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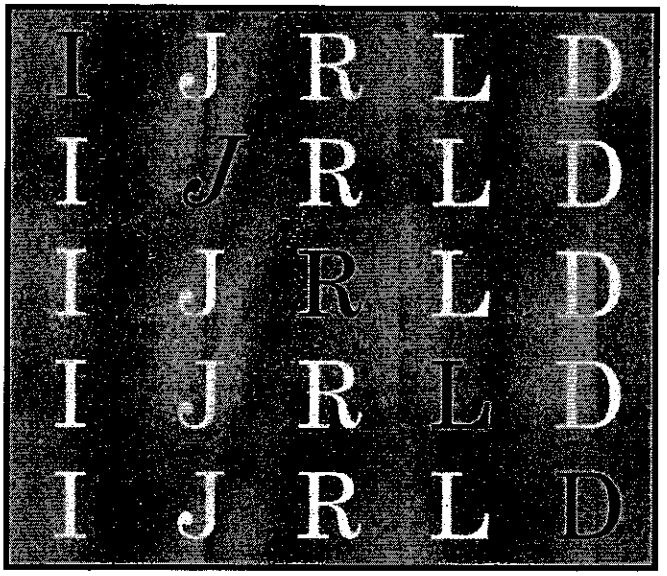

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William M. Cruickshank Memorial Lecture Delivered at the 2013 Conference of the International Academy for Research in Learning Disabilities

Specific Learning Disabilities in DSM-5: Are the changes for better or worse?[1]

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Abstract

DSM-5, the fifth edition of the American Psychiatric Association's *Diagnostic and Statistical Manual of Mental Disorders*, was published in May 2013, amidst a storm of controversy. This article focuses on changes made to the diagnostic criteria for Specific Learning Disorders (SLD). Primary criticisms of the changes in the SLD concern the aggregation of the DSM-IV subtypes into one overarching category, the failure to codify Dyslexia as a distinct type of SLD, and the inclusion of response to intervention as one component of the criteria. This article first summarizes the historical perspectives on SLD. Next, the changes made to the diagnostic criteria are presented, followed by a discussion of the rationale and evidence on which the changes were based. It concludes with a discussion of the possible impact on clinical practice, research and policy.

[1] This invited peer-reviewed article is based on the Cruickshank Memorial Lecture presented by Dr. Tannock at The International Academy for Research on Learning Disabilities, Boston, May 2013. From 2007 to 2013, Dr. Tannock was a member of the DSM-5 Work Group for ADHD and Disruptive Behavior Disorders and a liaison member of the Neurodevelopmental Disorders Work Group to advise on Learning Disabilities. She received funding from the Canada Research Chairs Program to partially support the research for this article.

"You could think of it as the book of our woes."

(Gary Greenberg: *The* **Book of Woe**: *The DSM and the Unmaking of Psychiatry*, 2013)

The DSM-5 is the fifth edition of the *Diagnostic and Statistical Manual of Mental Disorders* published by the American Psychiatric Association (APA, May, 2013). As with the previous versions, this new volume has received strong criticism from the public, individuals with LD and their families, policy makers, and from clinicians and researchers in the field of mental health. One explanation for the storm of controversy it spawned is the magnitude of its potential impact. Created initially to provide a common language about mental disorders for clinicians, the DSM is now used in the United States and other countries as a universal authority for the diagnosis of mental disorders: what constitutes a mental disorder, how mental disorders are to be conceptualized, and their diagnostic criteria. Thus, the DSM has a broad influence not only on the diagnosis of mental disorders, but also how they are perceived by the public, healthcare personnel, employers, and those in the school and judicial systems; how they are funded by medical insurance agencies; how research agendas are set; and how the public policy for mental health is maintained or changed.

Each new version of the DSM has received strong criticism, including the ongoing concern that each version continues to reify the concept of 'discrete disorders' of the mind, based on various sets of observable signs and symptoms, rather than on specific biological tests or atypical patterns of brain-based states (e.g., Casey et al., 2013; Francis & Nardo, 2013). Notably, each one of these purportedly discrete mental disorders shows marked heterogeneity and high rates of comorbidity (co-occurring disorders in one individual). The DSM-5 presented an opportunity to tackle these overarching concerns, and give careful consideration to the current boundaries drawn between various disorders and their subtypes. Accordingly, sets of guiding principles for making changes to the previous version (DSM-IV-TR) were compiled (e.g., Kendler et al., 2009; Regier, Kuhl, Narrow, & Kupfer, 2010). These guiding principles, as well as the administrative structure and procedures of the DSM-5, have been described elsewhere (e.g., Regier, Kuhl, & Kupfer, 2013; Tannock, 2013). Here, I summarize a few key guidelines and procedures that were particularly pertinent to the conceptualization and diagnosis of Learning Disabilities (LD).[2]

One guiding principle was to be mindful that the DSM is a medical manual designed primarily to be an evidence-based tool to guide clinicians in assessment and diagnosis of mental disorders. This principle was supported by the establishment of an external Scientific Review Committee (SRC), which provided external review of all proposals for diagnostic change (Kendler, 2013). Proposals were reviewed and scored independently by at least two SRC members, using a 6-point scale to evaluate their level of empirical support (Kendler,

[2] The term 'Learning Disabilities' will be used throughout this article, consistent with terminology used by IARLD, rather than the DSM-5 term 'Specific Learning Disorder.' The exception is when referring specifically to the condition as defined by DSM-5. Note that medical conditions are called disorders rather than disabilities: 'Learning Disabilities' is an educational term.

2013).[3] Three clusters of validating evidence were considered (antecedent, concurrent, predictive), as outlined by Robins and Guze (1970). Major changes needed stronger empirical justification in three specified validator categories that include: familial/genetic (antecedent); cognitive and biological factors, comorbidity (concurrent); diagnostic stability, course of illness, and response to treatment (predictive). Thus changes made to the diagnostic criteria for SLD were based on a comprehensive review of empirical and clinical evidence available at the time.

Other guiding principles were the requirements to balance scientific evidence and clinical utility, take a lifespan perspective (developmental continuities/discontinuities), and consider international compatibility and cultural influences on the expression and interpretation of mental disorders, as well as changes that facilitate harmonization of DSM with the International Classification of Diseases (ICD) and its impending 11th edition (World Health Organization, 1992).[4] This meant that the criteria for SLD needed to consider developmental changes in the manifestation of SLD across the lifespan as well as being culturally sensitive and relevant for countries other than the USA or other English-speaking countries, with diverse languages and symbolic systems (transparent versus deep orthography; alphabetic versus nonalphabetic symbol systems; numeral and counting systems). Moreover, since scientific knowledge had not yet advanced enough to use neuroscience and genetics to shape the conceptualization of mental disorders in DSM-5, the diagnostic criteria were to remain as behavioral descriptors.

The DSM-5 Manual advises that the diagnostic criteria "are offered as guidelines for making diagnoses, and their use should be informed by clinical judgment" (APA 2013, p.21). Each chapter has a section, called "Diagnostic Features", designed to help support diagnosis by providing more detailed explanation and discussion of the diagnostic criteria and associated features supporting a diagnosis, along with information about prevalence, developmental course, risk and prognostic factors, culture- and gender-related diagnostic issues, functional consequences of the disorder, differential diagnosis, and comorbidity.

The DSM-IV category of *Learning Disorders* is one of many disorders that underwent major changes in DSM-5 and which unleashed a flood of multi-media protestations, as well as international scientific commentary (e.g., Cavendish, 2013; Scanlon, 2013; Al-Yagon et al., 2013). Before discussing the DSM-5 changes to this diagnostic category, a digression is necessary to set the broader landscape of challenges in the field of

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[3] Scoring: 1= strong support; 2 = moderate support (acceptable); 3 = modest support (questionable); 4= limited support (probably not justified); 5 = poor support (do not include); and 6= insufficient data

[4] The World Health Organization (WHO) publishes a manual, the International Classification of Diseases (ICD), that lists specific diagnostic criteria for all medical illnesses, including mental disorders. Each country may publish its own diagnostic manual based on the ICD provided it does not change its intent and must update it in accordance with ICD updates. In the USA, the American Psychiatric Association (APA) was assigned responsibility for updating components related to mental disorders. Thus DSM-IV was based on ICD-9 and DSM-5 was based on ICD-10 but with cognizance of the impending ICD-11.

Learning Disabilities (LD), which faced the Work Group responsible for proposing any changes to its conceptualization or diagnostic criteria in DSM-IV.

Historical Conceptualization and Definition of LD

The field lacks a complete understanding of LD: instead there are burgeoning descriptions, guises, guesses, hypotheses, and controversies. To date, there is no international consensus as to what constitutes LD, its operational definition (diagnostic criteria), or who can or cannot conduct the required assessment or make the diagnosis.

Thus, prior to and throughout the decade-long making of the DSM-5, the field of LD faced substantial challenges at many levels: conceptual (e.g., What constitutes LD?); operational (e.g., How do we define who does and does not have LD?); political (e.g., Who has or should have ownership or responsibility for defining and treating LD? What are the socio-economic costs of LD? What degree of control should be accorded to advocacy groups for specific manifestations of LD?); and legal (What are the laws pertaining to LD in the US and other countries? Should federal law dictate who can assess LD, the assessment process, or its diagnostic criteria?). So one key issue is whether the changes wrought in DSM-5 are for better or for worse. What would 'Bill' Cruickshank have to say about DSM-5's conceptualization and definition of LD? The latter question necessitates a brief detour to summarize historical perspectives on LD. The history of LD has been well-documented by others (e.g., Hallahan & Mercer, 2001) and so will be merely summarized herein. Most notable, however, is that these accounts focus primarily on dyslexia or LD in general, with little or no mention of dyscalculia.

Early perspectives of LD shared some commonalities: a) recognition that impaired academic skills (reading, arithmetic) occur in the context of average or even superior intellectual abilities; and b) a focus on impairments in specific component skills (e.g., word reading, calculation) rather than viewing an academic domain as a unitary construct. Other important insights from these early perspectives include the notion that LD (dyslexia) was congenital, heritable, and manifested primarily by males. However, whether or not LD occurred as an isolated domain-specific deficit or could also be accompanied by deficits in other academic domains remained controversial, as it does today (e.g., as defined in the ICD taxonomy).

Underlying cognitive deficits (possible causal factors) focused initially on visual problems. For example, Hinshelwood (1917) postulated that the primary disability of children with word blindness was in visual memory for letters and words and that it was an inherited condition. Orton (1925) continued to emphasize visual problems and used the Greek term, strephosymbolia, to capture the frequently observed letter reversal that he attributed to mixed cerebral dominance. The advent of IQ tests (i.e., Standford-Binet, 1916) allowed Orton to directly evaluate the observed difference in a person's academic skills and intellectual ability. However, the notion of a discrepancy between measured IQ and achievement has been attributed to Monroe (1932), who used this criterion to identify

students with reading disabilities. Nonetheless, although Orton (1925), Monroe (1932), Kirk (1976) and others espoused an hypothesis of visually-based deficits and mixed cerebral dominance, they focused on phonics and sound blending techniques as instructional techniques, thereby paving the way for the prevailing view of reading disabilities as a language-based disorder.

The 1940s constituted the era of the 'brain-damaged child', which incorporated a broader array of cognitive deficits, including perceptual, perceptual-motor, and attention difficulties (e.g., Strauss & Kephart, 1955; Strauss & Lehtinen, 1947). However, it was not until the 1960s that LD emerged as a formal category – a term accredited to Kirk (1962) − and the notion of a discrepancy between IQ and achievement prevailed as a defining feature of LD. Likewise, Cruickshank incorporated the IQ-achievement discrepancy criterion in his definition of LD: "an inherent dysfunction in the learning process which is manifested in deficiencies in one or more academic skill subjects, language or communication problems and/or social adaptation problems," but also that was characterized by a "significant discrepancy between measured potential and measured performance of both an academic and social nature" (Cruickshank, 1984, p.7). Cruickshank also expanded the concept of LD, defining it as "an inherent dysfunction in the learning process which is manifested in deficiencies in one or more academic skill subjects, language or communication problems and or social/adaptation problems" (Cruickshank, 1984, p.7). He also proposed that these learning difficulties were the result of perceptual as well as linguistic processing deficits.

In the USA, the conceptualization of LD was consolidated in the federal definition (United States Office of Education, 1977) and in the definitions of professional organizations (e.g., National Joint Committee on Learning Disabilities, 1978), and LD achieved official federal status as an eligible category for direct services (Education for All Handicapped Children Act, 1975). According to the U.S. Federal Law (IDEA, 2004, LD is defined as "a disorder in one or more basic psychological processes involved in understanding or using language, spoken or written, that may manifest itself in the imperfect ability to listen, think, speak, read, write, spell, or do arithmetical calculations." Thus the notion of underlying deficits in cognitive processing as causal factors was instantiated in the conceptualization of LD. Moreover, LD was stated to include conditions such as perceptual disabilities, brain-injury, minimal brain dysfunction, dyslexia, and developmental dysphasia (thereby continuing its earlier conceptualizations), but excludes learning problems resulting from visual, hearing, or motor disabilities, mental retardation, emotional disturbance, or environmental, cultural or economic disadvantage. Thus this prevailing legal definition restricts the concept of LD to a language-based disorder, but does not include non-language-based learning difficulties, such as dyscalculia, as defined by some researchers. In other words, speech and oral language problems are included in the federal LD category (which are coded separately as Communication Disorders in ICD and DSM taxonomies), but neither learning difficulties in a basic sense (a.k.a., dyscalculia) nor motor skills are included. Thus, the federal/legal and medical categories of LD differ in the range of learning difficulties they

encompass as well as in the imputed boundaries between disabilities/disorders. Ongoing concerns about the DSM approach to nosology (e.g., Casey et al., 2013; Greenberg, 2013) have spurred in part a recent initiative by the US National Institute of Mental Health to focus on alterations in the brain and its substrates that might signal the location and source of human mental stresses or woes (RDoC: Research Domain Criteria Project; Cuthbert & Insel, 2013).

What is SLD according to DSM-5?

Many children experience difficulties learning in school, but not all such difficulties constitute SLD, as conceptualized in DSM-5. According to DSM-5, SLD is a type of Neurodevelopmental Disorder that impedes the ability to learn or use specific academic skills, such as reading, writing, or arithmetic, which serve as the foundation for other academic learning. Typically, academic skills do not simply 'emerge' with caregiver support and encouragement, as do talking or walking, but rather must be taught. The learning difficulties are 'unexpected' in that other aspects of development seem to follow a typical trajectory, or are only minimally delayed (e.g., grasping, walking, talking). Early signs of learning difficulties may be discernible in the preschool years (e.g., difficulty learning names of letters or to count objects), but they can only be diagnosed reliably after starting formal education. Within the meta-structure or organizational framework of DSM-5, SLD is located within the first chapter – Neurodevelopmental Disorders – alongside autism spectrum disorder (ASD), attention-deficit/hyperactivity disorder (ADHD), as well as communication disorders, developmental coordination disorder, and intellectual disabilities.

SLD is a clinical diagnosis that is not necessarily synonymous with 'learning disabilities' as identified within the education system: that is, not all children with learning disabilities or difficulties identified by the school system would meet a DSM-5 clinical diagnosis of SLD (although all those with a DSM-5 diagnosis of SLD would be expected to meet the educational definition of learning difficulties/disabilities). The two classification systems differ in their underlying purpose of identification, as well as in frequency, degree, intensity, persistence of symptoms, and impairments. That is, the DSM is a medical manual, designed to provide clear descriptions of and diagnostic criteria for psychiatric disorders to enable clinicians, researchers, and others to communicate about, study and treat people with these disorders, in a reliable manner. Thus, diagnosis does not necessarily dictate the need for intervention. By contrast, in the field of education, eligibility criteria define who needs access to special education and other related resources.

In DSM-5, SLD is understood to be a chronic condition that typically persists into adulthood, albeit with changes in the way the learning difficulties manifest (e.g., read slowly and with effort). In part, this is because adults learn compensatory strategies (e.g., avoid reading by using other media to obtain information or for calculation; use specialized software to assist with reading/writing activities or calculators to assist with numerical activities). Thus the diagnostic criteria for SLD also needed to be relevant for adults with

persisting learning difficulties, but who had never been formally recognized or diagnosed and seek help for their ongoing difficulties as an adult.

The causes of SLD are unknown, but research suggests that learning difficulties run in families, are heritable, and involve interplay of both genetic anomalies and environmental factors (e.g., prematurity, prenatal exposure to neurotoxins from tobacco, alcohol, street drugs, or other environmental toxins). Neither are the underlying mechanisms of SLD known, although both neural and psychological accounts exist, particularly for difficulties learning to decode words (e.g., Soltesz et al., 2013). Neuroimaging studies have revealed alterations in both structure and function, but it is unclear whether these brain differences are a cause, consequence or correlate of SLD (e.g., Butterworth & Kovas, 2013; Grigorenko, 2001). Hence, neuroscientific findings are considered in text discussions that accompany the DSM-5 framework, with the intent to update DSM-5 electronically as new diagnostically useful information from neuroscience or genetics becomes available (Kupfer, Kuhl, & Regier, 2013).

What changed from DSM-IV to DSM-5?

Two major changes were made, each of which contributed to what might appear as multiple changes: 1) one overarching category of learning disabilities (SLD) is defined, which is then characterized more precisely through the use of "specifiers" to provide a comprehensive description of its manifestations in the domains of reading, writing, and arithmetic, as presenting at the time of assessment; and 2) the IQ-achievement discrepancy criterion, which was the primary diagnostic criterion in the previous versions of DSM, was eliminated and is now replaced by four criteria in DSM-5.

Whereas previous versions of DSM differentiated various subtypes of LD (e.g., Reading Disorder, Disorder of Written Expression, Mathematics Disorder), DSM-5 conceptualizes these 'subtypes' as 'specifiers' for various manifestations of a single disorder that renders learning very difficult and effortful, despite at least average intellectual abilities, and which gives rise to marked impairment at home, school, work, and in daily activities. Whereas subtypes define mutually exclusive and jointly exhaustive phenomenological subgroupings, specifiers are not intended to be mutually exclusive or jointly exhaustive, so that more than one specifier may be coded. Specifiers are designed to afford an opportunity to define a more homogeneous subgrouping of individuals with the disorder (in this case, with SLD), who share some key features, and to inform clinical management. Importantly, specifiers refer to the current clinical manifestation at the time of assessment and are not intended to imply a permanent manifestation or condition. Three major specifiers are listed for SLD that are to be coded, each with examples of components that are commonly impaired in learning disabilities:

1. *Specific Learning Disorder With impairment in reading*: word reading accuracy, reading rate or fluency, reading comprehension;

2. *Specific Learning Disorder With impairment in written expression*: spelling accuracy, grammar & punctuation accuracy, clarity or organization of written expression; and
3. *Specific Learning Disorder With impairment in mathematics:* number sense, memorization of math facts, accurate or fluent calculation, accurate math reasoning.

Alternate terms, '*Dyslexia*' or '*Dyscalculia*' may be used as per clinician and client/family preference to specify 'With impairment in reading' or 'With impairment in mathematics', respectively. However, in this scenario, clinicians are advised to list the full range of difficulties that are currently manifest in learning, as well as the term 'dyslexia' or 'dyscalculia'. For example, for a child with marked difficulties in single word reading, spelling and in learning basic number facts, a clinician would code: 315.00 (F81.0) Specific Learning Disorder With Dyslexia (word reading accuracy, reading rate), and 315.2 (F81.1) With impairment in written expression (spelling accuracy), and 315.1 (F81.2) With impairment in mathematics (memorization of math facts).

As noted above, the second major change was to eliminate the DSM-IV requirement for an IQ-Achievement discrepancy as the primary diagnostic criterion for SLD. This former criterion has now been replaced with 4 specific criteria that delineate: A) the key behavioral characteristics of SLD; B) measurement of these characteristics; C) the individual's age at their onset; and D) exclusion criteria.

Criterion A provides a list of 6 typical manifestations of learning difficulties (with examples). One of the following symptoms must be present and persisted for at least 6 months despite the provision of intervention that targets the difficulties: i) inaccurate or slow and effortful word reading; ii) difficulty understanding what is read; iii) spelling difficulties; iv) difficulties with written expression; v) difficulties mastering number sense, number facts, or calculation; or vi) difficulties with mathematical reasoning. Criterion A incorporates the concept of 'response to intervention', but it is not meant to refer to the formal process or documentation as in current use in many state school systems in the USA (e.g., Fuchs & Vaughn, 2012; Mastopieri & Scruggs, 2005). Instead, it requires some evidence derived from the clinical interview and school reports that the learning difficulties persist despite the provision of some form of extra help, support or intervention for those difficulties (e.g., in the case of problems with reading comprehension, some attempt has been made to teach comprehension strategies or to enhance word reading fluency or related language skills that contribute to reading comprehension). The 6-month duration requirement is somewhat arbitrary, but is consistent with operationalization of 'symptom persistence' used for other DSM-5 diagnostic categories (e.g., ADHD, Oppositional Defiant Disorder, Schizophrenia) and is designed to help distinguish atypical from typical learning.

