in differentiated forms of processing has been re-evaluated in the presence of neuroimaging studies that establish the intricacies of hemispheric divisions of labour (Tulving, Kapurt,Craik, Moscovitch, & Houle., 1994). Old ways of conceptualizing hemispheric function (e.g., left-verbal, right-nonverbal) have been replaced with current conceptualizations, where hemispheric asymmetries appear to be process specific, not stimulus specific (Reynolds, Kamphaus, Rosenthal, & Hiemenz, 1997). The currently accepted division establishes the right hemisphere as being involved in novel, discordant, divergent, global forms of processing, resulting in fluid abilities for novel problem solving and new learning, while the left hemisphere processes routinized, concordant, convergent, detailed, and specific information resulting in crystallized knowledge (Goldberg, 2001; Hale & Fiorello, 2004). For instance, the left hemisphere specializes in common, straightforward, explicit language, while the right is called upon for implicit language, such as indirect meanings, metaphors, humor, idioms, and sarcasm (Bryan & Hale, 2001).

The *superior-inferior axis* of interpretation allows practitioners to interpret top (prefrontal) and bottom (subcortical) structure-function relationships. This axis is critical for regulation of brain function, with superior structures important for executive regulation and supervision of ongoing brain activity, and inferior structures important for executive efficiency and precision of action. Most of our psychopathologies are related to this axis, with neuroimaging evidence supporting poor superior-inferior functioning in disorders such as ADHD, depression, anxiety, and autism. However, some children with SLD can have problems with the axis, including reading, math, and writing subtypes, so the earlier dichotomy suggested – that the Zones of Overlapping are the source of SLD and the executive Superstructure is responsible for psychopathology is an oversimplification requiring more careful examination here, and in clinical practice.

Table 1 presents the various neuropsychological constructs associated with academic domains. Clearly, competence in reading, math, and writing require multiple brain structures and functions. A careful examination of the neuropsychology of these disorders, based on results of both neuropsychological test and neuroimaging studies (see Berninger & Richards, 2002; Fiorello et al., 2009; Hale et al., 2009; Hale & Fiorello, 2004), suggests dysfunction in one or more of the three axes can explain the type of SLD or other disorder a child is experiencing, and whether comorbid conditions can be explained by this dysfunction. For instance, poor working memory due to prefrontal dysfunction in depression can lead to reading comprehension problems. However, it is important to recognize that these psychological processes are interrelated, so pinpointing the exact cause for a SLD or other disorder requires a systemic approach and careful analyses of the cognitive, neuropsychological, academic, and behavioral data. It is only through careful CHT analyses that the child's pattern of performance, and associated characteristics, can be revealed.

Table 1
*Major Cortical Brain Regions Typically Associated with Academic Competence*

| Brain Region | Word Reading, Fluency, Comprehension | Mathematics Calculation and Word Problems | Written Expression and Spelling |
|---|---|---|---|
| Occipital Striate – Extrastriate | Orthography | Orthography | Orthography<br>Visualization |
| Superior Temporal | Phonology | Phonology | Phonology |
| Inferior Temporal | Sight Words<br>Rapid Naming<br>Fluency | Sight Words<br>(Reading Word Problems) | Sight Word Generation |
| Middle Temporal | Lexical-Semantic Knowledge | Math Fact Knowledge<br>Algorithm Knowledge | Lexical-Semantic for Idea Generation |
| Wernicke's Area | Comprehension | Comprehension | Comprehension |
| Somatosensory Parietal | | Touch for Writing<br>Kinesthetic Feedback | Touch for Writing<br>Kinesthetic Feedback |
| Parietal Zones of Overlapping | Alphabetic Principle (Sound-Symbol)<br>Letter Orientation | Number-Quantity Association<br>Spatial Alignment | Alphabetic Principle (Sound-Symbol)<br>Letter Orientation |
| Dorsolateral | Working Memory<br>Encoding/Retrieval | Working Memory<br>Encoding/Retrieval<br>Sequential Processing<br>Problem Solving<br>Fluid Reasoning | Planning<br>Organization<br>Retrieval<br>Ideational Flexibility<br>Evaluation<br>Revision |
| Cingulate | Rapid Naming<br>Fluency | Math Fact Automaticity | Integration of Process and Knowledge |
| Broca's Area/Exner's Area | Oral Expression<br>Articulation<br>Grammar/Syntax | Oral Expression<br>Grammar/Syntax<br>(Word Problems) | Written Expression<br>Grammar/Syntax |
| Occulomotor | Visual Tracking | Visual Tracking | Visual Tracking<br>Visual Proofing |
| Motor | | Praxis for Handwriting | Praxis for Handwriting |