Criterion B requires that the affected academic skills be confirmed and quantified as being below those expected for chronological age (i.e., low academic achievement) and cause significant impairment in academic or occupational performance or in activities of

daily living. This is to be done by means of both clinical assessment and individualized, standardized academic testing. No specific scores are included in this diagnostic criterion, but guiding principles are presented in the section on 'Diagnostic Features' in the accompanying text in DSM-5. One guiding principle advises clinicians to consider both the clinical indicators of learning difficulties (low academic achievement for age or average achievement that is sustainable only with extraordinarily high levels of support or effort) and psychometric evidence from individually administered, psychometrically sound and culturally appropriate, standardized tests of academic achievement. In countries or situations in which standardized tests are not available or relevant, then the clinician needs to review any available documentation of scores or reports. Another guiding principle is for clinicians to keep in mind that academic skills are distributed continuously in the population, so that there is no natural cut-point that can be used to differentiate individuals with and without SLD. Thus any threshold score used to signify low academic achievement is somewhat arbitrary and might vary across tests. A threshold score for low academic achievement is proposed (e.g., at least 1.5 standard deviations below the mean for age, which translates to a standard score ≤ 78, which is below the 7th percentile), but clinicians are advised that clinical judgment might support a more lenient cut-off in some circumstances (e.g., 1.0 to 1.5 standard deviations below the mean for age).

Criterion C specifies the age at onset of the learning difficulties: namely that they begin during the years of formal schooling. However, clinicians are advised that for some individuals, their learning difficulties may not fully manifest until later years (e.g., high school, post-secondary education, adulthood) when the demands for the affected academic skills exceed the individual's limited or compensatory capacities. For instance, demands for timed tests, reading or writing lengthy reports within a tight deadline, or excessively heavy academic or occupational workloads may exceed the individual's coping strategies, especially under situations in which support or accommodations that were provided in earlier years are no longer available.

Criterion D requires evidence that the learning difficulties are 'specific' in that they are not attributable to Intellectual Disabilities, uncorrected auditory or visual acuity deficits, other major psychiatric or neurological disorders, severe psychosocial adversity, lack of proficiency in the language of educational instruction, or absence or inadequacy of educational instruction. The DSM-5 definition of Intellectual Disabilities must be taken into account for the diagnosis of SLD: deficits in both intellectual and adaptive functioning that have an onset during the developmental period. According to DSM-5, individuals with Intellectual Disability have scores of approximately 2 or more standard deviations below the population mean, allowing a margin for measurement error (i.e., on IQ tests with a SD of 15 and a mean of 100, this involves scores at or below 65-75 [70 ± 5].

Also, clinicians are required to specify the current severity of the learning disabilities (mild, moderate, severe). Severity specifiers for SLD are based on an admixture of the range of learning difficulties and the likelihood of gaining proficiency in the academic skills given

specialized teaching, accommodations, or support services (at school, home, or workplace). For example, SLD of 'moderate' severity is described as having marked difficulties learning academic skills in one or more domains, so that some intervals of intensive and specialized teaching (in the school years) and some accommodations or support services (in home, school or work place) are likely to be required to acquire and use the academic skills proficiently. It should be noted that the severity specifiers were developed in response to the APA requirement to develop disorder-specific severity ratings: these severity ratings for SLD have yet to be validated.

What was the rationale and evidence base for these changes?

Rationale and evidence for a single overarching diagnostic category

The decision to define a single overarching diagnostic category, called 'Specific Learning Disorder' with specifiers for its various manifestations, was based on a comprehensive review of the empirical literature (prior to May, 2012) on antecedent, concurrent, and predictive validators.

Most of the evidence for antecedent validators that came from twin and family studies, supported the aggregation of DSM-IV-TR categories into one single category. For instance, although one large-scale family study found evidence of both disorder-specific familial transmission and co-segregation of arithmetic and reading/spelling difficulties (Landerl & Moll, 2010), twin studies consistently find significant genetic and shared environmental overlap amongst reading, mathematics, and written expression disorders (as well as with Attention-Deficit/Hyperactivity Disorder (Willcutt et al., 2010), suggesting that these purportedly distinct Learning Disorders have a common genetic etiology (Hart, Petrill, Thompson, & Plomin, 2009; Haworth et al., 2009; Kovas, Haworth, Dale, & Plomin, 2007; Olson et al., 2013; Willcutt et al., 2010). However, some studies measuring different components of reading, writing, or mathematics, found evidence of some unique genetic influences on math fluency and speeded writing copy (Olson et al., 2013.) Moreover, the review of environmental risk factors revealed robust evidence from meta-analyses, large-scale prospective studies, and systematic reviews, that prematurity or very low birth weight increases the risk for LD across all academic domains in childhood (Aarnouds-Moens, Weisglas-Kuperis, van Goudoever, & Oosterlaan, 2009; Johnson, Wolke, Hennessy, & Marlow, 2011; McGowan, Alderdice, Holmes, & Johnstin, 2011), as does prenatal exposure to nicotine (Anderko, Braun, & Auinger, 2010, Batstra, Hadders-Algra, & Neeleman, 2003;O'Callaghan et al., 2010; Yolton, Dietrich, Auinger, Lanphear, & Hornung, 2005). Similarly, studies of prior psychiatric history also supported one overarching category. For example, developmental history of Communication Disorders (Speech Sound Disorder, Specific Language Impairments, alone or in combination) in preschool years is a common precursor of all three LD categories listed in DSM-IV-TR, but particularly for poor skills in reading comprehension, spelling, arithmetic fact retrieval, and calculation (Anthony et al., 2011; Jordon, Wyllie, & Mulhern, 2010; Lewis et al., 2011). Moreover, one longitudinal

study of a community-based sample of children identified with pervasive speech/language disorders in kindergarten were found to have an estimated 3- to 6-fold greater risk for LD (all categories alone or in combination) in young adulthood compared to typically-developing youngsters (Young et al., 2002).

By contrast to the evidence from studies of antecedent validators, the literature on concurrent validators provided mixed findings with respect to 'lumping' versus 'splitting' LD. On the one hand, high rates of comorbidity amongst the various categories of LD across the lifespan and across divergent cultural/linguistic groups challenge their discreteness (Hart et al., 2009; Katusic, Colligan, Weaver, & Barbaresi, 2009; Kovas, Haworth, Harlaar, et al., 2007). For instance, a US epidemiological study revealed that about 75% of youth with Written Expression Disorder also meet criteria for Reading Disorder, and that about 50% with a Mathematics Disorder have comorbid Reading Disorder (Barbaresi, Katusic, Colligan, Weaver, & Jacobsen, 2005; Katusic et al., 2009). Moreover, most studies found that the academic impairments associated with one of the DSM-IV-TR disorders (e.g., reading disorder) extend far beyond those expected – for example, include deficits in those aspects of mathematics that require manipulation of the verbal code (Boets & De Smedt, 2010; De Smedt & Boets, 2010; Gobel & Snowling, 2010, Raghubar et al., 2009). On the other hand, however, this literature also confirmed that deficits can occur in just one academic domain (e.g., in written language but not in reading, or in math but not in reading (Barbaresi et al., 2005; Davis, Haworth, & Plomin, 2009; Katusic et al., 2009) or even in one academic skill within one academic domain, such as in word identification but not reading comprehension or vice versa (Snowling & Hulme, 2011). Likewise, studies of cognitive factors have provided mixed evidence. Small-scale studies indicate both shared and unique cognitive features amongst the DSM-IV-TR LD categories (Landerl, Fussenegger, Moll, & Willburger, 2009; Schuchardt, Maehler, & Hasselhorn, 2008; van der Sluis, van der Leij, & de Jong, 2005). In contrast, a large scale investigation of cognitive correlates of Reading Disorder in twins concluded that although this type of LD was typically associated with cognitive deficits in the phonological domain, not all of those affected manifest the same pattern or same number of deficits (Pennington et al., 2012). Moreover, findings from various twin studies of ADHD, and LD in Mathematics or in Reading, suggest that the cognitive profiles of these disorders differ only in subtle ways, mainly in terms of severity, and that the comorbidity between these disorders may be due to a common genetic risk factor leading to slow processing speed (Willcutt et al., 2010).

Studies of predictive validators have also provided mixed evidence for 'lumping' versus 'splitting'. On the one hand, there is evidence for the diagnostic stability of the various DSM-IV categories of LD, provided the same definition of LD was used across the various assessment points (Astrom, Wadsworth, & DeFries, 2007; Shalev, Manor, Auerbach, & Gross-Tsur, 1998; Shalev, Manor, & Gross-Tsur, 2005; Wadsworth, DeFries, Olson, & Willcutt, 2007). On the other hand, longitudinal studies provide strong evidence of a developmental accumulation of learning difficulties with increasing cognitive demands of the

curriculum. For instance, children with speech sound disorders in early childhood, later manifest difficulties learning to read, spell, and write in the school years (Lewis et al., 2011). Also, over 50% of children with phonologically-based reading difficulties but no apparent difficulties in learning basic arithmetic at age 5 years, manifest learning difficulties in mathematics as well as continued problems in reading at age 7 (Jordon et al., 2010). However, intervention outcome studies provide no evidence that intervention for one academic domain or its subskills transfers to other academic domains. In other words, the different subtypes of LD recognized by DSM-IV require and respond to different interventions (Lovett, Steinbach, & Frijters, 2000; Morris et al., 2010; Solis et al., 2012; Wilson, Revkin, Cohen, Cohen, & Dehaene, 2006).

In summary, the literature provided stronger support for "lumping" (cluster all manifestations of LD across the academic domains of reading, writing, arithmetic, under one diagnostic category with specifiers for current presentations) than for "splitting" (retain or expand the DSM-IV subtypes). Accordingly, to balance scientific integrity with clinical utility, the DSM-5 Work Group recommended (and the SRC approved) that the various types of DSM-IV-TR LD should be subsumed under a single category, and that the developmental distinctions and continuities amongst the DSM-IV-TR categories should be preserved by marking them as 'current presentation' using *specifiers* to code the various manifestations at the time of assessment. The Work Group had also considered the inclusion of an additional presentation of SLD – namely that of the purported 'non-verbal LD', but we concurred with the conclusion of a recent review of this entity, "there is little evidence to support its use in clinical practice (Spreen, 2011). This conclusion was based on the lack of reliable data on the prevalence of non-verbal LD and on its purported socio-emotional and neurological basis. Moreover, its diagnostic reliability, coverage, descriptive validity, and predictive validity have yet to be tested.

Rationale and evidence for eliminating the IQ-Achievement discrepancy criterion

The primary diagnostic criterion specified for each of the DSM-IV subtypes of LD was the requirement for a substantial discrepancy between IQ and academic achievement. The logic behind the IQ-discrepancy definition is that the cause of the learning difficulties would differ between those with and without IQ-achievement discrepancy. Thus, we sought evidence to support or refute the notion that individuals with learning difficulties with and without an IQ-achievement discrepancy differ in clinically meaningful ways (i.e., in antecedent, concurrent, and predictive validators).

The research indicates that poor readers of at least average intelligence (e.g., IQ $\geq$ 80) with and without an IQ-achievement discrepancy do not differ reliably in clinically meaningful ways. For example, in terms of antecedent validators, the single available study that compared the effects of different diagnostic criteria on familial aggregation of SLD in spelling found no evidence that the diagnostic criteria (regression-based IQ-achievement discrepancy v. low achievement) had any influence on the rate of family member affectedness (Schulte-Korne, Deimal, Müller, Gutenbrunner, & Remschmidt, 1996). By

contrast to the limited evidence for antecedent validators, numerous studies (e.g., Fletcher, Denton, & Francis, 2005; Francis et al., 2005; Siegel, 1992) and meta-analyses (Hoskyn, 2000; Maehler & Schuchardt, 2009; Stuebing et al., 2002) have been conducted to test for differences between discrepant and non-discrepant groups of children with LD in terms of cognitive processes that contribute to learning. Findings are consistent: the two groups do not differ in their cognitive processing skills. However, a recent and innovative taxometric analysis of cognitive processes in individuals with DSM-IV Reading Disorder did find some differences between discrepant and non-discrepant readers (O'Brien, Wolf, & Lovett, 2012). Yet, a recent neuroimaging study failed to find any differences in brain activation patterns in discrepant and non-discrepant readers: both groups showed the characteristic pattern of reduced brain activation in left parietotemporal and occipitotemporal regions (Tanaka et al., 2011). Moreover, Skiba, Landi, Wagner, & Grigorenko (2011) found no systematic effect of IQ-discrepancy or Low-Achievement definitions of SLD on candidate genes, suggesting that individuals with discrepant and non-discrepant IQ-achievement scores do not differ in terms of the biological basis of their LD. Furthermore, our review of studies of predictive validators also failed to find robust evidence of difference between those with and without an IQ-achievement discrepancy. The groups do not differ in long-term prognosis (Francis, Shaywitz, Stuebing, Shaywitz, & Fletcher, 1996; Share, McGee, & Silva, 1989), nor do they differ in terms of response to intervention (Hatcher & Hulme, 1999; Stuebing, Barth, Molfese, Weiss, & Fletcher, 2009; Vellutino, Scanlon, & Lyon, 2000).

It was clear that the literature does not support the external validity of the distinction between age-referenced and IQ-referenced definitions of SLD, although it should be noted that most of the research has focused on SLD in reading (DSM-IV Reading Disorder, a.k.a. Dyslexia), which is the most extensively researched manifestation of SLD. Thus, our review of literature from the past two decades concurred with several previous reviews (e.g., Francis et al., 2005; Cahan et al., 2012): there is no robust evidence to support the validity of this criterion. The criterion is conceptually and statistically flawed.

It was not surprising, therefore, that recent roundtable reports (e.g., President's Commission on Excellence in Special Education, 2002), articles (e.g., Stanovich, 2005; Sternberg & Grigorenko, 2002), and the Individuals with Disabilities in Education Act (IDEA, 2004) that governs the provision of special education services in U.S. public schools, all recommend the abandonment of the discrepancy model. However, none of these reports address the major residual problem: namely, with what should the IQ-achievement discrepancy criterion be replaced? Thus, the Work Group reviewed the literature to seek validation of three major approaches that have been proposed: i) inclusion of cognitive processing deficits (e.g., Hale, 2010; Kavale & Forness, 2000); ii) 'response-to-intervention' criterion (e.g., US Department of Education, 2004; Vaughn & Fuchs, 2003); and iii) augmentation of the low-achievement-for-age component of the DSM-IV criterion (e.g., Dombrowski, Kamphaus, & Reynolds, 2004; Tunmer & Greaney, 2009).

Cognitive processing deficits as a possible diagnostic criterion

The underlying premise is that various cognitive (psychological) processing deficits play a causal role in SLD and therefore would serve as valid indicators of SLD. The presumption of underlying cognitive processing deficits is part of the IDEA (2004) definition of SLD, and this approach is strongly supported in the field of neuropsychology as well as by advocacy groups (e.g., Hale et al., 2010).

One major critique of this approach is that 'processing deficits' are rarely measured directly, but inferred from scores on various neuropsychological tests, which in turn measure a complex web of cognitive, behavioral, and motivational processes (Ramus & Ahissar, 2012). A second major critique is the limited empirical support for the inclusion of cognitive processing deficits in the diagnostic criteria for SLD. For instance, although a meta-analysis found moderate to large effect sizes for differences in cognitive processing between children with SLD and typical development, there was no evidence that cognitive deficits contributed to differential diagnosis of SLD (Johnson et al., 2010). Also, a large-scale investigation of two population-based samples, from a US-based cross-sectional study and an international longitudinal study, found that cognitive predictors believed to have a causal role in dyslexia were neither necessary nor sufficient for the diagnosis of SLD in reading (Pennington et al., 2012). Cognitive processing skills cannot be used to rule in or rule out a diagnosis of RD, because the relationship between the cognitive processing skills and reading skill is probabilistic and not deterministic (i.e., not diagnostic).

By contrast, the Work Group's review of the literature on predictive validators revealed quite strong support for the inclusion of cognitive processing deficits as a diagnostic criterion for SLD. For example, several studies report that measures of cognitive processing skills associated with reading (e.g., phonological awareness, naming speed) predicted response to intervention in children with RD (Al Otaiba & Fuchs, 2002; Frijters et al., 2011; Fuchs, Fuchs, & Compton, 2012). However, counter arguments include: i) cognitive deficits associated with RD are not unique to this disorder but are shared with other neurodevelopmental disorders, such as ASD, ADHD, and developmental coordination disorder (e.g., Willcutt et al., 2010); ii) cognitive processing deficits that underlie other manifestations of SLD (mathematics, written expression) remain unclear (Geary, 2010; Ramus & Ahissar, 2012); and iii) the required assessment of cognitive processing skills may be prohibitively expensive and waiting lists are often long (Compton, Fuchs, Fuchs, Lambert, & Hamlett, 2012). Thus the Work Group ruled out cognitive processing deficits as a possible diagnostic criterion for SLD based on consideration of its empirical evidence and clinical utility.

Response-to-Intervention (RTI) as a diagnostic criterion for SLD

A central premise of the RTI approach to the identification of students with SLD is that by providing evidence-based instruction, the possibility that the learning difficulties are a result of inadequate instruction is ruled out. That is, the RTI model assumes that it will differentiate children with SLD from those who are low achieving because of inadequate

educational instruction. RTI has been integrated into US federal law (IDEA, 2004), with all 50 states permitting RTI in SLD identification (Fuchs & Vaughn, 2012). Accordingly, the Work Group reviewed the literature to seek answers to two key questions. First, is diagnostic intervention necessary for the identification of SLD? Diagnostic intervention is defined as evidence-based, small-group instruction for a specified and limited duration, in terms of weeks. Second, does RTI reduce the number of false positives and thereby reduce the prevalence of SLD?

The limited available evidence indicated that an extensive period of diagnostic intervention is not necessary, provided that initial screening is supplemented with standardized testing and a requirement of persisting learning difficulties (Fuchs & Vaughn, 2012; Fuchs et al., 2012; Compton et al., 2012). Studies of the impact of RTI on the prevalence of SLD yield mixed findings: one study reported a substantial drop in the percentage of students meeting criteria for RD after RTI (Torgeson, 2009), whereas more recent studies found only small and negligible reductions on the prevalence of SLD (e.g., Fuchs et al., 2012). One confounding factor is that the overall prevalence of SLD has decreased in the US over the past decade due to other factors (political, administrative changes in the accountability framework in education; economic recession reducing special education services). Moreover, there are several major inherent problems with the use of RTI to identify individuals with SLD, including: i) RTI-based definitions of SLD have a very high rate of false positives (students who do not have SLD) (Fuchs et al., 2012); ii) It remains unclear what constitutes effective evidence-based instruction for the various academic domains, particularly math, written expression, and reading comprehension, and particularly for adolescents; iii) training of teachers in such methods is also lacking (e.g., Scanlon, Gelzheiser, Vellutino, Schatschneider, & Sweeney, 2008); iv) there is an implicit requirement to use 'cut-points' to establish response or non-response to instruction, but such cut-points have not yet been established or validated and response to instruction most likely exists on a continuum, so any cut-point will be arbitrary (Fletcher & Vaughn, 2009); v) it remains unclear how RTI can differentiate those with learning difficulties from those with problems associated with other disorders (e.g., ASD, ADHD, emotional problems), who may also exhibit poor responsiveness to intervention for reasons other than SLD (Mastropieri & Scruggs, 2005); vi) the RTI approach to SLD identification is causing considerable confusion in USA Case Law and the Courts (e.g., Daves & Walker, 2012; Zirkel, 2011, 2012); and vii) the use of formalized RTI intervention would increases expenses for educational systems that are already facing significant challenges and would not be applicable in countries other than the USA, nor is it relevant for adults.

Accordingly, the Work Group ruled out the inclusion of a formalized RTI-based approach as used in the USA, as a diagnostic criterion for SLD. However, an important premise of the RTI approach is the persistence of learning difficulties despite the provision of appropriate instruction. Symptom persistence as a diagnostic criterion is common in many disorders defined in DSM-IV (e.g., ADHD, Oppositional Defiant Disorder, Schizophrenia),

but has never been included in the diagnostic criteria for LD in any previous version of DSM. Moreover, a scan of the literature revealed that whereas the defining criteria for SLD in mathematics (or dyscalculia) typically require evidence of persisting difficulties over two years, such a requirement is rarely if ever required for RD (Geary, 2011a). Outside the USA, RTI has not been embedded in law, but several countries embrace the principle of RTI in their defining criteria for SLD (e.g., Belgium, Netherlands, New Zealand: Gersons-Wolfensberger & Ruijssenaars, 1997; Tunmer & Greaney, 2009).Thus, as recommended by the DSM-5 Work Group and approved by the SRC, the concept of symptom persistence despite the provision of support, extra help, or intervention, was incorporated into one of the diagnostic criteria for SLD (Criterion A).

Augmented low-achievement as a potential diagnostic criterion

There is general agreement that a low-achievement (LA) criterion is a necessary criterion for SLD, but that it is not sufficient as the sole criterion, because there are many factors other than SLD that contribute to low achievement (Chiu, McBride-Chang, & Dan, 2012). Moreover, when used as the sole criterion it yields a higher prevalence rate than the IQ-achievement criterion (particularly when using a liberal cut-off point as is common in the research literature − such as the 90th percentile or 0.75 SD below mean for age) and has insufficient discriminant validity for the identification or diagnosis of SLD (Barbaresi et al., 2005; Hale et al., 2010; National Joint Committee on Learning Disabilities, 2011; Stuebing et al., 2009). However, there remains heated debate and ongoing controversy, particularly in the USA, as to how best to augment the LA criterion to replace the IQ-achievement discrepancy criterion.

Key issues included in the Work Group's review of the literature were: i) the specific cut-off scores used to indicate LA; ii) the impact of also requiring persistence of symptoms or impairment; and iii) the impact of excluding various disorders (particularly, Intellectual Disabilities). As summarized below, this review of antecedent, concurrent and predictive validators provided moderate but not unequivocal support for including a modified LA criterion in the diagnostic criteria for SLD.

In general, evidence for an augmented LA criterion was strongest when a fairly stringent cut-off score was used to index low achievement (i.e., achievement scores ≤ 1.5 SD below the population mean), combined with a requirement for average IQ (or exclusion of Intellectual Disabilities). For example, these combined criteria were used in a study that found familial transmission of SLD (Landerl & Moll, 2010) and moderate heritability of SLD in reading, math, and language, as well as marked overlap in genetic influences on these seemingly diverse academic skills (Kovas, Haworth, Dale et al., 2007; Kovas, Haworth, Harlaar et al., 2007; Haworth et al, 2009). Also, large-scale longitudinal studies of children with SLD in math revealed distinct and persistent difficulties, with the severity of problems varying as a function of the LA cut-off score, with more severe problems associated with scores < 10th percentile, corresponding to ≤ 1.5 SD below the population mean (Geary, 2011a). The use of an augmented LA criterion of SLD has been found to be applicable to

college students (Callens, Tops, & Brysbaert, 2012) and adults with SLD, including those with high IQ (Swanson, 2012). Both studies used low IQ as an exclusionary criterion and required a history of persisting symptoms, but used different LA cut-off scores (Callens: < 10th percentile; Swanson: < 25th percentile). Moreover, a review of case-selection criteria used in 13 major DNA collections for SLD in reading revealed that the majority used an LA criterion augmented with an exclusionary criterion for Intellectual Disabilities (Skiba et al., 2011). Once again, those studies using more stringent LA cut-offs to define the phenotype yielded more significant findings. Importantly, large-scale studies that used stringent cut-off scores (≤ 1.5 SD below the population mean) plus a requirement for at least average IQ (or exclusion of Intellectual Disabilities), found evidence of longitudinal stability of SLD in reading or mathematics (Astrom et al., 2011; Auerbach, Gross-Tsur, Manor, Shaelv, 2008; Geary, 2011b; Stock et al., 2010).

Accordingly, based on the comprehensive review of the available literature (as of May 2012), the Work Group recommended the use of an augmented LA criterion with guidelines for what constitutes low achievement, persistence of symptoms, and what conditions or disorders should be excluded. Thus the text explains that low achievement needs to be operationalized based on the severity of scores on several standardized achievement tests. Most evidence supports the use of a fairly stringent cut-off of at least 1.5 SD below the population mean for age – but a more lenient cut-off score (e.g., 1 to 1.5 SD) might be appropriate given strong clinical evidence of learning difficulties (e.g., family history of SLD, lack of progress in learning over the academic year, etc.). In addition, evidence of persistence of learning difficulties is required. There is little evidence on which to base decisions as to the period of time required for "persistence." Data from the literature on SLD in mathematics would suggest a period of about 2 years; the literature on SLD in reading provides no guidelines. We proposed that a period of at least 6 months would be reasonable, based on criteria used in Belgium and the Netherlands and the Health Council of the Netherlands report (Gersons-Wolfensberger & Ruijssenaars, 1997). Consistent with this report, an additional requirement during this 6-month period is the provision of academic instruction that targets the learning difficulty (e.g., Callens et al., 2012). Also, confounding factors, such Intellectual Disability or borderline IQ, should be taken into consideration, as well as other mental disorders and sensory impairments in vision and hearing. Finally, our proposal was to link response-to-intervention with the requirement for persistence of the learning difficulties (new Criterion A), rather than as a separate and additional criterion. The rationale for this decision is to avoid misinterpretation of 'response to instruction' as requiring extensive documentation of the various tiers of intervention provided and quantification of non-response, all of which might serve to delay diagnosis and access to services. The intent of its use as a qualifier of 'persistence' is to ensure that clinicians (and schools) check to make sure that the individual has received academic instruction that focuses on the area of academic difficulty, and that the individual still manifests learning difficulties.

Implications for Clinical Practice, Education, and Research

The DSM-5 diagnostic criteria for SLD reflects two major changes, each of which necessitated other changes: 1) one overarching category of SLD with specifiers to characterize the specific manifestations of learning difficulties in three major academic domains (reading, writing, mathematics) at the time of assessment; and 2) elimination of the IQ-achievement discrepancy requirement that was replaced by an augmented low-achievement criterion. Four diagnostic criteria must be met: i) at least one of six symptoms of learning difficulties that have persisted for at least 6 months despite the provision of extra help or targeted instruction; ii) confirmation and quantification of low achievement for age that causes impairment in academic or occupational performance, or in activities of daily living, using comprehensive clinical assessment plus individually-administered standardized tests of academic achievement; iii) onset of learning difficulties during the school-age years, although they may not fully manifest until young adulthood in some individuals; and iv) learning difficulties not attributable primarily to other disorders (Intellectual Disabilities, uncorrected auditory or visual acuity problems, other mental or neurological disorders) or adverse conditions (psychosocial adversity, lack of proficiency in the language of instruction, inadequate instruction). These changes are likely to have some impact on daily clinical practice, clinical research, the educational system, professional organizations and advocacy groups for LD, as well as on individuals with LD, their families, community perspectives of LD, and funding agendas. Implications of the required shifts in practice are discussed below.

One substantial practice shift is necessitated by the change from subtypes of LD (Reading Disorder, Mathematics Disorder, Written Expression Disorder) to one overarching category of SLD. For clinicians and researchers, the change will require comprehensive assessment of academic skills, and may reduce the challenges associated with defining the subtype of LD (especially when test scores vary across academic domains, with some falling just below clinical threshold). Instead, specifiers may be used to more precisely characterize the range of problems manifesting at the time of assessment. The identification of a single overarching category of LD is consistent with the US federal law (IDEA 2004), and many educational systems in which LD is delineated as an eligible category for special education, other services, and specific funding. This change may help reduce the confusion of parents and educators when 'additional' LDs are identified in later school years, and help them better understand the developmental changes in manifestation of SLD, which are in part triggered by the increasing learning demands of the curriculum (e.g., early struggles to read single words are often followed by difficulties learning math facts, spelling problems, and difficulties understanding what is read, including mathematical word problems). However, this change also may require retraining of clinicians, school psychologists, and educators to identify and understand this conceptualization of LD and how to design learning pathways for each student with LD, who will have divergent and changing manifestations of their learning difficulties. Hopefully, this change might lead to better alignment of practice between clinical and educational communities. However, the impact on research funding is

unknown: currently US federal funding (NIH) is higher for ASD than for dyslexia and that for dyslexia is substantially greater than for dyscalculia (e.g., Bishop, 2010). Will this change have a negative impact on individuals with a diagnosis of dyslexia or dyscalculia (who often refer to themselves as 'dyslexic' or 'dyscalculic') or on dedicated professional organizations or advocacy groups (e.g., International Dyslexia Association)? It should not, since these terms may be used to specify the nature of their SLD, according to individual preference. Moreover, the requirement to use specifiers to characterize the range of academic skills affected by dyslexia might increase awareness that 'dyslexia' typically encompasses far more difficulties than those related to decoding and spelling words.

A second practice shift is indicated by the abandonment of the IQ-achievement discrepancy criterion as well as the omission of cognitive processing deficits in the diagnostic criteria. The discrepancy model has served as the fundamental conceptualization of LD for decades, despite robust evidence that it is conceptually and statistically flawed. Thus, intellectual assessments have been the core of assessment for LD: they will no longer be required for a DSM-5 diagnosis of SLD, except when Intellectual Disabilities are suspected. Similarly, the notion of underlying cognitive processing deficits as causal to the academic learning difficulties is a widely held postulate, despite ongoing controversy as to which specific processes define LD, and which neural anomalies are related to it (e.g., Rumsey, 2006; Swanson, 2008). In DSM-5, there is no requirement for lengthy and costly neuropsychological assessment of cognitive processing skills for a diagnosis of SLD: such assessment might inform intervention plans but is not required for diagnosis.

A third and related shift will be needed by the new criteria (particularly Criteria A and B), which call for evidence of symptom persistence and the use of a wider array of data that may be used to confirm and quantify low academic achievement. By contrast to the DSM-IV category of LD, psychometric data alone are insufficient for a DSM-5 diagnosis of SLD. Moreover, the need to demonstrate persistence of symptoms despite the provision of extra help or instruction means that evaluations cannot be completed in isolation from the instructional context. These changes will necessitate a much closer collaboration between educators, clinicians, and parents, to provide access to formal and informal school records, academic portfolios and instructional history, as well as information from psychoeducational and clinical assessments. Closer and ongoing collaboration between clinicians, educators, parents, and the individual with SLD might lead to less confusion and frustration while navigating both worlds (educational, clinical) and better outcomes.

The hope is that the DSM-5 criteria for SLD will be reflected in educational and healthcare policies. However, the full impact of the substantial changes made in the DSM-5 diagnostic criteria for SLD must await their international use and validation in epidemiological, longitudinal, neurobiological, and controlled treatment-outcome studies, and feedback from their use in clinical and educational practice, and from individuals with SLD and their families.

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William M. Cruickshank Memorial Lecture Delivered at the 2008 Conference of the International Academy for Research in Learning Disabilities

Executive Function and Metacognition in Students with Learning Disabilities: New Approaches to Assessment and Intervention[5]

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Abstract

Success in our 21st century schools is linked with students' mastery of a wide range of academic and technological skills that rely heavily on executive function processes. This article describes a theoretical paradigm for understanding, assessing, and teaching that emphasizes the central importance of six executive function processes: goal setting, cognitive flexibility/shifting, organizing, prioritizing, accessing working memory, and self-monitoring (Meltzer, 2007, 2010, 2013a). For each of these core processes, there is an emphasis on the effects of executive function on learning as well as some of the challenges experienced by students with learning disabilities. There is also a focus on the interactions among executive function processes, self-awareness, effort, and persistence as well as the major principles of intervention and treatment.

[5] This article is based on the William Cruickshank Memorial Lecture presented in Toronto, Canada at the 32nd Annual Meeting of the International Academy for Research in Learning Disabilities, June, 2008.

"Mike's performance has been unpredictable all year! He has many creative ideas and he participates actively in classes. However, he is usually late with written papers and projects and he does not seem to care about his homework. His test grades fluctuate from the 90s to the 60s. His other teachers have told me that they think he is lazy. I think that Mike may have a problem." (8th grade teacher)

Success in our 21st century schools is linked with students' mastery of a wide range of academic and technological skills which rely heavily on executive function processes. Beginning in the early grades, students are increasingly required to take greater responsibility for their own learning by organizing and integrating a large amount of information that is rapidly changing. They are also expected to become proficient at note-taking, studying, and test-taking, all tasks that depend on students' cognitive flexibility and their ability to prioritize information. Furthermore, students' academic success depends on their ability to plan their time, organize and prioritize materials and information, think flexibly, mentally juggle information, and monitor their own progress. Therefore, it is important to help students, particularly students with learning disabilities (LD), to understand *how* they learn and to teach them specific strategies that address these executive function processes.

For the purposes of this paper, "executive function" is used as an umbrella term that is broader than metacognition and incorporates a range of interrelated processes responsible for goal-directed behavior (Anderson, 2002; Anderson, Jacobs, & Anderson, 2008; Eslinger, 1996; Gioia, Isquith, Guy, & Kenworthy, 2001; Meltzer, 2013). More specifically, the term, "executive function" refers to a wide range of cognitive processes that are controlled by the prefrontal cortex (Eslinger, 1996). These comprise:

- Metacognitive knowledge about tasks and strategies
- Flexible use of strategies
- Attention and memory systems that guide these processes (e.g. working memory)
- Self-regulatory processes such as self-monitoring

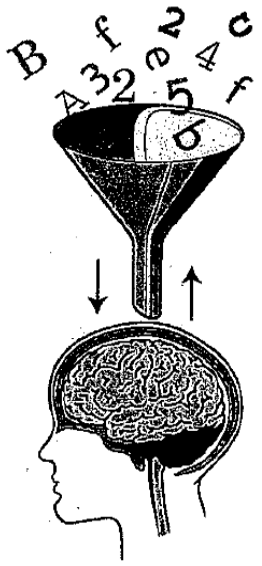
The work summarized here is built on the seminal research of Flavell on goal-oriented problem-solving (Flavel, Friedrichs, & Hoyt, 1970) and the studies of Brown and Campione (Brown, Bransford, Ferrara, & Campione,1983; Brown & Campione,1986) on metacognition and self-regulation, as well as the more recent models of executive function (Barkley, 1997; Bernstein & Waber, 2007; Denckla, 2005, 2007; Gioia, Isquith, Guy, Kenworthy, & Barton, 2002).

In this paper, based on my Cruickshank Memorial Lecture, I describe a theoretical paradigm for understanding, assessing, and teaching that emphasizes the central importance of six executive function processes: goal setting, cognitive flexibility/shifting, organizing, prioritizing, accessing working memory, and self-monitoring (Meltzer, 2007, 2010, 2013a). For each of these core executive function areas, I discuss the effects of executive function on the learning process and describe some of the challenges experienced by students with learning difficulties. I focus on the interactions among executive function processes, self-awareness, effort, and persistence as well as the major principles of intervention and treatment.

Executive Function Processes and Academic Performance

> *"When I have to write a paper, I sit down at my computer but my mind feels like it's stuck. I try to write but I can't figure how to get my mind unstuck. I grab at an idea and write a sentence. I get so frustrated when I have written only a few sentences after an hour, so I give up."* (John, 15 years, 9th grade)

Students with executive function weaknesses often have difficulty coordinating and integrating the different subskills involved in many academic tasks such as writing, summarizing information, executing and completing projects in a timely manner, and studying for tests (Meltzer, 2010; Meltzer & Basho, 2010). These students often have difficulty organizing and prioritizing information and they struggle when they are required to shift flexibly in order to utilize alternate approaches. Working memory and self-monitoring weaknesses also make it difficult for these students to mentally juggle information, self-monitor, and self-check. As a result, they overfocus on details, while ignoring the major themes and feel as if their brains become "clogged" with information as they struggle to produce. The paradigm that has guided our work on executive function is based on the analogy of a "clogged funnel," as illustrated in Figure 1 (Meltzer, 2004, 2007, 2010, 2013a; Meltzer & Krishnan, 2007). Because these students cannot shift flexibly among alternative approaches to "unclog" the funnel, their written work, study skills and test performance are compromised, and their academic grades do not reflect their strong intellectual ability.



Executive Function Paradigm

- Goal-setting
- Shifting flexibly
- Organizing
- Prioritizing
- Accessing Working Memory
- Self-monitoring

Interact with:
- Attention
- Emotional control
- Self-regulation

Figure 1. Executive Function Paradigm, adapted from Meltzer (2004), Copyright 2007 by the Guilford Press, Reprinted by permission.

Table 1. Executive Function Processes Required for Academic Performance

Prioritizing

- Planning and allocating time to the many steps involved in different assignments (e.g., writing papers, taking notes for history or science, or completing long-term projects).
- Prioritizing by allocating more time and effort to major projects and tests.
- Figuring out which details are critical and which details can be ignored when reading, taking notes, or writing essays.
- Estimating how much time to spend on reading and research versus output (e.g., writing a paper, editing, and layout).

Organizing

- Organizing ideas, such as summarizing key ideas on strategy cards rather than rereading the text over and over.
- Organizing materials such as class notes, textbooks, and study guides.
- Organizing workspace (e.g., reducing distractions and clutter).

Shifting

- Shifting flexibly from the major themes to the relevant details to meet the demands of the reading, writing, or studying task.
- Using outlines such as graphic organizers or linear outlines to get "unstuck" when writing papers or projects.
- Shifting between operations and between words and numbers for math computation or word problems.

Accessing Working Memory

- Studying strategically so that students connect concepts and can "juggle information mentally" in order to access this information on a long-term basis.
- Remembering to hand in completed assignments on time.
- Remembering to bring necessary books and materials from school to home and back again.

Self-monitoring/ Checking

- Reviewing papers and tests to identify frequent error pattern
- Developing personalized error checklists to correct errors when writing papers, taking tests or completing homework
- Checking and correcting "careless errors" when writing papers, taking tests, or doing homework.

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These difficulties become more evident during middle and high school due to the larger volume and complexity of the workload as well as the increasingly demanding curriculum (see Table 1). As a result, these students struggle to perform at the level of their intellectual potential, which can be extremely frustrating and often affects their motivation as well as their academic performance.

Executive Function Strategies, Self-Concept, and Effort:
The Foundation of Academic Success

Our research has shown that motivation, self-understanding, and academic self-concept are connected cyclically with students' use of executive function strategies as well as their effort and persistence (Meltzer, Katzir, Miller, Reddy, & Roditi, 2004; Meltzer & Krishnan, 2007) (see Figure 2). These cognitive and motivational processes are the underpinning of academic success for all students (Brunstein, Schultheiss, & Grässman, 1998; Helliwell, 2003; Kasser & Ryan, 1996; Meltzer, Reddy, Pollica, & Roditi, 2004; Pajares & Schunk, 2001; Sheldon & Elliot, 1999).

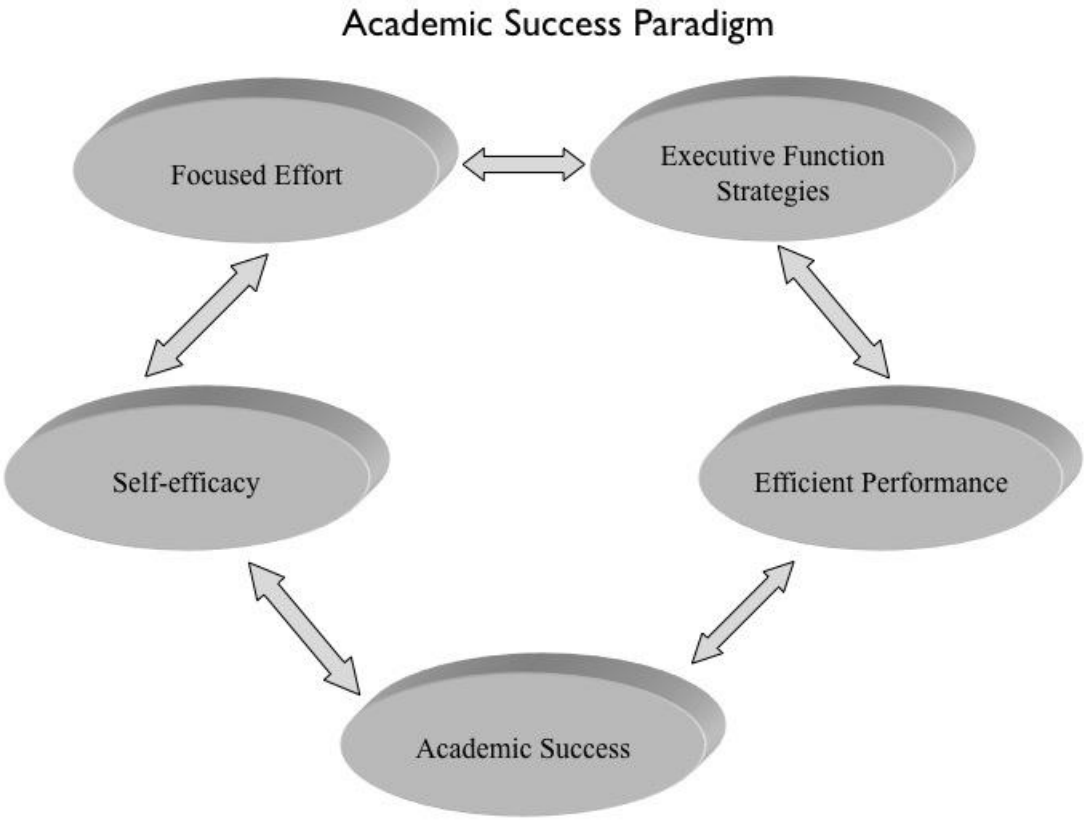

Figure 2. Academic Success Cycle

Adapted From: Meltzer, L J., Reddy, R., Pollica, L., & Roditi, R. (2004). Copyright 2004 by the International Academy for Research in Learning Disabilities. Reprinted by permission.