*Hemispheric Functions and Academic Achievement*

When acquiring a new academic skill, the frontal lobes and right hemisphere are highly involved, with executive functions working with right hemisphere functions to determine what is novel and what is known about a given academic task. The goal during learning is to shift the novel content from right frontal to left posterior regions for proficient performance, consistent with neuroimaging findings for novices and experts (Goldberg, 2001; Hale & Fiorello, 2004). As subject matter becomes well-known, the majority of processing shifts to the left hemisphere for long-term storage of automatized information and skills. When these automatized skills are later recruited to respond in a setting similar to the initial learning environment, the frontal lobes again become involved in conjunction with the left hemisphere, allowing for the expansion of learned material (e.g., retrieval of information from long-term memory). Finally, when one must think flexibly and adaptively to extend previous knowledge to novel situations or incorporate new knowledge into existing schemas, the right hemisphere once again becomes involved. This activation occurs under the direction of the frontal lobes, allowing one to capitalize on prior knowledge and learned skills. Overall, academic competency requires good executive skills and hemispheric cooperation to allow for seamless and efficient learning and application of knowledge (Hale et al., 2008).

For example, as is the case in early stages of learning any novel task, the right hemisphere is activated when children are learning the sound-symbol associations necessary for word reading. As a child starts to master these associations, activity becomes more dominant in the left hemisphere where routinized behaviors are processed (Goldberg, 2001; Shaywitz, 2003; Temple, 2003). Children who have trouble creating these associations rely heavily on right hemisphere processing for holistic and novel processing of stimuli (Ramus, 2004). Reading in these children is less automatized, thus they show substantial trouble with automatic word recognition. They also use Broca's area to help with word attack skills through articulatory mechanisms. As reading becomes more efficient (e.g., left hemisphere predominance), fMRI activation in the right hemisphere and Broca's area declines (e.g., Simos et al., 2007).

This is because the left hemisphere is a specialist in processing of automatic, routinized information (Goldberg, 2001; Bryan & Hale, 2001), so it especially important for achievement or crystallized abilities. The left hemisphere shows activation when proficient readers perform routinized tasks like remembering word meanings or recalling the sound associated with a written symbol (letters). Children with reading disabilities do not show the activation of the left posterior hemisphere typical of proficient readers (Temple, 2003; Shaywitz et al., 2004). Indeed, the left hemisphere is vitally involved in many aspects of reading, including decoding, word recognition, lexical-semantic processing, and receptive and expressive language (Fiorello et al., 2006; Hale et al., 2008; Daelaar, Veltman, Rombouts, Raaijmakers, & Jonker, 2003). However, it is imperative to remember that reading tasks involve both hemispheres, to varying degrees. While the left hemisphere is more likely to be involved in reading that engages well-known, uncomplicated syntax and familiar language, the right hemisphere becomes involved when content becomes difficult, novel, or ambiguous (Bryan & Hale, 2001; Fiorello et al., 2009; Hale & Fiorello, 2004).

### *Integrating Neuropsychological Principles in Current Assessment and Intervention Practices*

As discussed earlier, the best of both worlds for assessment and intervention rests in individualized assessment and intervention using a variety of data sources, and both nomothetic and idiographic interpretation of the data. With a nuanced appreciation of brain-behavior relationships, both on standardized norm-referenced tests and classroom performance, practitioners will have skill at making assessment results meaningful for intervention, especially if they adopt a Cognitive Hypothesis Testing approach. If a balanced practice approach is adopted (see Hale, 2006), RTI can be combined with comprehensive evaluation for nonresponders. The lack of response in RTI only identifies those in need of individualized neuropsychological assessment; it is the neuropsychological evaluation that determines the specific type of disorder interfering with academic achievement and/or behavior. This combined approach allows practitioners to manage a large number of children with academic difficulty, while providing individualized assessment and intervention when needed for nonresponders. Identifying the pattern of processing through neuropsychological assessment not only makes empirical sense, it also addresses the fact that children's academic difficulties may stem from specific developmental deficits, rather than developmental delays (Hale et al., 2010a).