Therefore, executive function strategies are critically important for improving academic performance. As is evident from Figure 2, students' use of executive function strategies often increases their efficiency as well as their accuracy, and they begin to improve academically. Academic success, in turn, boosts students' self-confidence and self-efficacy so that their effort is more focused on achieving their personal goals. Consequently, a cycle of success is promoted when students focus their effort on applying executive function strategies to their schoolwork (Meltzer, 2010; Meltzer, Katzi et al. 2004; Meltzer, Reddy, Pollica et al., 2004, Meltzer, Reddy, Sales et al., 2004). Students therefore need to understand their own learning profiles and which strategies work well for them, as well as why, where, when and how to use specific strategies. This ability to think about their own thinking and learning, referred to as metacognitive awareness (Flavell, 1979), is strongly associated with students' motivation, effort, and willingness to use executive function strategies in their schoolwork.

Executive function strategies can provide a lifeline to academic success for all students as they learn how to set realistic goals, focus their effort on achieving these goals, and self-regulate their cognitive, attentional and emotional processes (see Figure 3). Furthermore, when students begin to improve academically as a result of using these executive function strategies, they are more motivated to work hard and to persist despite their difficulties, which builds resilience and academic success (Meltzer, 2010; Meltzer, Reddy, Brach, Kurkul, & Basho, 2011; Meltzer, Reddy, Brach, Kurkul, Stacey et al., 2011).

Assessment of Executive Function

> *"Jamie is a very bright student whose grades are inconsistent. He does well on quizzes and short tests but he often does not hand in his homework. I wish I knew how to help him.*" (8th grade teacher)

Informal assessment methods can help us to understand students' use of executive function processes and to pinpoint *why* and *how* particular students may be struggling. It is then possible to intervene by introducing specific instructional approaches, assessing students' progress, and modifying instruction. This continuous cycle that links assessment and teaching allows instructional methods to be adjusted to the changing needs of students. Many of these principles are incorporated in the Response to Intervention (RTI) approach that is now used more widely in U.S. schools to improve early identification of reading and learning difficulties (Fuchs & Fuchs, 1991; Kame'enui, 2007).

Currently, there are very few measures available for assessing students' use of executive function strategies. The most widely-used and reliable questionnaire system is the *Behavior Rating Inventory for Executive Function* (BRIEF; Gioia et al., 2001; Gioia et al., 2002). The BRIEF comprises a parent questionnaire, a teacher questionnaire, and a self-rating form for students from 5 years old into adulthood. The 86 items assess behaviors associated with the most important executive function processes, e.g.: *"Forgets to hand in*

homework, even when completed; Gets caught up in details and misses the big picture; Becomes overwhelmed by large assignments; Underestimates the time needed to finish tasks" (Gioia, Isquith, Guy, & Kenworthy, 2001).

Another criterion-referenced assessment system that compares students', teachers', and parents' perceptions of students' metacognitive awareness and strategy use, is the Metacognitive Awareness System or MetaCOG (Meltzer, 2010; Meltzer, Reddy, Pollica et al., 2004; Meltzer & Krishnan, 2007; Miller, Meltzer, Katzir-Cohen, & Houser, 2001). The MetaCOG, for use with 9-18 year olds, comprises five rating scales that allow educators to compare their own judgments with their students' self-ratings of their effort, strategy use, and academic performance (see Table 2).

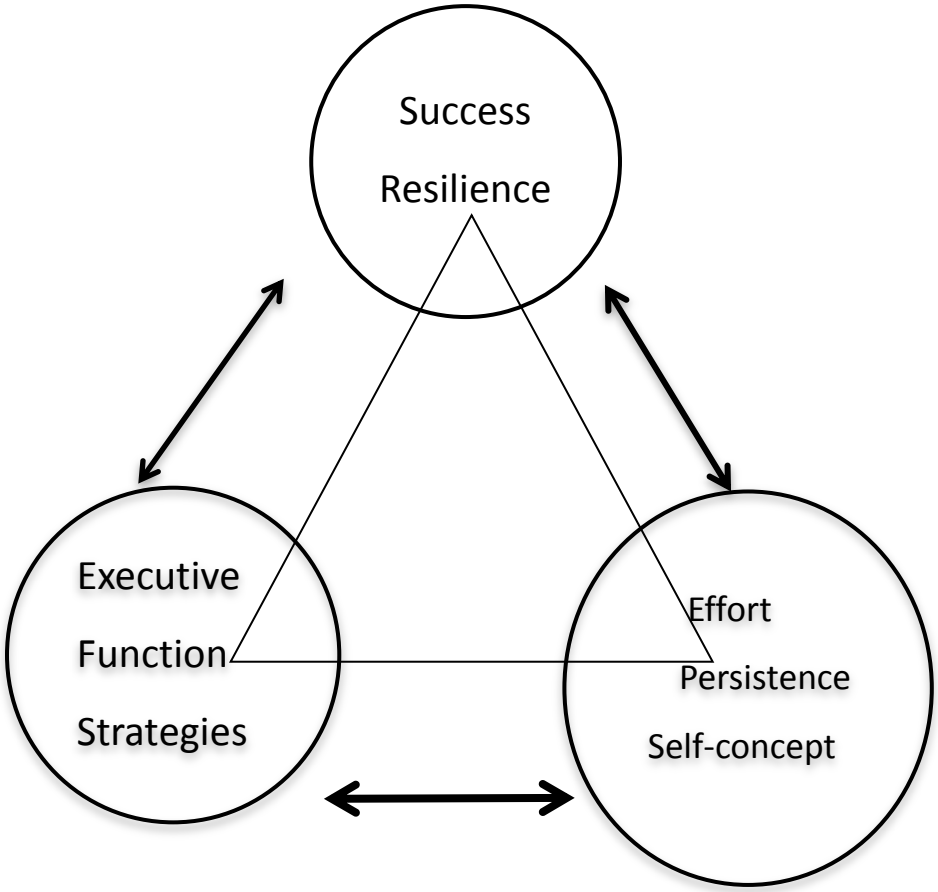

Figure 3. Academic Success Paradigm. From Meltzer (2010); Meltzer, Reddy, Brach, Kurkul, & Basho (2011).

Table 2.

Metacognitive Awareness Survey System (MetaCOG)

STUDENT Questionnaires

- ME – Motivation and Effort Survey
- STRATUS – Strategy Use Survey
- MAQ – Metacognitive Awareness Questionnaire

TEACHER Questionnaires

- TPSE – Teacher Perceptions of Student Effort
- TIQ – Teacher Information Questionnaire

5-point rating for all surveys

Ratings focus on students' performance in selected academic domains that depend on executive function processes, namely, written language, homework, studying, and taking tests (see Tables 2a & 2b; Meltzer, Katzir-Cohen, Miller, & Roditi, 2001; Miller et al., 2001). Completion of the MetaCOG surveys helps students and teachers to better understand students' individual learning profiles, which provide baseline information for improving students' metacognitive awareness and teaching them to use executive function strategies.

Table 3a.

MetaCOG Sample Items: Students' vs Teachers' Ratings of their Performance on Academic Tasks that involve Executive Function Processes

ME –Students	**TPSE-Teachers**
Please judge how well you do on:	***Please judge how well this student does on:***
• Organization	• Organization
• Long-term projects	• Long-term projects
• Making a plan before starting work	• Making a plan before starting work
• Using strategies in my schoolwork	• Using strategies in his/her schoolwork
• Checking my work	• Checking his/her work
• Homework	• Homework
• Tests	• Tests
• Long-term projects	• Long-term projects

Systems such as the MetaCOG can be used for different purposes over the course of the school year: (a) To understand students' views of their own effort, use of strategies, and

academic performance; (b) To help educators and clinicians to compare their own judgments with their students' self-perceptions; (c) To develop a system for teaching strategies that help students to become strategic learners who plan, organize, prioritize, shift flexibly, memorize, and check their work; (d) To track students' understanding and implementation of these strategies over time.

Table 3b.

MetaCOG Sample Items: Students' vs Teachers' Ratings of their Motivation and Effort on Academic Tasks that involve Executive Function Processes

ME –Students	**TPSE-Teachers**
• Doing well in school is important to me.	• Doing well in school is important to this student.
• I spend as much time as I need to get my work done.	• S/he is a hard worker.
• I keep working even when the work is difficult.	• S/he doesn't give up even when work is difficult.
I work hard on:	***Please judge how hard this student works***
• Homework	• Homework
• Long-term projects	• Long-term projects
• Studying for tests	• Studying for tests
• Other activities (sports, music, art, hobbies)	• Other activities (sports, music, art, hobbies)

Note: The ME and TPSE each comprise 36 items using a 1-5 rating scale.

MetaCOG Student Surveys

Motivation and Effort Survey (ME) (Meltzer, Katzir et al., 2004; Meltzer, Reddy, Pollica et al, 2004; Meltzer, Reddy, Sales et al., 2004). The ME consists of 38 items that assess students' self-ratings of their effort and performance on different academic tasks that

depend on executive function processes (alpha =.91[see Tables 3a & 3b], Meltzer, Sayer, Sales, Theokas, & Roditi, 2002). Students rate themselves on a 1-5 scale (from never to always) in terms of how hard they work and how well they do in selected academic areas such as reading, writing, math, homework, studying for tests, and long-term projects (e.g., *I spend as much time as I need to get my work done; I finish my work even when it is boring; I do schoolwork before other things that are more fun*). Students are also asked to describe themselves as learners.

Strategy Use Survey (STRATUS) (Meltzer, Katzir et al., 2004; Meltzer, Reddy, Pollica et al, 2004; Meltzer, Reddy, Sales et al., 2004). The STRATUS consists of 40 items that assess students' self-reported strategy use in reading, writing, spelling, math, studying and test-taking (alpha = .945). Items focus on students' perceptions of their use of strategies for planning, organizing, remembering, and self-checking (e.g., *When I have to remember new things in school, I make up acronyms to help me; Before I write, I plan out my ideas in some way that works for me (outline, list, map); When I do math, I ask if my answers make sense*.)

Metacognitive Awareness Questionnaire (MAQ) (Meltzer, Katzir et al., 2004; Meltzer, Reddy, Pollica et al, 2004; Meltzer, Reddy, Sales et al., 2004). The MAQ consists of 18 items that assess students' understanding of what strategies are and how they can apply strategies to their schoolwork (e.g., *When you begin something new, do you try to connect it to something you already know?; When you begin something new, do you try to think about how long it will take and make sure you have enough time?*).

MetaCOG Teacher Surveys

Teacher Perceptions of Student Effort (TPSE; Meltzer, Katzir et al., 2004; Meltzer, Reddy, Pollica et al, 2004; Meltzer, Reddy, Sales et al., 2004). The TPSE is the teacher version of the ME and consists of 38 items that assess teachers' ratings of students' effort in different academic domains (alpha = .980; see Tables 3a & 3b). Teachers rate students' effort and performance in reading, writing, math, homework, tests, and long-term projects, all academic tasks that rely on executive function processes (e.g., *He spends as much time as needed to get his work done; She does not give up even when the work is difficult*.) Teachers also rate students' overall strategy use and academic performance in response to the question: "If you had to assign a grade for this student's overall academic performance, what would this be?"

MetaCOG Parent Surveys

Parent Perceptions of Student Effort (PPSE). The PPSE consists of 38 items that assess parents' ratings of students' strategies and the effort they apply in different academic domains that require the use of executive function processes. Items are identical to those used on the student self-report survey (ME), and the teacher survey (TPSE).

As was discussed, student, teacher, and parent reports can be directly compared to

determine the overall consistency in their ratings of many of the core components of executive function processes across different settings (see Tables 2a and 2b). However, it must be kept in mind that students' perceptions of their own effort and strategy use are often very different from their parents' and teachers' perceptions, as has been shown in a number of studies (Meltzer, Katzir et al., 2004; Meltzer, Reddy, Pollica et al, 2004; Meltzer, Reddy, Sales et al., 2004; Stone & May, 2002).

In summary, survey systems that raise teachers' and clinicians' awareness and understanding of students' effort, and use of executive function strategies, can improve their understanding of why and how students may be struggling. These systems can also help teachers to implement and monitor the effectiveness of specific instructional strategies, as will be detailed next.

Strategies that Address Executive Function Processes

Intervention research has shown that explicit and highly structured metacognitive instruction benefits all students and is essential for the academic progress of students with learning and attention difficulties (Deshler, Ellis, & Lenz, 1996; Deshler & Schumaker, 1988; Meltzer Katzir et al.; Paris, 1986; Pearson & Dole, 1987; Rosenshine, 1997; Swanson, 2001; Swanson & Hoskyn, 1998, 2001). Comparisons of different interventions highlight several important principles of this instruction:

- Strategies should be taught explicitly and systematically, using scaffolding and modeling, and providing time for practice (Pressley, Goodchild, Fleet, Zajchowski, & Evans, 1989; Swanson, 1999, 2001; Swanson & Hoskyn, 1998).
- Strategy instruction should be embedded in the curriculum (Deshler & Shumaker, 1986; Deshler, Warner, Schumaker, & Alley, 1983, 1996; Ellis, 1993, 1994).
- Students should be exposed to activities that help them to understand their strengths and weaknesses so that they can select strategies that match their learning profiles and learn how to generalize these strategies to different content areas (Meltzer, 1996; Meltzer, Roditi, Houser, & Perlman, 1998).
- Metacognitive awareness and effective strategy use are promoted when teachers provide systematic and explicit instruction focused on executive function strategies (see Table 1) and when they include strategy use in their grading systems.

One example of an easily implementable classroom system is to teach students to complete strategy reflection sheets that require them to think about and to write down the strategy they have used to approach their homework or to study for tests. These strategy reflection sheets are designed to promote metacognitive awareness, encourage students to use strategies systematically, and remind them to check and edit their work (see Figures 4a and 4b). When grades for homework and tests include points for completing these strategy reflection sheets, teachers promote strategic habits of mind and students are more likely to make the effort needed to use these strategies consistently. In other words, metacognitive awareness and effective strategy use are promoted when teachers make strategy use count in the classroom.

Strategy Reflection Sheet

What strategies did you use for this writing assignment?

___ BOTEC ___ Personalized Checklist

___ Mapping and Webbing ___ Sentence Starters

___ Graphic Organizer ___ Other:

___ Linear Outline ___ Introduction Template

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Figure 4a. Strategy reflection sheet for writing: Structured questions that scaffold the writing process.

The following sections focus on each of the key executive function processes, namely, setting goals, shifting flexibly/cognitive flexibility, organizing and prioritizing, accessing working memory and self-monitoring/self-checking. Strategies for addressing these processes are summarized briefly as well.

Goal-Setting

Goal-setting refers to the ability to set specific, realistic objectives that can be achieved within a defined period of time. Goal-setting also involves the selection of goal-relevant activities, predicting and planning for obstacles, effective and efficient strategy use, focused effort, and persistence. Goal-setting and planning help students to understand the task's objectives, identify the steps involved in accomplishing the task, and organize the time and resources needed to complete the task. When students set their own goals, they show greater commitment and are more motivated to attain these goals (Schunk, 2001; Winne, 1996, 2001; Zimmerman, 2000; Zimmerman & Schunk, 2001). Goal-setting also enhances self-efficacy, achievement, and motivation (Schunk, 2001). Krishnan, Feller and Orkin (2010) emphasize that goal-setting requires students to:

- Understand their learning strengths and weaknesses
- Understand the 'big picture' and envision the end point of a task
- Value the task
- Learn to set goals that are attainable

Strategy Reflection Sheet

What strategies did you use for this writing assignment?

_____

_____

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Figure 4b. Strategy reflection sheet for writing: Open-ended questions

Students who are able to set goals and shift from broad concepts and major themes to relevant details and back again (Meltzer, 2007), are usually more successful with the complex tasks that are typical in our 21st century schools. In contrast, students with poor self-understanding of their learning profiles often fail to set realistic short-term and long-term goals. This lack of direction often compromises their academic performance (Krishnan et al., 2010; Stone & Conca, 1993; Swanson, 1989; Torgesen, 1977).

Goal-setting and time management strategies are critically important for promoting independent learning (Hughes, Ruhl, Schumaker, & Deshler, 2002; Krishnan et al., 2010; Sah & Borland, 1989). Beginning in the early grades, students can be taught effective goal-setting and time estimation strategies. These strategies help students to build goal-oriented schedules by planning their schedules and estimating their work time for less structured homework time. Weekly and monthly calendars help to impose structure and build self-monitoring strategies so students can track deadlines for long-term projects, pace themselves when completing assignments, and monitor the accuracy of their time estimates. Strategies for juggling the amount of time assigned to homework, long-term projects, studying, and after-school activities are increasingly important as students advance through the grades. From the early grades, students also need to learn how to analyze the goals of their assignments and to plan their approach to long-term projects and papers. In the higher grades, students benefit from strategies for breaking down tasks into manageable parts so they can juggle multiple deadlines for many different ongoing assignments and projects.

Cognitive Flexibility/ Shifting

Cognitive flexibility, or the ability to think flexibly and to shift approaches, is probably the most important executive function process, and is often a major weakness in students with learning and attention difficulties (Meltzer, 1993; Meltzer

& Krishnan, 2007; Meltzer & Montague, 2001; Meltzer, Solomon, Fenton, & Levine, 1989). The ability to shift problem-solving approaches, to integrate different representations, and to adapt to unexpected situations develops across the lifespan and varies across individuals (Brown, 1997; Cartwright, 2008a, b, c; Deák, 2008; Dweck, 2008; Elliott & Dweck, 2005). Developmental changes from childhood into adulthood influence children's ability to manage the cognitive complexity of academic tasks and to process information from multiple sources simultaneously (Andrews & Halford, 2002; Cartwright, 2008a, b; Zelazo & Műller, 2002). In the elementary grades, students' understanding of the importance of using a range of different approaches is more limited than it is for middle and high school students. In the higher grades, students' ability to learn new concepts is often associated with their willingness to shift approaches flexibly and to abandon previously successful techniques (Cartwright, 2008a, b). Students' motivation, interest, passion, and emotional mindsets also influence their willingness to try different approaches and to shift flexibly from one approach to another, rather than continuing to rely on the same approach to tasks (Alexander, 1998; Paris, Lipson, & Wixson, 1983; Shanahan & Shanahan, 2008).

This ability to shift approaches and to synthesize information in novel ways is essential for effective reading, writing, math problem solving, note-taking, studying and test-taking. More specifically, accurate and efficient reading decoding requires students to flexibly coordinate the letter-sound relationships with the meanings of printed words (Cartwright, 2008a, b, c). In other words, students need to recognize the importance of what Gaskins (2008) refers to as "crisscrossing the landscape" in order to select decoding approaches that fit the text. Reading comprehension requires students to recognize the purpose or goal of reading, process the meaning of text, flexibly access their background knowledge (Cartwright, 2008a, b, c), and monitor their comprehension (Block & Pressley, 2002; Pressley & Afflerbach, 1995). Reading for meaning also taxes students' ability to flexibly manage many different types of linguistic information at the word-level, sentence level, and paragraph level (Brown & Deavers, 1999; Goswami, Ziegler, Dalton, & Schneider, 2001, 2003). More specifically, students must shift between the major themes and relevant details, between the concrete and the abstract, and between literal and symbolic meanings. Similarly, when writing, students need to shift between the important concepts and supporting information and they also need to separate their own perspective from that of the reader. In the math domain, students' understanding of concepts, computational procedures, and word problems depends on their cognitive flexibility. Students are required to shift from the words and sentences in math problems to the numbers, operations, algorithms and equations needed to solve the problems (Roditi & Steinberg, 2007). They also need to learn how and when to shift problem-solving schemas so their final calculations are accurate and logical (Montague & Jitendra, 2006). In content area subjects, including science and history, students are required to read texts where they need to differentiate main ideas from details.

Furthermore, many words and phrases have multiple meanings, and students' understanding of these texts depends on their use of context clues to shift flexibly among different possible meanings. Similarly, learning a foreign language requires a significant amount of flexible thinking, as students are challenged to shift back and forth between their native language and the language they are learning. Finally, studying and test-taking require students to shift among different topics and problem types as they are often presented with information that is formatted differently from the way in which they learned.

For students who struggle to shift flexibly between perspectives and to process multiple representations easily, academic tasks often become progressively more challenging as they advance beyond the first few grades in school. Furthermore, these students experience mounting difficulty as the curriculum demands increase in complexity and require them to interpret information in more than one way, change their approach when needed, and choose a new strategy when the first one is not working (Westman & Kamoo, 1990). Therefore, students need a variety of opportunities to practice shifting problem-solving approaches, to think flexibly, and to use their knowledge in different ways (Bereiter & Scardamalia, 1993; Dweck, 2008). When teaching emphasizes problem-solving and critical thinking, students are required to think flexibly about ways in which their solutions could lead to different possible outcomes (Sternberg, 2005). Furthermore, when teaching encourages peer discussion and collaborative learning, students are exposed to multiple viewpoints (Yuill, 2007; Yuill & Bradwell, 1998) and can be challenged to approach problems from the perspectives of their peers. Therefore, classrooms and schools that teach students to think flexibly and to solve problems from different perspectives across the grades and content areas lay the foundation for life-long success in their students.

Organizing and Prioritizing

"The way my mind works with that liquefied gobble of dots, my notes would look scattered on a page. One of the most useful strategies I learned was multi-column notes. With this system, I learned to make a hierarchy of notes and…. to use this structure to relate my ideas. This structure helped me to study and to write long papers." (Brandon, college graduate)

Organizing and prioritizing are important executive function processes that underlie most academic and life tasks. These processes affect performance from the earliest years and have a stronger influence in the higher grades when students are required to organize a large volume of materials and information. Reading and note-taking, studying for tests, and completing writing assignments all require students to impose their own structure on the information presented to them. How easily students learn and remember information depends on the ease with which they use strategies to organize and prioritize concepts and details, so that working memory is less cluttered (Hughes, 1996). While many students successfully participate in classes and accurately complete structured homework

assignments, they often have more difficulty with independent, open-ended tasks which require them to organize and prioritize information and ideas.

Students therefore need to learn strategies for systematically organizing and prioritizing their time, their materials, and their ideas. They also need to learn how to apply these strategies to their reading, writing, note-taking, studying, and test preparation. Instruction that includes organizational strategies should be explicit, systematic, and incorporated in the curriculum across the grades (Krishnan et al., 2010). In fact, teachers in the elementary grades usually create structured systems in their classrooms that help students to organize the materials in their desks, bookbags, and lockers. However, many students do not internalize these processes and they need additional activities that promote metacognitive awareness and self-understanding. Furthermore, students need activities that help them to understand their own learning profiles as well as the specific organizational strategies that they find helpful. As students advance to the higher grades, they are often expected to use planners, assignment books, binders, and notebooks independently; teachers need to build time into the daily school schedule to ensure that students are using these systems systematically. This structure remains important at the high school level when many students, especially students with learning and attention difficulties, still need explicit systems and strategies for organizing and prioritizing their homework, long-term assignments, and study time. When organizational strategies are taught systematically in the context of school assignments at all grade-levels, students become metacognitive learners who internalize these strategies and are more likely to succeed academically (Krishnan et al., 2010). Success, in turn, increases students' motivation to use these strategies independently and to generalize across different content areas and contexts (Meltzer, 1996, 2010; Swanson, 1999).

Strategies for organizing and prioritizing information underlie efficient reading comprehension, written language, note-taking, and studying. Templates, thinking maps, and graphic organizers provide a structured format for helping students to read for meaning, extract major themes, and relate new with known information (Kim, Vaughn, Wanzek, & Shangjin, 2004). Graphic organizers are also effective for improving students' reading comprehension, note-taking, and written language across a wide range of subject areas including language arts, science, and social studies (Bos & Anders, 1992; Bulgren, Schumaker, & Deshler, 1988). Most importantly, these organizational strategies can be taught across the grade levels from elementary school through high school (Horton, Lovett, & Bergerud, 1990; Krishnan et al., 2010; Scanlon, Duran, Reyes, & Gallego, 1992). Many students, especially students with learning disabilities, struggle to organize and prioritize their ideas for summarizing, taking notes, and writing. They often need assignments to be broken down explicitly with organizers and templates that match both the goals of the assignment and their learning profiles (Graham & Harris, 2003; Harris & Graham, 1996). Two- and three-column outlining and note-taking strategies can provide this structure. For example, the Triple Note Tote strategy (ResearchILD & FableVision, 2003) guides students

to find the main ideas, differentiate the major concepts and details, "chunk" information into manageable parts, predict test questions, and develop strategies for memorizing information.

As students are required to manage a larger and larger volume of information while juggling the time they allocate to their homework, extracurricular activities, and social activities, strategies for organizing and prioritizing their lives assume increasing importance so that they can remain focused on their goals.

Accessing Working Memory

Working memory refers to the ability to store information for short time periods while simultaneously manipulating the information mentally, e.g., holding the main themes in mind while sorting through the details, or calculating a math problem mentally. Working memory is a critically important process that focuses the mind, directs mental effort, and also helps students to ignore distractions and to accomplish tasks (de Frockert, Rees, Frith, & Lavie, 2001; Swanson, 1999; Tannock, 2008). In fact, Baddeley (2006) and Swanson (Swanson & Sáez, 2003) have proposed that working memory often functions as the "central executive" that directs all other cognitive processes, including a student's ability to inhibit impulses, shift attention, and direct effort to the task. Working memory, therefore, plays a critical role in listening comprehension, reading comprehension, oral communication, written expression, and math problem solving, as well as efficient and accurate long-term learning (Swanson & Sáez, 2003).

Memorizing information in the classroom is heavily dependent on students' ability to focus and sustain their attention in order to make connections, retain information, and retrieve relevant details (Tannock, 2008). In fact, attention and memory are so strongly linked that the two processes are often viewed as part of the same executive process (Swanson & Sáez, 2003). To remember, retain, and retrieve information, students benefit from learning strategies for sustaining their attention, attaching meaning to information, and chunking information to reduce the memory load, as well as rehearsal and review (Kincaid & Trautman, 2010). When students are able to make meaningful associations, they are more successful with the transfer of information into long-term memory and later retrieval (Mastropieri & Scruggs, 1998).

From 4th grade onwards, academic tasks rely increasingly on these working memory processes. Consequently, strategic students are generally more successful than their less strategic peers on tasks that require them to focus on multiple processes simultaneously, such as following directions, responding to oral questions, and completing multi-step instructions (Kincaid & Trautman, 2010). Reading comprehension and written language are also heavily dependent on working memory. In these areas, students need to remember and manipulate multiple details, such as spelling and punctuation, while simultaneously focusing on remembering the main ideas, organizing their ideas, prioritizing important information, and figuring out which details to ignore. Young students may also need to think about handwriting and accurate letter formation, which may not yet be automatic for them. Similarly, summarizing, taking notes, and studying for tests require students to focus on

multiple processes simultaneously and to remember key ideas, formulate notes while listening, and identify major themes while writing (Kincaid & Trautman, 2010).

Given the heavy memory load imposed in our 21st century information-driven classes, and the emphasis on working memory and mental manipulation, it is particularly important to explicitly teach memory strategies to improve students' ability to retain and retrieve facts, processes, and concepts. Teachers need to help students to learn how to prioritize and select information to be memorized, in order to reduce the load on working memory. Most importantly, students need to be given sufficient time to process and practice memory strategies, and to develop their own personalized strategies for remembering challenging information. Strategies for organizing and prioritizing complex information often help students to bypass their working memory difficulties by reducing the memory load. Strategies for chunking information and retaining important details can help students to mentally manipulate information in working memory and to recall more information (Mastropieri & Scruggs, 1991, 1998; Scruggs & Mastropieri, 2000). Mnemonics, acronyms, and crazy phrases help students to connect new information to what they already know and to make meaningful connections to seemingly disconnected information (Carney, Levin & Levin, 1993). Different types of mnemonics improve retention of information and enhance working memory, in particular, keywords, pegwords, acronyms, acrostics, and visuals (Mastropieri & Scruggs, 1991, 1998; Scruggs & Mastropieri, 2000).

Self-Monitoring and Self-Checking

Self-monitoring refers to the ways in which learners manage their cognitive and metacognitive processes to track their own performance and outcomes (Zimmerman, 1998, 2000; Zimmerman & Kitsantas, 1997; Zimmerman & Schunk, 2001). The ability to self-monitor depends on students' metacognitive awareness, as well as their flexibility in shifting back and forth from the end-product of their efforts to the goals of the tasks. Students' self-monitoring strategies are linked with their ability to recognize why, where, when, and how to use specific strategies, to check the effectiveness of their strategy use, to evaluate and revise their strategy use, and to continually adjust their use of strategies based on the task demands (Bagnato & Meltzer, 2010).

Many students, especially students with learning and attention problems, have difficulty reflecting, monitoring their own learning, and evaluating the connections among their effort, strategy use and performance. As they focus their effort on reading, writing, math problem-solving and content learning, they may struggle to monitor their attention and performance, and may have difficulty shifting among a range of problem-solving approaches or strategies that are available to them (Graham, Harris, & Olinghouse, 2007; Klingner, Vaughn, & Boardman, 2007; Montague, 2003). Students therefore need systematic, structured, and scaffolded instruction so that they begin to use self-monitoring strategies flexibly in order to become independent learners (Graham & Harris, 2003; Reid & Lienemann, 2006). For example, personalized checklists and mnemonics can help students to edit their writing by focusing on their organization of ideas, sentence structure, use of

tenses, and spelling. Similarly, checklists and questions can encourage students to check back and forth between the computational details and the main ideas, for example: "Does my answer make sense?"

Numerous studies have shown that systematic teaching of self-monitoring strategies can improve performance significantly (Graham & Harris, 2003; Harris & Graham, 1996; Reid, 1996; Reid & Harris, 1993; Shimabukuro, Prater, Jenkins, & Edelen-Smith, 1999). Explicit, structured teaching encourages students to slow down and to allocate the necessary time to spiral back and forth so that they can check their own performance in relation to the demands of different tasks (Meltzer, Sales Pollica, & Barzillai, 2007; Reid & Lienemann, 2006). Furthermore, students learn to recognize the value of shifting mindsets in order to review their work (Bagnato & Meltzer, 2010; Meltzer & Basho, 2010).

In summary, effective self-monitoring requires students to reflect on their progress towards a goal, to select strategies that match their learning profiles, and to alter strategies that are not effective (Bagnato & Meltzer, 2010). As will be discussed in the next section, students' motivation and emotional mindsets frequently affect their willingness to make the often superhuman effort needed to stop, reflect, check and correct their work. These self-monitoring processes are critically important for long-term academic and life success.

Emotional Self-Regulation

Students' attention and their ability to engage actively in the learning process are associated with their ability to regulate their emotions inside and outside the classroom (Brooks, 1991; Stein, 2010; Tangney, Baumeister, & Boone, 2004). The effects of emotion on the learning process follow a continuum. Specifically, extreme emotional reactions (e.g., anxiety, anger) often disrupt students' attention and ability to stay on task as well as their ability to learn and remember new information (Goldberg, 2001; Stein, 2010). In contrast, moderate emotional arousal has a positive influence on students' attention and executive function processes including working memory, cognitive flexibility, and inhibition (Gross, 2007; Stein, 2010). More specifically, the relationship between anxiety and performance is characterized by an inverted U-shaped curve. In other words, academic performance is often poor when students are not engaged and show low levels of anxiety, as a result of which they do not make the effort needed to succeed. At the other end of the spectrum, students' academic performance is compromised when their level of anxiety is so high that it interferes with their attention, working memory and overall performance (Goleman, 1995).

Students' self-understanding as well as their ability to regulate and shift their emotions are, therefore, important for efficient learning. As they develop strategies for regulating their emotional responses, they more easily attend to instructions, sustain their effort, and curb their frustration in response to difficult tasks (Stein, 2010). Self-regulatory strategies are particularly important for students with attention problems and learning disabilities. These students depend on structured approaches and routines that help to reduce

their emotional distractibility and impulsivity so that they can sustain their motivation and manage the many simultaneous demands of the classroom (Stein & Krishnan, 2007).

The SMARTS and Drive to Thrive Programs: Blending Executive Function Strategies with Peer Mentoring

Building students' emotional self-regulation in conjunction with the other executive function processes can be accomplished through school and classroom-based programs that promote students' self-understanding, self-concept, and consistent use of executive function strategies while promoting effort, persistence, and resilient mindsets.

The *Drive to Thrive* and SMARTS programs focus on building a cycle of academic success in all students through teacher training supplemented by a peer tutoring and peer mentoring system (Meltzer, 2013a, b; Meltzer, Katzir et al., 2004; Meltzer, Noeder et al., 2007; Meltzer, Reddy, Pollica et al., 2004; Meltzer, Reddy, Sales et al., 2004; Meltzer, Reddy, Brach, Kurkul, Stacey et al., 2011; Meltzer, Reddy, Brach, & Kurkul, 2012). Teachers are trained to create a culture of strategy use in their classrooms and to promote metacognitive awareness in their students by embedding executive function strategies in their curriculum and daily teaching practices. The following principles guide the programs (Meltzer & Basho, 2010; Meltzer, Katzir et al., 2004; Meltzer, Reddy, Pollica et al, 2004; Meltzer, Reddy, Sales et al., 2004; Meltzer, 2007):

- Teachers understand and acknowledge the interactions among effort, strategy use, academic self-concept and classroom performance as well as the cycle that builds persistence, resilience and long-term academic success.
- Teachers foster metacognitive awareness and strategic mindsets in their students.
- Teachers acknowledge that effort is domain-specific and that students may sometimes work hard in one content area (e.g., math) and not another (e.g., language arts).
- Teachers acknowledge the importance of peer mentoring and peer tutoring and they build time and resources into the school day for the purposes of implementing a program such as SMARTS (see below).

- Teachers acknowledge that peer mentoring and peer tutoring provide a powerful forum for helping students to understand their learning profiles, to develop metacognitive awareness, and to recognize the important roles of executive function strategies as well as effort and persistence.
- Students view themselves as part of a community of learners who can help one another through peer mentoring and peer tutoring (see below). Emotional self-regulation is also strengthened as part of this program.
- Students understand that executive function strategies and focused effort are important for academic success.
- Students recognize that persistence and determination are critical for fostering academic and life success.

- Students begin to value the *process* of learning as they become cognitively flexible and learn to shift flexibly during problem-solving and other academic tasks.

One example of a school-based peer mentoring program is the recently-developed SMARTS Executive Function and Mentoring program (Gray, Meltzer, & Upton, 2008; Meltzer, 2013b; Meltzer, Reddy, Brach, Kurkul, & Basho, 2011; Meltzer, Reddy, Brach & Kurkul, 2012; Meltzer, Kurkul, Reddy, Greschler, & 2013). SMARTS is an acronym for Success, Motivation, Awareness, Resilience, Talents, and Strategies, each of which is a core component of the program. The SMARTS program focuses on promoting resilience and academic success by teaching executive function strategies and building metacognitive awareness and persistence in all students, particularly in students with learning and attention difficulties**.** Teachers are trained to implement the SMARTS Executive Function and Mentoring Curriculum which comprises thirteen strategies in the core executive function areas and includes tasks that:

- Increase students' metacognitive awareness, self-understanding, and academic self-concepts.
- Improve students' understanding and use of executive function strategies in six broad areas: goal-setting, organizing, prioritizing, using working memory, shifting flexibly, self-monitoring.
- Increase students' effort and persistence in school as well as their motivation to engage in the learning process and to improve their academic performance.
- Promote students' mentorship and leadership skills through peer mentoring.

Students are placed in mentor-mentee pairs and work together to learn and practice executive function strategies, with mentors coaching their mentees to build their self-confidence. To reinforce the learning and application of these strategies, the SMARTS curriculum culminates in a project that focuses on improving students' engagement, motivation, strategy use, and effort (Gray, 2007; Meltzer, Reddy, Brach, Kurkul, Stacey et al., 2011).

Findings from our recent SMARTS intervention studies with middle and high school students have highlighted the importance of strengthening students' self-understanding, cognitive flexibility, and flexible thinking (Meltzer, Reddy, Brach, Kurkul, & Basho, 2011; Meltzer, Reddy, Brach, Kurkul, Stacey et al., 2011; Meltzer, 2013b). Specifically, findings from one of our school-based studies showed that SMARTS students with higher cognitive flexibility scores were more goal-oriented, more persistent, and made greater effort in school (Meltzer, Reddy, Brach, Kurkul, & Basho, 2011; Meltzer, Reddy, Brach, Kurkul, Stacey et al., 2011). These more flexible students also used more strategies in their schoolwork and were more organized. Classroom teachers rated these students as having stronger academic performance and as checking their work more frequently (Meltzer, Reddy, Brach, Kurkul, & Basho, 2011; Meltzer, Reddy, Brach, Kurkul, Stacey et al., 2011). The social connections provided by peer mentoring increased students' engagement in the learning process as well as their goal-orientation and motivation. Overall, students' cognitive flexibility, academic self-

concept, and goal-orientation influenced students' effort, persistence, and academic performance.

These findings have relevance for teachers and emphasize the importance of increasing students' self-understanding, knowledge of executive function strategies, and academic self-concepts. Together, these initiate a positive cycle in which students show increased effort and self-concept, and more consistent use of executive function strategies, resulting in improved academic performance (Meltzer & Basho, 2010; Meltzer, Sales Pollica et al., 2007). Stronger academic performance helps students to feel more engaged and more invested in making the effort to use strategies in their classwork, homework and long-term projects, the foundations of academic and life success.

Conclusions

Over the past few decades, technology has had a significant impact on the complexity and pace of the classroom curriculum and there is now greater emphasis on the importance of teaching students to problem-solve flexibly and to organize, prioritize, and self-monitor. For students with learning and attention difficulties, advances in brain-based measures will help us to refine our understanding of the effects of executive function weaknesses on academic performance as well as the efficacy of our interventions. These techniques will eventually help educators and parents to foster flexible thinking, effort, persistence, and resilience so that we can improve the long-term outcomes for students with learning and attention difficulties.

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Pilot Study for Standardizing Rapid Automatized Naming and Rapid Alternating Stimulus Tests in Arabic

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Abstract

This study examined the acceptability, reliability, and validity of the Arabic translated version of the Rapid Automatized Naming and Rapid Alternating Stimulus Tests (RAN/RAS; Wolf & Denckla, 2005) for Jordanian students. RAN/RAS tests are a vital assessment tool to distinguish good readers from poor readers. These tests have been demonstrated to be reliable and valid across different gender, racial, age, and language groups. This pilot study had four major phases: forward-backward translation, training of the examiners, pilot standardization, and estimation of reliability and validity. A sample of 250 students (six to nine years old) was recruited from four public primary schools in Jordan. Results indicated that the Arabic RAN/RAS Tests are valid, reliable, and cost-effective measures of predicting reading ability. Specifically, Arabic RAN/RAS Tests can be used with confidence to identify students who are at risk of reading difficulty.

Studies have shown that students who are not successful in learning early literacy skills in the first years of schooling are likely to remain poor readers in later years (Francis, Shaywitz, Stuebing, Shaywitz, & Fletcher, 1996) and, consequently, have reduced motivation and poor self-esteem (Torgesen, 2004).Early intervention to prevent the development of reading difficulties can be an effective way to ameliorate this problem (Torgesen et al., 1999). Therefore, screening in the early grades should accurately identify students at risk for failing to develop skills in reading. Accordingly, it is necessary to investigate the cognitive correlates of reading skills to identify students who are predicted to struggle with reading or language acquisition.

Previous research has identified several cognitive and academic variables that are correlates or causes of reading disabilities. Specifically, hypotheses about the causation of specific reading disabilities, or dyslexia, have been derived from theories regarding the relationships between and among basic reading skills and phonological awareness (e.g., Abbott, Walton,& Greenwood, 2002; Catts, 1996; Torgesen, Wagner, Rashotte, Burgess, &

Hecht, 1997), working memory (de Jong, 1998; Swanson & Saez, 2003), rapid automatized naming (RAN; Catts, Gillispie, Leonard, Kail, & Miller, 2002; Denckla & Cutting, 1999; Wolf & Bowers, 1999; Wolf, Bowers, & Biddle, 2000), and processing speed (Kail, Hall, & Caskey, 1999; Nicolson & Fawcett, 1999).However, among these factors, phonological awareness and RAN are particularly important theoretically because of the double-deficit hypothesis proposed by Wolf and Bowers (1999). According to the hypothesis, individuals with deficits in both phonological awareness and RAN will experience more severe reading difficulties than individuals with only one of the deficits. Because research to date has been conducted primarily to investigate phonological awareness (e.g., Torgesen et al., 1997), the focus of this study was to validate the role of RAN in Arabic language reading.

Several decades of research consistently point to strong relations between reading and RAN (for review see Bowers, Golden, Kennedy, & Young,1994; Wolf, 1997).Naming speed, or RAN, is defined as the speed at which names are retrieved in identifying colors, letters, digits and objects; slow RAN scores appear to differentiate readers with dyslexia from typical readers (Catts et al., 2002; Denckla & Cutting, 1999; Wolf et al., 2000).Wolf and Denckla (2005) concluded that both naming speed and reading can be conceptualized as a large system with multiple and overlapping perceptual, cognitive, linguistic, and motoric processes (for a review see Wolf & Bowers, 1999, 2000).

Despite the acknowledged importance of RAN in predicting reading, there is still no consensus as to what cognitive process or processes are driving the relationship between RAN and reading and how RAN's influence changes across time(e.g.,Närhi et al., 2005). Torgesen, Wagner and their colleagues (e.g., Torgesen, Wagner, &Rashotte, 1994; Torgesen et al., 1997) have argued that RAN tasks primarily assess the rate of access to and retrieval of stored phonological information in long-term memory (or speed of lexical access). In addition, Kail et al. (1999) suggested that cognitive processing speed would mediate age-related changes in phonological awareness, naming speed, and visual-spatial skills because each of these constructs may be directly affected by the speed of processing. An important component of this view is that a weakness in processing speed impacts not only reading but all other related language skills. On the other hand, Wolf and Bowers (1999) presented RAN as another possible correlate of reading disability, accounting for a significant amount of variance over and above what is explained by phonological awareness.