Using a cognitive/neuropsychological strengths and weaknesses processing approach through individualized comprehensive evaluation ensures only true positives for a disorder will be identified, and embraces the well-established link between cognitive processing and academic achievement. For example, to accurately identify a SLD, processing weaknesses should be associated with achievement deficits, and these difficulties should be found in the presence of processing strengths for children to meet the statutory and regulatory criteria for this disorder (Berninger & Richards, 2002; Decker, 2008; Dixon et al., 2011; Flanagan et al., 2010; Fiorello et al., 2006; Hale, Kaufman, Naglieri, & Kavale, 2006; Hale et al., 2010a, 2010b; Mather & Gregg, 2006; Semrud-Clikeman, 2005; Wodrich, Spencer, & Daley, 2006).

Hale & Fiorello's (2004) Concordance-Discordance Model (C-DM) offers a SLD identification method grounded in neuropsychology that follows the principles of CHT. Individual assessments are conducted with standardized cognitive and achievement measures to establish the presence of: a cognitive strength(s), a cognitive weakness(es), and an achievement deficit(s) (Hale & Fiorello , 2004). The null hypothesis that there is no cognitive processing weakness associated with the achievement deficit, or that there are no cognitive strengths relative to the cognitive weaknesses, is tested using the relatively straight forward standard error of difference formula (SED; Anastasi & Urbina, 1997) with practitioners determining whether to use 95% or 99% confidence in decision making. When combined with RTI, the C-DM approach to identifying cognitive weaknesses in the presence of cognitive integrities results in fewer children identified with SLD (Hale et al.., 2010b). This C-DM approach has been adapted in modern achievement measures such as the WIAT-III, where it is termed a Processing Strengths and Weaknesses model. To implement a C-DM method for identifying SLD, please see the step-by-step process in Hale, Wycoff, and Fiorello (2010b).

Idiographic analysis of cognitive and neuropsychological assessment data not only leads to more accurate diagnostic decision making, but it can be used to inform intervention as well (e.g., Dixon et al., 2011; Fiorello et al., 2009; Hale et al., 2010a, 2010b; Miller, et al., 2008). CHT intervention methods are supported by recent neuroimaging and neuropsychological research showing that children with SLD and other psychopathologies use different brain areas than typical children to complete cognitive and academic tasks (Berninger & Richards, 2002; Hale et al., 2008; Simos et al., 2007). Interestingly, children who respond to intervention display normalization of brain function on neuropsychological and neuroimaging measures (Berninger & Richards, 2002; Coch, Dawson, & Fischer, 2007; Simos et al., 2007). It is only a matter of time before these technologies become prevalent and cost effective, and it is predicted that we will one day be using neuroimaging to determine RTI.

## Conclusion

The cognitive processes underlying academic skills such as reading, mathematics, and writing are complex, and intertwined with psychosocial functioning. Thus, reductionistic approaches to assessment, instruction, and intervention often prove unsuccessful for young learners who do not respond to intervention. Assessment models must be sensitive and specific enough to account for the diversity of processing assets and deficits that lead to academic achievement and psychosocial problems within the context of normative levels of achievement for any given developmental stage. When standard instructional techniques are unsuccessful in helping struggling learners, differentiated and individualized instruction should take place, informed by neuropsychological theories and practices. In this chapter we propose that combining current preventative models (e.g., RTI) with comprehensive evaluation of cognitive and neuropsychological processes will meet the academic and behavioral needs of all children. As Bandura's (1978) Reciprocal Determinism model told us long ago, effective practice requires an understanding of cognition, behavior, and environmental interactions. As neuropsychological theory, research, and practices have emerged to affirm the value of A.R. Luria's (1973) seminal idiographic position, they are now being incorporated into classroom instruction and intervention, which we believe represents the future of education.

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