Another open question focuses on the need to use and compare the influence of different RAN tests. Researchers have also investigated the different formats of RAN tasks (objects, colors, numbers, letters;e.g., Bowey, McGuigan, &Ruschena, 2005; Neuhaus, Foorman, Francis, & Carlson, 2001; van den Bos, Zijlstra, &Broeck, 2003; Wolf & Bowers, 1999). As an additional procedure, Wolf and Denckla (2005) introduced Rapid Alternating Stimulus (RAS) tasks as promising predictors of reading ability. These tasks require students to name 2- and 3- set combinations of letters, numbers, and colors. The new RAN/RAS Tests contain RAS tasks in the following formats: (a) 2-set letters and numbers, and (b) 3-set

letters, numbers, and colors. Currently, very little research exists regarding the utility and significance of RAS tasks.

Recently, Abu-Hamour, Urso and Mather (2012) conducted a comprehensive literature review to explore findings on the relationship between RAN and reading skills. They concluded that: (a) RAN letters followed by RAN numbers are the strongest predictors of reading skills (Bowey et al., 2005; Compton, 2003; Neuhaus et al., 2001; Van den Bos et al., 2003); (b) RAN appears to be distinct from phonological skills in the sense that it accounts for independent variance in word reading and reading comprehension (Manis, Doi, & Bhadha, 2000; Wolf & Bowers, 1999); (c) the independent contribution of RAN to word reading and reading comprehension is larger for younger readers and students with reading disabilities (Manis et al., 2000; Wolf & Bowers, 1999); (d) RAN accounts for independent variance in both word-reading accuracy and speed, although the relations are stronger with speeded measures (Manis, Seidenberg, & Doi, 1999; Wolf & Bowers, 1999); (e) RAN is not an effective predictor of non-word reading skills (Manis et al., 1999; Wolf & Bowers, 1999); (f) RAN has a strong correlation with orthographic skills (Cutting & Denckla, 1999; Manis et al., 1999; Sunseth & Bowers, 2002; Wolf & Bowers, 1999); and (g) RAN can be used with confidence to predict later reading in many languages other than English (Landerl &Wimmer, 2000; van den Bos, Zijlstra, &Lutje Spelberg, 2002).

Moreover, available studies confirm that RAN plays an essential role in learning and predicting reading in shallow orthographies, that is to say, in orthographies in which there is a high rate of grapheme-phoneme correspondence (deJong & van der Leij, 2002; Landerl & Wimmer, 2008). Under these circumstances the phonological requirements are reduced, which means that in languages such as German (Wimmer & Mayringer, 2002) and Dutch (de Jong & van der Leij, 2002), phonological decoding is easily learned, and when there are difficulties they are related to reading speed or fluency. Therefore, in shallow orthographies, deficits in RAN represent one of the main characteristics of reading disabilities, and RAN is a better predictor of reading performance than is phonological awareness (de Jong & van der Leij, 2002). Different results have been documented recently in the Arabic language by Taibah and Haynes (2011).The researchers investigated contributions of phonological awareness, rapid naming (object, color, letter, and digit) and phonological memory to basic decoding and fluency skills in Arabic in Grades K-3. Within-grade analyses indicated that phonological awareness accounted for more variance than RAN, regardless of grade or the nature of the reading outcome measure. However, RAN's capacity to predict variance, while less than that of phonological awareness, tended to rise steadily and was highest in Grade 3. This may be due to the transition of the Arabic language orthography from being shallow and transparent to being deep and opaque in Grade 3 (Abu-Rabia & Siegel, 2002, 2003).Given the orthographic shift from transparency to opacity that occurs in Arabic, questions arise as to the role that RAN may play in predicting reading development.

Several graphical features of the Arabic language create certain difficulties in learning and teaching reading skills. First, Arabic is an alphabetic language with 28 letters, written in

a joined fashion from right to left (Abu Rabia & Siegel, 2002). All letters are consonants except for three long vowels. Another three short vowels (diacritics) do exist in the form of separate diacriticals, not as independent graphemes. When one of these diacritics appears on certain letters, it gives the letter a completely different sound; for example, the letter *k* could have any one of the sounds /ka/, /ki/, or /ku/. If the same letter *k* comes in a word where it does not need a vowel, its sound will be /ek/. Therefore these diacritics or short vowels appear in Arabic script with a high degree of regularity and students can read by predicting the sound of the letters. However, in most modern and printed Arabic text (Grade 3 and above) vowel signs are not given, therefore reading relies more on the context rather than spelling and Arabic script becomes more irregular (Abu Rabia, 2002; Abu Rabia & Siegel, 2002). Second, Arabic script is written in a cursive fashion, where each individual letter has multiple forms or shapes according to its position within the word. Many letters, furthermore, have similar graphemes but their phonemes are completely different. In the Arabic alphabet, twenty letters have grapheme similarity with at least one or two other letters (Breznitz, 2004). Third, a greater influence of orthographic processing over phonological processing could be related to diglossia in Arabic. Saiegh-Haddad (2007) has argued that differences between the spoken form of Arabic experienced by the pre-school child (e.g., a local dialect) and the standard form of Arabic used in education and writing disrupts the construction of phonological representations of Arabic. Fourth, the glottal stop in Arabic, referred to as the "hamza", although a fully functioning consonant, is treated as a diacritical mark and can be written many different ways, depending on its position in the word, resulting in various complex spelling conventions (Elbeheri, Everatt, Mahfoudhi, Abu Al-Diyar, &Taibah, 2011).

With such challenges to teaching and learning the Arabic language, it is necessary to explore valid and reliable measures that can be used to predict reading. Arab countries lack screening and diagnostic tests that can be used to identify students with reading disability (Al-Natour, Al-Khamra, & Al-Smadi, 2008; Taibah & Haynes, 2011).This study was intended to measure Arabic RAN using the Arabic version of Rapid Automatized Naming and Rapid Alternating Stimulus Tests (RAN/RAS; Wolf & Denckla, 2005) among students in Grades1 to 4.

Brief Description of RAN/RAS Tests

RAN/RAS Tests are used to assess naming speed. On RAN Tests, examinees are asked to recognize and name accurately and rapidly visual symbols, such as letters, numbers, objects, and colors. The RAS Tests comprise 2-Set Letters and Numbers and 3-Set Letters, Numbers, and Colors. Wolf and Denckla (2005) reported test-retest corrected reliability coefficients ranging from .81 to .98 for different educational levels (i.e., elementary, middle, high school, and all ages). A second type of reliability, inter-rater reliability, ranged from .98 to .99 for the RAN/RAS Tests. Regarding validity, the content validity evidence is solid and the RAN/RAS tasks are consistent with many similar tasks found in the literature. Content validity assesses whether a test covers the right material; it is built into the test during its

development. In this instance, the objects, colors, numbers, and letters that comprise the tests were all high frequency items that had been used in prior research.

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Regarding criterion-prediction validity, the manual provides correlations with tasks similar to those found in the Comprehensive Test of Phonological Awareness (CTOPP: Wagner, Torgesen, & Rashotte, 1999; $r = .71$ and $r = .72$). The magnitude of these correlations does indicate acceptable criterion-related validity for the RAN/RAS. In addition, the test's manual confirms an expected negative correlation between age and performance. The correlations between reading tasks and the RAN/RAS tests are, as expected, more moderate, but still lend support for the RAN/RAS tests. These results are very promising since the Arabic RAN/RAS Tests will be used ultimately to identify students at risk for reading failure.

Significance of the Study

Reading disabilities need to be assessed at early stages and the earlier the assessment, the better chance of positive outcomes in education (Torgesen, 2004). Reading difficulties are a concern for all nations and communities. Specific learning disabilities that lead to problems with acquiring literacy have an estimated prevalence rate of, on average, about 5% to 8% of a population within many different countries around the world (Smythe, Everatt, & Salter, 2004). The difficulty and complexity of Arabic language orthography supports the need to validate a screening tool such as RAN/RAS Tests in Arabic to predict reading skill in the early stages of school. RAN may be a marker of difficulties in orthographic, rather than phonological, processing (e.g., Bowers et al., 1994; Wolf et al., 2000). Although phonological measures can provide a basis from which to identify and predict reading difficulties, additional measures that can predict the sophisticated orthographical features of Arabic should be able to provide more precise predictions of Arabic literacy learning (Al-Mannai & Everatt, 2005; Elbeheri et al., 2011).Educational systems in Arab countries lack valid and reliable assessment tools that can be used to identify students who are at risk of developing reading difficulties. For example, researchers in Jordan have stated in numerous reports and articles that the Jordanian educational system is in need of valid assessment tools to identify students with reading disability and provide them with appropriate interventions (Al-Khateeb, 2008; Al-Natour, 2008).

In Jordan, despite tremendous work in providing remedial and special education services to students with special needs, the directorate of special education still faces various challenges. Al-Khateeb (2007), consultant to the Ministry of Education, highlighted some of these challenges; they include lack of screening and diagnostic tests, and lack of standardized measures to identify students with reading disability. Al-Natour et al. (2008) came to the same conclusion, stating: "due to the absence of formal diagnostic tools, it is almost impossible to estimate the prevalence of reading disability in Jordan" (p. 72). Developing a

formal assessment tool that can be used to determine reading disability is a necessity in Jordan as well as other Arab countries. The development of a screening instrument for the purpose of identifying at-risk children at the time of school entry and providing identified children with systematic interventions is very important (Al-Khateeb, 2007, 2008; Al-Natour, 2008; McBride, 2007).When a child's problems are recognized early, school failure can to a large extent be prevented or reduced (Raikes et al., 2006).

Studies that have examined predictors of early reading skill in Arabic are sparse. To the author's knowledge, no studies have been conducted to investigate the applicability, reliability, and validity of RAN/RAS Tests measures to Arabic speaking children, with the exception of the recent Arabic studies that correlated a couple of RAN measures with reading outcomes (Elbeheri et al., 2011; Taibah & Haynes, 2011). Re-standardizing a reliable, valid, and cost-effective measure like the RAN/RAS Tests should be apriority for Arabic speaking countries.

Purposes of the Study

The purposes of this study were to explore the RAN/RAS Tests' acceptability, reliability, and validity in Jordanian students who speak the Arabic language. This study addressed the following questions:

Study Question 1: Are the Arabic RAN/RAS Tests reliable measures of the naming speed?
Study Question 2: Are the Arabic RAN/RAS Tests good measures for distinguishing naming ability among different ages?
Study Question 3: Will the intercorrelation of Arabic RAN/RAS Tests scores be high?
Study Question 4: What is the relationship between the Arabic RAN/RAS Tests and Arabic Language Grade Point Average?
Study Question 5: Can the Arabic RAN/RAS Tests be used to identify children with reading disabilities from children with average reading abilities?
Study Question 6: What is the best model among Arabic RAN/RAS Tests for predicting average third grade reading skill?

Method

Participants

A total sample of 250 children (200 without reading difficulties and 50 with SLD in reading) from six to nine years old participated in the study. Arabic speaking participants were recruited from four public primary schools in the southern region of Jordan. The first sample covered first, second, third, and fourth grade with 50 average reader participants for each grade. These students were required to have an Arabic Grade Point Average (Arabic GPA) of 67 and above. Another sample comprised 50 third grade students with SLD; it was recruited to answer the fifth question of the study. Students with reading disability can be easily found in Grade 3 and above because Arabic orthography starts to shift from being shallow and transparent to being deep at this grade level. The second sample of students was

identified by resource room teachers to be participants in this study. Due to the lack of standardized assessment in Jordan, these teachers rely heavily on teacher-made tests of academic achievement and some other checklists, rating scales and observations of reading disability to make eligibility decisions. In addition, for the purpose of this study, an Arabic GPA of 66 and below was used as a cut off point for the inclusion of students with SLD.

All participants were chosen randomly and consent forms were sent to parents, seeking their agreement for participation. Parents who agreed to let their children participate in the study were asked to complete a short questionnaire that addressed the inclusion criteria of this study. The participants were selected from a larger set of students (623) who were assessed to meet the requirements for inclusion in the study: intelligence within the average range, native speakers of Arabic, no noted emotional or behavioral disorder, no noted attention disorders, and no sensory impairments. The Arabic RAN/RAS Tests were administered to all participants. In addition, a word reading list was administered to third grade students with and without reading difficulties. The reading list words (nouns and verbs) were selected from several literature-based reading series used in the educational system in Jordan as supplementary materials to the accredited third grade curriculum. The words represented the reading skills that students are expected to master throughout the entire school year. The sample's characteristics with regard to age, grade, gender, and students with SLD in reading are presented in Table 1.

Table 1.

The Sample's Characteristics

Age in Years	Age Range in Months	Mean Age in Months	Grade	Gender		Students with SLD	Total Number of Students
				Female	Male		
6	75-82	79	1	25	25		50
7	88-94	91	2	24	26		50
8	100-107	103	3	50	50	50	100
9	112-118	115	4	24	26		50
							250

Note. SLD=Specific Learning Disability in Reading.

Procedure

The translation, reliability, and validity, as well as descriptions of the study measures, are presented in the following sections. The pilot study of the Arabic RAN/RAS Tests was normed on a sample of 200 participants in Grades 1to 4. Another sample of 50 third grade students with SLD in reading also participated. Incentives (pencils and stickers) were given to all participants. The two samples were assessed in the spring semester of the 2012

academic year. The data were collected for both samples by four trained teachers residing in the southern region of Jordan. These teachers have a degree in special education and childhood education. During the data collection, the author had weekly updates and discussions with the examining team to address crucial points in the tests' administration and to provide feedback.

Translating the RAN-RAS Tests into the Arabic language. The researcher utilized appropriate translation procedures (Brislin, 1986) prior to administering the Arabic RAN/RAS Tests to a sample of Jordanian students. First, two native speakers of Arabic, fluent in English, independently translated the RAN-RAS Tests into Arabic. Second, a back translation of the Arabic version into English by a bilingual resident of the United States who is fluent in both English and Arabic languages was conducted. Third, all translators reached a reconciliation of the forward-backward translations. Fourth, a pre-test was conducted with a convenience sample of 20 children (6-9 years) to assess ease of comprehension, possible ambiguities, and alternative wording. Finally, the author asked three referees in the field of educational assessment who work in two universities in Jordan to judge the content of the Arabic RAN/RAS Tests, the administration procedures, and the accuracy of the translation by comparing it with the original English RAN/RAS Tests. All suggested changes were taken into consideration to improve the Arabic version of RAN/RAS Tests.

Reliability studies. Instruments that have adequate reliability will measure true if they yield the same scores across short periods of time and across different examiners. Instruments that have poor reliability will usually yield markedly different scores when given at different times, when administered by different people, or when different forms are used. The researcher investigated two types of reliability in this study of the Arabic RAN/RAS Tests: test-retest reliability and inter-rater reliability.

Test-retest reliability. The Arabic RAN/RAS Tests were administered twice to the same sample (the 200 students without disabilities); the intervening time was approximately two weeks. The mean timing scores and standard deviations for the first and second testings and correlations between the two testings are found in Table 2. The resulting coefficients, which range from .85 to .96, are large enough to demonstrate that the pilot normative evaluation has acceptable test-retest reliability.

Inter-rater reliability. Two examiners scored 25% of the tests independently. The correlation between the two scorers yields a relational index of agreement. The results of these scorings were correlated, and the coefficients ranged from .98 to .99. The coefficients, listed in Table 4, provide strong evidence supporting the Arabic RAN/RAS Tests' inter-rater reliability.

Validity studies. According to the *Standards for Educational and Psychological Testing* (AERA, APA, & NCME, 1999), validity "refers to the degree to which evidence and theory support the interpretations of test scores entailed by proposed uses of tests" (p. 9). Several types of validity were tested to evaluate the Arabic RAN/RAS Tests. First, content validity was established by examining the appropriateness of the types of items included, the

completeness of the item sample, and the way in which the items assess the content. In this instance, the objects, colors, numbers, and letters that comprise the tests were all high frequency items that had been used in prior research. Second, to investigate construct validity, intercorrelations of Arabic RAN/RAS Tests scores were calculated. In addition, various statistical analyses were performed to explore whether Arabic RAN/RAS Tests could differentiate performance among different ages or grades.

Table 2.
Test-Retest Reliability for the Arabic RAN/RAS Tests

	First Testing		**Second Testing**		
Grade Level of Sample	*M*	*SD*	*M*	*SD*	*r*
First Grade (*n* = 50)					
Objects	55.42	14.27	54.18	15.59	.85
Colors	54.66	13.26	52.38	12.72	.89
Numbers	47.50	14.39	45.64	14.05	.94
Letters	48.92	17.20	46.44	16.27	.96
2-Set Letters and Numbers	60.04	19.53	58.00	19.171	.91
3-Set Letters, Numbers, and Colors	64.70	19.17	61.18	17.61	.91
Second Grade (*n* = 50)					
Objects	50.94	13.99	49.96	14.37	.86
Colors	48.80	12.69	47.20	13.43	.92
Numbers	34.68	8.72	32.72	9.25	.95
Letters	36.96	11.47	34.46	11.40	.95
2-Set Letters and Numbers	47.78	12.51	45.44	13.82	.94
3-Set Letters, Numbers, and Colors	49.84	13.60	48.42	13.77	.94
Third Grade (*n* = 50)					
Objects	47.22	7.98	44.26	9.16	.88
Colors	50.00	11.08	48.74	12.091	.89
Numbers	33.62	8.65	31.42	9.24	.94
Letters	34.98	6.74	32.24	6.72	.93
2-Set Letters and Numbers	43.70	10.32	40.42	10.11	.93
3-Set Letters, Numbers, and Colors	48.00	13.37	45.90	13.32	.93
Fourth Grade (*n* = 50)					
Objects	45.18	9.003	43.08	9.33	.88
Colors	44.96	8.583	42.00	9.09	.88
Numbers	32.56	10.912	31.08	10.73	.95
Letters	33.12	10.644	30.30	11.09	.96
2-Set Letters and Numbers	38.38	9.812	35.22	10.28	.93
3-Set Letters, Number and Colors	39.74	10.747	37.42	11.18	.95

Table 2. (Continued)

	First Testing		**Second Testing**		
Grade Level of Sample	*M*	*SD*	*M*	*SD*	*r*
All Grades (*N* = 200)					
Objects	49.69	12.22	47.87	13.15	.87
Colors	49.61	11.97	47.58	12.43	.90
Numbers	37.09	12.42	35.72	12.36	.95
Letters	38.50	13.51	36.36	13.24	.96
2-Set Letters and Numbers	47.48	15.70	45.02	15.56	.94
3-Set Letters, Numbers, and Colors	50.67	17.02	48.48	16.45	.94

Note. *M*=Mean, *SD*=Standard Deviation, *r*=Correlation Coefficient.

Criterion-related validly was investigated by conducting Pearson product moment correlations between Arabic RAN/RAS Test scores and Arabic language GPA. The Arabic GPA reflects students' ability on three basic Arabic skills: reading, writing, and spelling in the accredited Arabic curriculum in Jordan. The Arabic GPA is a numeric average of all grades achieved in a given school semester. The purpose of GPA is to provide a barometer of overall performance of a student in his or her classes, as well as to create a system that allows for comparisons between students, and a class ranking system. In the Jordanian educational system, students are ordered and assigned a numerical rank against their peers based on their GPA, starting with number 100 for the student with the highest GPA and 0 for the student with the lowest GPA. The rubric for the Arabic GPA is excellent (90-100), very good (80-89), good (70-79), satisfactory (60-69), minimal pass (50-59), and failure (< 50). In this research, the mean Arabic GPA of the average reader was 79, with a range of 67 to 98 and standard deviation of 9.6. For students with SLD, the mean was 52, with a range of 40 to 66 and standard deviation of 6.8.

Finally, to distinguish good readers from poor readers and predict reading ability, the RAN/RAS Tests scores were used to predict reading scores on a list of one hundred and thirty words. This list was developed by the researcher to assess word reading growth during third grade and administered to 50 students without reading difficulties and to 50 third grade students with SLD in reading. This word list was constructed from the curriculum they were expected to learn (e.g., Deno, 1985; Shinn, 1989).

Arabic RAN/RAS Tests

The Arabic RAN/RAS Tests consist of six brief, individually administered tests of naming speed. The RAN portion comprises four tests, each prompted by a set of familiar stimuli (objects, colors, numbers, or letters). Each set consists of five high-frequency items (randomly repeated to yield 50 items per set). The RAS portion comprises two tests, each prompted by a set of familiar stimuli. One of these, "2-Set Letters and Numbers," consists of

50 alternating letters and numbers. The second, "3-Set Letters, Numbers, and Colors," consists of 50 alternating letters, numbers, and colors. Each of the six tests is presented by way of a glossy, folded cardboard sheet that the manual refers to as a stimulus card. The cover (8.5 x11 inches) has 10 practice items presented in two rows of 5. Unfolded, the sheet (17 x11 inches) displays the actual test: 5 rows, with each row containing 10 of the stimulus items.

Administration requires the six stimulus cards, an examiner record form, and a stopwatch. Simple directions for administration are conveniently printed on the examiner's record form. The 10 items on each cover serve as a "practice run" in order to check that the child can identify the items and so that he or she understands to work as quickly and accurately as possible. Once the practice items are completed, the examiner unfolds the stimulus card to display the 50 stimuli. The examinee is directed to read the items as quickly as possible without making mistakes. All tests take only 5 to 10 minutes to administer.

Results

Preliminary Data Analysis

The Kolmogorov-Smirnov test was performed to test the hypothesis that the data were normally distributed. The data for average readers displayed normal distributions for all Arabic RAN/RAS Tests, Arabic GPA, and Word Reading variable *D* (50). The statistics ranged from .11 to .23; all statistics were non-significant ($p > 0.05$). Slightly lower performances (positively skewed distributions) were detected in the SLD students. This finding was expected due to the fact that some of the students were identified by their teachers as low achievers. To improve the shape of the distributions, the responses of outliers whose scores were ±2 SD or more from the group mean were replaced by a value equal to the next highest non-outlier-score plus 1 unit of measurement (Tabachnick & Fidell, 2001).

The Standard Error of Measurements

The Standard Error of Measurements (SEMs), reported in Table 3, can be used to estimate the confidence interval that surrounds a particular test score. The SEM is based on the formula $SEM = \text{SD} \times \sqrt{1 - r}$ (SD: Standard Deviation and *r*: reliability) and establishes a zone within which an individual's true score probably lies. The smaller the SEM, the more confidence one can have in the test's results. RAN/RAS Arabic Tests have small SEMs (ranging from 1.78 to 5.85); examiners can use it with confidence.

Table 3.

Standard Errors of Measurement (SEMs) at Four Grade Levels

	Grade Level				
RAN/RAS Tests	First Grade	Second Grade	Third Grade	Fourth Grade	Average
Objects	5.52	5.23	2.76	3.11	4.15
Colors	4.39	3.58	3.67	2.97	3.65
Numbers	3.52	1.94	2.11	2.43	2.5
Letters	3.44	2.56	1.78	2.12	2.47
2-Set Letters and Numbers	5.85	3.06	2.73	2.59	3.55
3-Set Letters, Numbers, and Colors	5.75	3.33	3.53	2.40	3.75

Note. SEMs are based on time sampling reliability coefficients reported in Table 2.

Table 4.

Summary of the Arabic RAN/RAS Tests' Reliability Related to Two Types of Reliability

	Reliability Coefficient	
RAN/RAS Tests	Test-Retest	Inter-Rater
Objects	.87	.99
Colors	.90	.98
Numbers	.95	.98
Letters	.96	.99
2-Set Letters and Numbers	.94	.99
3-Set Letters, Numbers, and Colors	.94	.99

The Arabic RAN/RAS Tests' Validity

Age differentiation. The raw score means and standard deviations for the Arabic RAN/RAS Tests at four age intervals are presented in Table 5. The contents of the table demonstrate that the measures are related to age. Means become smaller as the participants grow older (i.e., older children take less time to name the stimulus items). This observation is verified by the coefficient found in the bottom row of the table, which shows the relationship of age to test performance. The correlations range from -.36 to -.54 across the six tests.

Table 5.
Means and Standard Deviations for the Arabic RAN/RAS Tests at 4 Age Intervals and Correlations with Age

	RAN/RAS Tests											
	Objects		Colors		Numbers		Letters		2-Set Letters and Numbers		3-Set Letters, Numbers, and Colors	
Age	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
6	55.42	14.27	54.66	13.26	47.50	14.39	48.92	17.20	60.04	19.53	64.70	19.17
7	50.94	13.99	48.80	12.69	34.68	8.72	36.96	11.47	47.78	12.51	49.84	13.60
8	47.22	7.98	50.00	11.08	33.62	8.65	34.98	6.74	43.70	10.32	48.40	13.42
9	45.18	9.00	44.96	8.58	32.56	10.91	33.12	10.64	38.38	9.81	39.74	10.74
Correlation with Age	-.36		-.35		-.46		-.44		-.51		-.54	

Note. All correlations coefficients are significant at the $p < .01$ level.

Intercorrelation of Arabic RAN/RAS Test scores. Because all of the Arabic RAN/RAS tests measure visual-verbal processing speed, one would expect them to be highly related. The raw scores of the entire pilot sample were intercorrelated. The resulting coefficients are reported in Table 6. The correlations are statistically significant at the $p < .01$ level of confidence and are indicative of at least large relationships (i.e., r values above .50). Obviously, the relationship between Letters and Numbers was very high (i.e., r values above .70).

Table 6.
Intercorrelation of Arabic RAN/RAS Tests

RAN/RAS Tests	Objects	Colors	Numbers	Letters	2-Set Letters and Numbers	3-Set Letters, Numbers, and Colors
Objects	1	.72	.71	.72	.76	.71
Colors	.72	1	.71	.68	.71	.73
Numbers	.71	.71	1	.86	.82	.84
Letters	.72	.68	.86	1	.81	.80
2-Set Letters and Numbers	.76	.71	.82	.81	1	.93
3-Set Letters, Numbers, and Colors	.71	.73	.84	.80	.93	1

Note. All correlations coefficients are significant at the $p < .01$ level.

Relationship of Arabic RAN/RAS Tests to Arabic GPA. The RAN/RAS Tests scores were correlated with the Arabic GPA for all participants in the first sample. All of the coefficients are statistically significant; they range in magnitude from -.22 to -.35 across the six tests. The highest correlation was found between the Arabic GPA and RAN Numbers and the lowest between the Arabic GPA and RAN Objects.

Table 7.
Relationship of Arabic RAN/RAS Tests to Arabic Language Grade Point Average (Arabic GPA)

RAN/RAS Tests	Arabic GPA
Objects	-.22
Colors	-.27
Numbers	-.35
Letters	-.30
2-Set Letters and Numbers	-.28
3-Set Letters, Numbers, and Colors	-.28

Note. All correlations coefficients are significant at the $p < .01$ level.

Distinguishing good readers from poor readers. Another way to demonstrate a test's validity is to show that its scores discriminate between relevant groups. In the case of the rapid naming tests, it would be important to show that the test scores clearly delineated groups of children with average reading abilities from groups of children with dyslexia or reading delays or any other conditions that might cause them to do poorly on tests of serial rapid naming (Wolf & Denckla, 2005).

The average naming speed difference between third grade students with and without SLD. All assumptions for performing independent *t*-tests were examined. No violations of normality and homogeneity of variance were detected. The variances were equal for the SLD student group and the average reader student group, $F(1, 98) = .68$, $p = 0.411$, which is greater than 0.05. On average, students with SLD took a longer time in average naming speed ($M = 49.91$, $SD = 7.83$) than did students without disabilities ($M = 42.99$, $SD = 7.88$). This difference was significant, $t(68) = -4.40$, $p = 0.000$, which is less than 0.05, and represents a medium-sized effect ($r = .40$).

The average reading difference between third grade students with and without SLD. All assumptions for performing independent *t*-tests were examined. No violations of normality and homogeneity of variance were detected. The variances were equal for the students with SLD group and the students without disabilities group, $F(1, 98) = .21$, $p = 0.645$, which is greater than 0.05. On average, students with SLD correctly read fewer words ($M = 84.80$, $SD = 9.70$) than did students without disabilities ($M = 97.54$, $SD = 9.60$). This

difference was significant, $t(68) = 6.95$, $p = 0.000$, which is less than 0.05, and represents a medium-sized effect ($r = .57$).

The Arabic RAN/RAS Tests' predictive model of word reading for third grade average readers. To test this hypothesis, individual hierarchical multiple regression was performed to test the relative contributions of Arabic RAN/RAS Tests in the prediction of word reading. Assumptions were tested by examining normal probability plots of residuals and a scatter diagram of residual versus predicted residual. No violations of normality, linearity, or homoscedasticity of residuals were detected. In addition, box plots revealed no evidence of outliers. RAN Letters and then RAN Numbers were entered in the first block. RAS 2-Set Letters and Numbers; RAS 3-Set Letters, Numbers, and Colors; RAN Colors; and RAN Objects were entered in the second block. Regression analyses revealed that the best model for predicting word reading for the third grade students consisted of just RAN-Letters and Numbers Tests $F(2, 47) = 17.62$, $p < .05$; R^2 for the model = .42, and adjusted $R^2 = .40$. Table 8 presents the hierarchical regression predicting word reading by RAN/RAS Tests.

Table 8.
Hierarchical Regression Predicting Word Reading by RAN/RAS Tests

Predictor Variables	Zero-order *r*	*B*	*SEB*	β
Step 1				
Constant		129.89	5.71	
RAN letters	-.65	-.95	.19	-.67
RAN numbers	-.35	.02	.15	.02
Step 2				
Constant		122.58	7.36	
RAN letters	-.65	-1.03	.20	-.72
RAN numbers	-.35	-.08	.19	-.08
RAS 2-set	-.27	.04	.20	.05
RAS 3-set	-.29	.01	.20	.01
RAN colors	-.13	.04	.20	.04
RAN objects	-.08	.19	.21	.16

Note. $n = 50$. Zero-order r = The ordinary correlations coefficient, B = The un-standardized regression coefficients, *SEB* = The standard error of B, β = The standardized regression coefficients, $R^{2 =}$ .42 for Step 1, R square change ($\Delta R^{2)}$ = .03 for Step 2.

Discussion

The purposes of this study were to explore the RAN/RAS tests' acceptability, reliability and validity in Jordanian students who speak Arabic. Very rigorous steps of translation were performed to assure content validity (Brislin, 1986). With regard to reliability, for tests such as RAN/RAS tests reliability coefficients must approximate or exceed .80 in magnitude, but coefficients of .90 or above are considered the most desirable (Salvia, Ysseldyke, & Bolt, 2010). Arabic RAN/RAS tests' reliability was investigated by

both test-retest and inter-rater agreement. The resulting coefficients were very high. The short time between the two testing sessions, providing clear and explicit instructions for administering the Arabic RAN/RAS Tests, the students' familiarity with the format and testing technique, and the absence of any mistakes in the tests' format or instructions helped to achieve the high inter-rater and test-retest reliabilities. In addition, very small SEMs were detected, which leads to the conclusion that the Arabic RAN/RAS tests scores are consistent across a short period of time and across different examiners.

Several indicators of Arabic RAN/RAS Tests' validity were found. First, Arabic RAN/RAS tests scores distinguished participants of different ages or grades. Older participants took less time to name stimulus items than younger ones. These findings support the hypothesis that the Arabic RAN/RAS tests scores will decrease as participants' chronological age increases. Second, high to very high correlations were found among all Arabic RAN/RAS Tests. Because all of the RAN/RAS Tests measure visual-verbal processing speed, one would expect them to be highly related. Similar results have been reported independently by other researchers (Felton & Brown, 1990; Manis et al., 2000).

Next, Arabic RAN/RAS Tests were good predictors of Arabic GPA. The Jordanian Arabic curriculum focuses on three basic Arabic skills: reading, writing, and spelling. All these skills are highly related since the Arabic language has high correspondence between the letters and sounds (shallow orthography) in the early grades. Although researchers have paid more attention to the relationship between rapid serial-naming tasks and reading, it seems that other language skills in regular orthographies can be predicted as well by the Arabic RAN/RAS Tests. As was expected from other research, (e.g., Wimmer, 1993; Wolf & Bowers, 1999), the third grade students with SLD had slower naming speeds and read fewer words correctly than average readers.

Finally, the hierarchical multiple regression analyses revealed that the best model for predicting word reading for the third grade average reader students consisted of just RAN-Letters and Numbers, with a higher contribution from RAN-Letters. The results of this study were in agreement with the findings of earlier studies, which found that letters were the most powerful predictor of word reading skill (Abu-Hamour et al., 2012; Bowey et al., 2005; Neuhaus et al., 2001; van den Bos et al., 2003; Wolf & Bowers, 1999).The finding that RAN letters were the best predictor of third grade students' reading skill is not surprising. RAN letters and word reading have many commonalities. Random letter strings and meaningful words are reported to be processed similarly, as both are subjected to intense lexical evaluation in classic language-related brain areas (Jessen et al., 1999; Misra, Katzir, Wolf, & Poldrack, 2004). Arabic RAN letters are presented in rows and demand right-to-left sequencing, as does reading in Arabic. Furthermore, letter names provide anchors upon which to map acoustically similar phonemes (Treiman, Tincoff, Rodriguez, Mouzaki, & Francis, 1998). Both Arabic RAN tasks and reading demand efficient visual and verbal processing of letters.

In conclusion, as indicated in the introduction section, some characteristics of the Arabic system may result in great difficulty for children learning to read. Most of these factors or characteristics are related to the orthographic features of Arabic language. The orthographic factors are powerful predictors of reading and reading comprehension in Arabic (Abu-Rabia, 2002). The results of this study support the suggestion that RAN tests suit the needs of Arabic language assessment, since many researchers are in favor of using RAN tests for predicting difficulties in orthographic as opposed to phonological processing (e.g., Bowers & Wolf, 1993; Bowers et al., 1994; Wolf et al., 2000).

Limitations, Implications, and Future Research

As is the case with any study, the conclusions drawn must be viewed within the context of the study's limitations. Foremost among the limitations was external validity. Participants were first to fourth-grade students from the southern region of Jordan. The generalizability of findings to other geographic areas, grades, and students should be further investigated. External validity limitations are further compounded by the sample size of the study. Future studies using larger samples of children from diverse geographic areas and other Arab countries yielding results similar to this pilot study would reassure examiners that they "may use this instrument with confidence."

RAN/RAS tests are vital evaluation tools. They are easy to administer, cost-effective, time-saving, and a very effective way to screen and identify students at risk for reading problems. Given the promising results of this pilot study, re-standardizing these tests in Arabic would be very helpful for school age students (5to 18). Arabic RAN/RAS tests can be used to (a) avoid the *wait-and-fail* methods, referring to the policy of not promptly addressing the reading difficulties of young children but instead waiting to do so until they are older, and (b) initiate early identification of young children who are at risk for reading failure and provide them with appropriate and timely interventions.

Based on the findings of this study, one may conclude that the Arabic RAN/RAS Tests: (a) are reliable and valid measures of the ability to perceive a visual symbol and name it accurately and rapidly, (b) can predict Arabic reading skills in general, and (c) differentiate children with reading disabilities from children with average reading abilities. Thus, pending the outcomes of larger-scale replication studies, examiners may use this instrument with confidence.

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The Development of a Math Strategy in Spanish for Latino English Language Learners at Risk for Math Disabilities

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Abstract

Math content for English Language Learners (ELLs) is unforgiving in terms of the constant need to build specific math and reading knowledge. As a result, ELLs may not only need math support but also reading comprehension support. The purpose of this study was to assess the effectiveness of a word problem solving strategy called Estratégica Dinámica de Matemáticas (EDM). EDM was designed to provide math strategy support in the native language based on students' reading and language comprehension levels. A changing criterion multiple baseline design was used to instruct six second-grade Latino ELLs at risk for math disability. As compared with the baseline phase, EDM increased word problem solving for all participants. All students' level of performance were maintained and generalized during follow-up sessions. This study has implications for a native language intervention that focuses on comprehension strategy training to facilitate word problem solving performance.

Keywords: English language learners, dynamic assessment, math comprehension strategies, single subject research design

In the American public education system (K-12), a large and growing number of students come from homes where English is their second language. These English language learners (ELLs) represent more than 5 million students, of which 75% are Spanish speaking (Planty et al., 2009). The challenges for many ELLs are not only overcoming a language barrier, but also achieving mathematically. Math achievement data indicate that ELLs are not performing at the same levels as their native English-speaking counterparts (National Center

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for Education Statistics, 2009). Rapid growth of the ELL population, as well as their low levels of math achievement and its consequences (e.g., high dropout rates, poor job rates, and poverty) create a vital need for improving instructional quality and enhancing student math outcomes.

The Problem

Word problem solving has its own developmental trajectory that is distinct from, but related to, reading comprehension (National Research Council, 2001). Although most ELLs develop sufficient number sense in school to perform word problem solving computations adequately, when reading word problems, many ELLs simply do not have the academic vocabulary and language skills to decipher the meaning of the sentences, and to apply this meaning to selecting suitable algorithms presented in word problems (Orosco, Swanson, O'Connor, & Lussier, 2013). As an example, the following word problem requires multiple comprehension skills for problem solving: "20 toy soldiers with helmets and 9 soldiers without helmets are for sale. The soldiers have green uniforms. How many soldiers are for sale?" Although a word problem like this is a math problem translated into words, every part of understanding a word problem is language and reading dependent (e.g., knowing that a mathematical operation can be signaled with a variety of terms, such as *how many*). Along the path of word problem understanding, an ELL needs to build and draw upon specific math terminology, math concepts, and reading comprehension skills. When ELLs carry out this cognitive processing, limitations in academic language and reading skills can lead to barriers in learning (Solano-Flores & Trumbull, 2003). Given the abstract and multistep nature of word problems, it is important that instructional models for ELLs provide a strategic approach not only in the English language but also in the student's native language in order to improve math solution accuracy.

Many of the comprehension strategies associated with the highest effect sizes for improving achievement of students at risk, directly and explicitly teach students strategies that prompt them to reflect before, during, and after word problem solving with instructional feedback (National Mathematics Advisory Panel (NMAP), 2008). These math strategies include: (a) methods of explicit and direct instruction that teach conceptual understanding of math concepts and principles of a word problem (e.g., Fuchs, Fuchs, Finelli, Courey, & Hamlette, 2004; Griffin & Jitendra, 2008; Jitendra, DiPipi, & Perron-Jones, 2002; Jitendra, Griffin, Deatline-Buchman, & Sczesniak, 2007; Orosco, Swanson, O'Connor, & Lussier, 2013; Swanson, Hoskyn, & Lee, 1999; Xin & Jitendra, 1999; Xin, Jitendra, & Deatline-Buchman, 2005), (b) visual representation techniques designed to bridge a connection from verbal information to symbolic understanding by creating a mental model (e.g., Jitendra & Xin, 1997; Jitendra et al., 1998; Jitendra et al., 2007; Van Garderen & Montague, 2003), (c) using instructional feedback with peer assisted learning strategies during instruction (e.g., Fuchs et al., 2008a; Fuchs, Fuchs, Yazdin, & Powell, 2002), and (d) small group instruction, instructional modeling, corrective feedback, and student verbalizations (Baker, Gersten, & Lee, 2002; Gersten et al., 2009; Swanson, 1999).

Although a great deal of evidence supports the value of teaching comprehension strategies (e.g., NMAP, 2008), much less is understood about how to adapt these instructional strategies for ELLs because much of the past research has focused solely on monolingual English-speaking students. In addition, the few math studies conducted with ELLs have not utilized their native language. ELL research continues to indicate that one of the strongest predictors of academic development is the use of the native language in instruction (Slavin & Cheung, 2005). Therefore, it may be critical that ELLs acquire math strategies in their native language, as the use of the home language may provide these students with the language comprehension skills necessary to understand first the math content they are reading, then to summarize key ideas, and finally to self-question while problem solving. Because of this, it is also important to learn which components of word problem-solving strategies are most effective for ELLs and how best to support them so that they can develop optimal strategy usage, especially when learning is mediated through the native language (García, Arias, Murri, & Serna, 2010).

Another challenge that arises from the math research is the high dependency on static measures (e.g., administered pre- and posttest), which assess a student's current problem-solving achievement by presenting scripted tasks that require the student to access previous learned knowledge with little teacher input (e.g., Grigorenko, 2009; Haywood & Lidz, 2007; Sternberg & Grigorenko, 2002; Swanson & Lussier, 2001). Because of this dependence on static measures, traditional assessment procedures have not been able to incorporate teacher-student interaction as part of the testing process nor measure to what degree feedback can help a student overcome problem-solving challenges. As a result of this, there is an opportunity in the math literature to develop an assessment model that can be used to identify word-problem solving challenges, make diagnostic decisions, and propose instructional strategies that address learning challenges to ELL students. The purpose of this study was to assess the effectiveness of such a math comprehension strategy procedure based on a dynamic assessment (DA) framework with ELL students.

In traditional static models of assessment and instruction, the student's current competencies are measured, and the assessor does not intervene so as not to "influence" the results (Haywood & Lidz, 2007; Sternberg & Grigorenko, 2002). In contrast, DA models both assess the student's current state of competency and determine whether substantive changes can occur in student performance due to instructional scaffolding across an array of increasingly more challenging tasks, in order to determine the student's immediate potential for learning. During DA, a teacher facilitates a student's ability to build on prior knowledge through student-teacher interaction, and uses this mediation process as a way to help the student internalize new information (Vygtosky, 1978). A standardized protocol is used to measure the distance, the difference between, and/or change from unassisted performance to a performance level with assistance (i.e., Zone of Proximal Development, ZPD; Sternberg & Grigorenko, 2002). One of the major strengths of DA is that it provides a clear link between assessment and teaching because it can incorporate a student's response to instructional

feedback (Swanson & Orosco, 2011). Thus, the benefit of using a DA measure of assessment on a math comprehension strategy framework is that it not only provides more information about the learning processes of the student but it also allows for a more fluid development of a strategy measure through ongoing refinement, while the contextual relevance helps to establish a strategy assessment's validity (Shephard, 2000).

Although the DA literature is vast, the empirical validity of dynamic assessment with regard to math is sparse (e.g., Fuchs et al., 2008b; Seethaler, Fuchs, Fuchs, & Compton, 2012), particularly regarding assessments with Latino ELLs at risk for math disabilities (MD) (e.g., Orosco, Swanson, O'Connor, & Lussier, 2013). While the literature is clear that word problem solving limitations in ELLs are related to academic language and reading performance, whether DA procedures in the native language add additional information to the prediction of growth in math in ELLs at risk for MD beyond traditional testing procedures has not been tested. In addition, because of the individualized nature of DA, the literature has not typically reported the reliability and validity in treatment-oriented studies (Caffrey, Fuchs, & Fuchs, 2008). Alternatively, more research-oriented DA methods, such as graduated prompts, have been found to be more efficient and standardized for research and practice (Haywood & Lidz, 2007). The purpose of this study was to investigate a dynamic assessment math strategy called Estratégica Dinámica de Matemáticas (EDM) based on a graduated prompt framework that was developed in the participants' native language (Spanish). EDM was operationally defined in this study as the interventionist modifying math language via a four-level math vocabulary modification procedure (see Table 1) to the students' level of math comprehension, and then providing strategy instruction feedback by means of verbal probes that assessed students' level of word problem solving ability in their native language. This study addressed two research questions with Latino ELLs:

1) To what extent does EDM facilitate a student's word problem solving accuracy when compared to the baseline conditions?
2) To what extent does EDM maintain word problem solving skills accuracy in follow-up sessions?

Method

Setting and Participants

Six second-grade Latino ELLs at risk for math disability from a southern California dual language (English/Spanish) elementary school classroom participated in this study. For the purposes of this study, Latino English language learners (Latino ELLs) was defined as those students who speak Spanish as their native language 100% of the time at home, are identified as coming from Latin American descendants (e.g., Mexican, Mexican-American), are in the process of acquiring English as a second language, and who have not achieved full English proficiency (California English Language Development Test, CELDT; Marr, Rodden, & Woods, 2009). The school's population consisted of 453 students (55% Hispanic (all Latino ELLs), 22% African Americans, 14% White, 5% Asian, and 4% other).

Table 1.

Los Afectos de la Estratégica Dinámica de Matemáticas Resolviendo Problemas de Palabras en los Estudiantes que están Aprendiendo Inglés como Segundo Idioma

Nivel de Modificación Lingüística (Linguistic Modification Level)	Descripcion (Description)	Ejemplo (Example)
Principiente (Nivel 1) (Basic (Level 1))	Terminos de matemáticas utilizados en conversaciones diarias (Math terms used in everyday conversation)	antes (before), después (after), combinar (combine), extra (extra) junto (together), más (more), más que (greater than), en total (total), menos (fewer), surtir (sort), menos que (fewer than), quitar (take away)
Intermedio (Nivel 2) (Intermediate (Level 2))	Términos no directamente asociados con un específico contenido de la área de matemáticas (Math terms not directly associated with a specific math content area)	adición (addition), agregan (sum), dígitos (digits), division (division), multiplicación (multiplication), factor (factor), factores (factors), resta (subtraction)
Avance Intermedio (Nivel 3) (Advance Intermediate (Level 1))	Términos de matemáticas directamente asociados con un específico contenido de la área de matemáticas (Math terms directly associated with a specific content area)	cociente (quotient), divisor (divisor), divisible por (divisible by), dividend (dividend), mínimo común denominador (least common denomimator), mínimo común múltiplo (least common multiple)
Vocabulario Técnico (Nivel 4) (Technical Vocabulary (Level 4))	Términos de matemáticas asociados con un específico contenido del tema de la area (Math terms associated with a specific math content area topic)	perímetro (perimeter), area (area), cilindro (cylinder), pulgada (inch), metro (meter), centímetro (centimeter), milla (mile), rectángulo (rectangle), cuadrado (square), triángulo (triangle), cubo (cube), triángulo recto (right triangle)

Note. Adapted from G. Ernst-Slavit & D. Slavit (2007); Orosco, Swanson, O'Connor, & Lussier (2013)

The majority of participants were from reduced socio-economic backgrounds based on school district reporting of 75% of the school's student population participating in the free or reduced-price lunch program.

This study was conducted as a pullout program during school hours for 17 sessions (average 20-25 min per session) over a five-week period and was a supplementary curriculum intervention to the general education math curriculum (*California Houghton Mifflin Matemáticas Grade 2,* Houghton Mifflin Company, 2002) that students received as part of their regular school day (50 minutes per day). The curriculum used in this study was part of the school's math program of developing new teaching techniques, interventions, and strategies that promoted students' oral language development (e.g., vocabulary development) by building their background knowledge (e.g., modifying the linguistic complexity of math language and rephrasing math problems, and building knowledge from real world examples) within a standards-based math education (National Research Council, 2001). Participant selection criteria (see Table 2) included: (a) a school district home language survey that indicated the student's dominant language spoken at home was Spanish; (b) scoring below grade level on district reading and math assessments; (c) the California English Language Development Test (CELDT; Marr, Rodden, & Woods, 2009) to define ELL status; (d) the Batería III Woodcock-Muñoz: Pruebas de Aprovechamiento, Prueba 10: Problemas Aplicados (students who performed in the lower 25th percentile were included in the at-risk sample; Fletcher et al., 1989); (e) teacher recommendation for Spanish intervention based on students previously experiencing word problem solving challenges and having been designated at risk for math disability; and (f) parent consent. The CELDT is a measure of English proficiency (listening, speaking, reading, and writing) with reliability scores between .73 and .94 across grade levels (Marr et al., 2009).

Students' word problem solving skills were measured with the *Batería III Woodcock-Muñoz: Pruebas de Aprovechamiento, Prueba 10: Problemas Aplicados* (Muñoz-Sandoval, Woodcock, McGrew, & Mather, 2005). This subtest measures the ability to analyze and solve math problems. This test has a mean standard score of 100 and a standard deviation of 15. The *Batería III* was calibrated both inside and outside the United States (Spanish-speaking world). The *Batería III* was standardized on a stratified normative sample of 1,692 native Spanish-speaking participants and has a reported internal reliability coefficient of 0.95 for *Prueba 10* age 9 (Woodcock, McGrew, & Mather, 2007). The same test was also administered at post assessment. Pre- and posttest data were compared with multiple baseline data, in determining whether EDM positively mediated learners' word problem–solving skills (i.e., math comprehension) over time. Table 2 provides descriptive, school-related information and *Batería III: Prueba* 10 data.

Table 2
Demographic, School-Related Data, and Prueba 10 Pre and Post Test Scores

Student	Gender	Age	District Reading Assessment Level	District Math Assessment Level	Prueba 10 Pretest Percentile (%)	Prueba 10 Pretest Standard Score	Prueba 10 Posttest Percentile (%)	Prueba 10 Posttest Standard Score
Alma	Female	7.7	1.5	Below basic	18	86	21	88
Lissette	Female	8.1	1.7	Below basic	19	87	22	89
Miles	Male	8.2	1.6	Below basic	19	87	22	89
Blanca	Female	8.1	1.8	Below basic	20	88	21	88
Daniel	Male	8.2	2.0	Below basic	20	88	23	89
Vincent	Male	7.7	1.9	Below basic	20	88	23	89
M		8.0	1.75		19.33	87.30	22.00	88.83
SD		.22	.17		.82	.82	.89	.41

Note: Prueba 10 = Batería III Woodcock-Muñoz: Pruebas de aprovechamiento, Prueba 10: Problemas aplicados

Intervention

The EDM intervention was designed on a reciprocal teaching foundation (Palinscar & Brown, 1984) and the features associated with effective math instruction (e.g., collaborative group work, interactive dialogue, procedural strategies; e.g., Baker, Gersten, & Lee, 2002; Gersten et al., 2009; NMAP, 2008; NRC, 2001). EDM was implemented in two phases: (a) teaching the strategies, and (b) collaborative learning group activity or student pairing. Students were first pretaught specific math concepts, ideas, vocabulary and terminology in Spanish for each lesson by elaborate teacher modeling. As students came to understand the information presented, the teacher then began to integrate and embed probes and strategy instruction with collaborative learning.

Phase 1: Teaching the strategies. Students learned five word problem-solving strategies: *Saberlo-Qué se de la pregunta* (Know it-What do I know about the question), *Buscarlo-Necesito encuentrar el vocabulario y los numeros importantes* (Find it-I need to find the important vocabulary and numbers), *Muestralo* (Set it up), *Resolverlo* (Solve it), and *Comprobarlo* (Check it).

1. *Saberlo*. *Saberlo* is a strategy to activate students' prior knowledge, to facilitate their predictions about what is already known about the problem. The strategy consists of two activities: (a) brainstorming about the problem and (b) making predictions on how the problem may be solved. The teacher introduces the word problem (which has been read aloud) by asking them to think about the word problem and to then find the question. In this step, the teacher prompts the students to tell (a) what they know about the question and (b) what they think they will learn from the problem.
2. *Buscarlo*. *Buscarlo* teaches students to find critical information for meaning and understanding to solve the problem, and teaches them how to use strategies to help

them figure out unknown words or concepts.

3. *Muestralo*. *Muestralo* helps students begin to set up problem solving during reading by stopping after each sentence to find the main idea and to check to see if this information is relevant to solving the problem. Students are taught to identify the main concept of a sentence by answering the following questions: (a) What is this sentence about? and (b) Is this information needed to solve the problem? In addition, students are taught to write this information down, so that they can begin to use it to solve the problem.
4. *Resolverlo*. The *resolverlo* strategy takes the information that has been gathered and writes it into a number sentence that tells about the problem. The teacher and students then discuss it and set to work to solve the problem. Students check their understanding by generating and answering questions about what they have read and reviewing what they have learned by summarizing the key ideas presented in the word problem, solving it, and checking it.
5. *Comprobarlo*. The *comprobarlo* strategy focuses on presenting students with standard algorithms to solve the problem, explain how and why they work, and offers them as one way to solve a problem. In addition, during this strategy, it is important for students to understand that there are multiple ways, including the ones they may have invented, to solve a problem correctly.

Phase 2: Cooperative learning and/or student pairing. Once students were proficient in strategy usage, they were provided a collaborative approach between the teacher and student that allowed the students to practice this method. In this stage, the student was assigned the leadership role and imitated the teacher's role. Within this process, the student generated and asked questions to check for understanding. The student then solved the problem and checked to see if it was answered correctly. If answered incorrectly, the problem-solving process was repeated between the teacher and student again, to see where mistakes were made. As they reviewed, the teacher monitored the student's effectiveness by providing probes as needed (e.g., reading words, clarifying math concepts, or reminding students of a strategy skipped). If word problem solving challenges persisted, the teacher then retaught specific strategies by means of reciprocal teaching (Palinscar & Brown, 1984) until the student understood them.

Experimental Design

A changing criterion multiple baseline design across subjects (Horner et al., 2005; Kazdin, 2010; Kratochwill et al., 2010) was used to evaluate the effects of the EDM intervention strategy. In this design, each intervention session is associated with a stepwise criterion rate for the target behavior (i.e., word problem solving level of difficulty was advanced after a student solved a set of word problems correctly). Participants were selected and categorized based on teacher recommendation (i.e., low math and reading scores in Spanish), and the amount of intervention needed, and from this, a list was generated that rank

ordered students based on the amount of intervention needed. After students' solution accuracy was stable in the baseline phase (see baseline section for description), the independent variable was introduced and maintained across subjects until the minimum number of sessions necessary to establish criterion response stability (minimum of three sessions above the baseline mean) was achieved. All participants were individually administered four word problems per intervention session similar to those used during the baseline phase.

Word problems. All word problems were matched to those used in daily instruction. However, word problem presentations were modified to capture four levels of language difficulty: conversational, non-associated content, associated content, and technical vocabulary. During each session, four word problems per level were administered. These word problems were linguistically modified based on a scaffolding ladder that parsed the language of mathematics into four levels, with each level providing scaffolding that supported the next higher level of word problem solving development. Level 1 word problems were embedded in math terms used in every conversation (high frequency words), Level 2 word problems incorporated math terms not directly associated with a specific math content (general math words), Level 3 word problems incorporated math terms directly associated with a specific math content area (specialized math vocabulary), and Level 4 incorporated math terms associated with a specific math content area topic (technical vocabulary). As an example of this scaffolding, a Level 2 word problem may have asked, Juan tiene 24 monedas que agregan 27¢. ¿Qué monedas tiene? (Juan has 24 coins worth a sum of 27¢. What coins does he have?). In this case, the word problem was made less linguistically complex by taking the Level 2 math term (agregan, sum), and teaching a level one meaning (total) without altering the math concept being taught.

Probing. In this study, a probing procedure was developed in Spanish by the researcher (Appendix A), in which the dependent variable was the word problem language level (i.e., the administration of four word problems per level with the algorithm for solution constant across all levels) achieved with the strategy intervention. The probe was designed to recompose differing levels of word problem-solving skills through the application of five prompts (scaffolds) in determining the student's word problem achievement with and without scaffolding. Scoring of the five prompts involved the assignment of points at each prompt (0 = incorrect response, 1 = correct response). As part of the probing procedure, each student was asked to solve four word problems at their zone of proximal development language level. After a 3-minute duration, if the student was having difficulty solving the problem, the student was given the prompts with 1 minute to answer each prompt. Another prompt (with a maximum of five) was initiated if the student failed to respond correctly to the previous one. The administration of prompts averaged 4 to 5 minutes in duration. The number of prompts administered to solve the problem was used to establish the student's level of intervention needed to solve word problems accurately.

Procedure

Baseline phase. At the baseline, each participant was individually administered math problems in Spanish that contained four progressive language levels of word problem solving difficulty. The word problems included addition, subtraction, multiplication, and division. Students were instructed to do their best, and given as much time as needed to solve the problems. None of the participants required more than 10 minutes in attempting to solve the problems. This established the baseline score for each participant. The baseline determined the language level at which word problems could be accurately solved without assistance. This also established the starting level for the intervention curriculum. Five of the six participants (Alma, Lissette, Miles, Blanca, and Daniel – all aliases) started at word problem solving Level 1. Vincent (also an alias) established a Level 2 baseline.

Intervention phase. A bilingual trained classroom teacher and the researcher alternated sessions in applying the intervention. Both the research and teacher had received training at the graduate level in ESL/Bilingual reading and math pedagogy, and the teacher was trained on how to use the intervention. The word problem solving intervention was delivered individually, and consisted of three steps: (a) preteaching math concepts and vocabulary, (b) strategy instruction that integrated math concepts and vocabulary, and (c) up to 5 probes to improve word-problem solving performance. Each instructional session lasted an average of 25 minutes. After each session, students were administered a set of four math word problems based on their current language level to solve without probes or any other form of assistance. Each student was required to correctly solve these problems at their unassisted level (demonstrating 100% mastery) in order to progress to the next level.

Preteaching concepts and vocabulary (step 1). At this step, the student was provided with direct and explicit instruction of key concepts and vocabulary from math word problems that they were asked to solve for the session. The student was provided with a series of 3- x 5-inch index cards that had a vocabulary word written on one side and was blank on the other side. The intervention teacher modeled the activity by holding up the card, looking at the word, pronouncing the word (asking the student to repeat the word), providing various meanings of the word through contextualization (e.g., everyday language), writing these on a vocabulary chart, and then applying them to a math problem. On the blank side of the card students were asked to write a student friendly definition of the word and write a math example (so that they could practice these words at home). The researcher stated (see Appendix B for English vocabulary translation), Esta es la palabra *sumar (suma)*. La palabra *sumar* puede significar *mas, anadir, o combinar* con el signo (+). (On the chart board the interventionist wrote +, *mas, contar, poner, combinar*. Next, the interventionist contextualized this vocabulary, "Julio fue al mercado y compró 5 paquetes de piedritas rojas y 5 paquetes de piedritas azules para poner en la pecera. ¿Cual es la suma de todos los productos? ¿Qué significa la palabra *suma* (writing *suma* on the chart board)? *Suma* significa *combinar* (+). ¿Cual es la suma de todos los productos? Cinco paquetes de piedritas rojas y cinco paquetes de piedritas azules son diez. Interventionist, “Ahora me puedes dar un

ejemplo. Student, “Yo fui a la tienda y compró 3 paquetes de piedritas rojas y 3 paquetes de piedritas azules. ¿Cual es la suma? Suma significa combinar. Tres mas tres seis paquetes de piedritas (3 + 3 = 6). ¡Muy bien!"

If the student encountered challenges in providing an example, the interventionist prompted the student with other contextualized examples, until the student understood. This was repeated three times with all the vocabulary covered for that session.

Comprehension strategies instruction (step 2). During each intervention session, the teacher/researcher modeled the problem solving process by applying strategies using a cue sheet (see Appendix C for Spanish example and Appendix D for English translation) developed for the study. In this step, this strategy asked the student to consider her/his background knowledge on the word problem they were reading; in addition, the student was asked to identify the problem by determining the question and identifying vocabulary. If the student struggled with the task, the teacher provided further support via probing. The instructor also provided systematic and ongoing feedback that sought to build upon preteaching strategies. Next, the teacher and student collaborated in finding the key data to set up the problem, and then to calculate and solve the problem. The teacher then noted whether the problem had been solved correctly and directed the student to generate questions so she/he could determine whether the student comprehended the problem. Asking the student to evaluate what she or he had learned by summarizing the key concepts presented in the word problem did this.

Dynamic assessment (step 3). The DA step of the intervention involved the participants being assessed using probes (Appendix A) to assess word problem-solving accuracy. The student was administered a set of four word problems with the math vocabulary and concepts reviewed during intervention. This duration of this administration averaged 10 minutes. If the student answered the problem independently (correctly without probes), the student was given a total score of 5 (correct response) and moved to the next level in the following intervention session. If the student was not able to answer the question correctly, she/he was given a score of 0 for that problem and then given the probes in sequence. If the student answered the problem with the first probe's assistance correctly, she/he was then scored a 1 on probes needed and moved on to the next problem. If the student was unable to answer the problem correctly with the first probe, the student was given additional probes (a maximum of 5) at the current level with the number of probes needed being recorded. Students changed levels when the criterion of 100% was achieved at their current level.

Social Validity

At the conclusion of the study, the social validity of the intervention was assessed using a three-question interview protocol. During this interview, the participants were asked questions in Spanish regarding their satisfaction with EDM (e.g., ¿Crees que EDM te ayudó a comprender los problemas de palabras? Explique por favor. Do you think that EDM helped you to understand word problems? Please explain.).

Interobserver Agreement and Treatment Integrity

In order to check on the degree to which intervention techniques were being applied in teacher interactions with students, a treatment integrity checklist based on the sequence of probe statements (e.g., pacing, quality of instruction, and scaffolding) for each intervention was applied. The checklist was completed at the beginning (two sessions), middle (two sessions), and end (two sessions) of the intervention phase by an observer. The observer would code for fidelity via a checklist and score "yes" or "no" for each probe observed. A total agreement calculation method for each session (i.e., dividing the number of agreements between the probe responses by the number of disagreements and then multiplying by 100) indicated the consistent presence of intervention behaviors being used at 100%. Interobserver agreement for all four levels was 90% at baseline, and 100% at intervention and maintenance phases. The dependent measure across all training sessions was the "language level" of proficiency without assistance. To progress through the levels of criterion performance, each student was required to solve four consecutive word problems at their unassisted level (100% mastery).

Results

Figure 1 displays the language level criterion for word problems for each participant as a function of baseline, intervention, and maintenance sessions. Visual analysis showed increases in word problem solving accuracy as a function of language difficulty. During each session, students were administered a set of four word problems starting at Level 1. Table 3 lists the number of word problems solved correctly and incorrectly, with an accuracy percentage score (APS) based on the administration of these problems per session. An asterisk (*) denotes the student's move to the next criterion level. Also shown are Batería III Prueba 10 pre–posttest gains (Table 2).

Baseline Performance

The student named Alma received a total of three baseline sessions, and her mean APS was 50%. Next, Lissette was administered four baselines, and her mean APS was 44%. Miles was given five baselines, and his mean APS was 65%. Blanca was administered six baselines, and her mean APS was 63%. Daniel was administered seven baselines, and his mean APS was 71%. Finally, Vincent was administered eight baselines, and his mean APS was 63%. Although the participants' performance on word problem solving was stable, when these scores were broken down into language level (4 problems correct without help), five of the six participants (Alma, Lissette, Miles, Blanca, and Daniel) started at a baseline Level 1. Vincent established a Level 2 intervention phase, as a result of higher reading and math

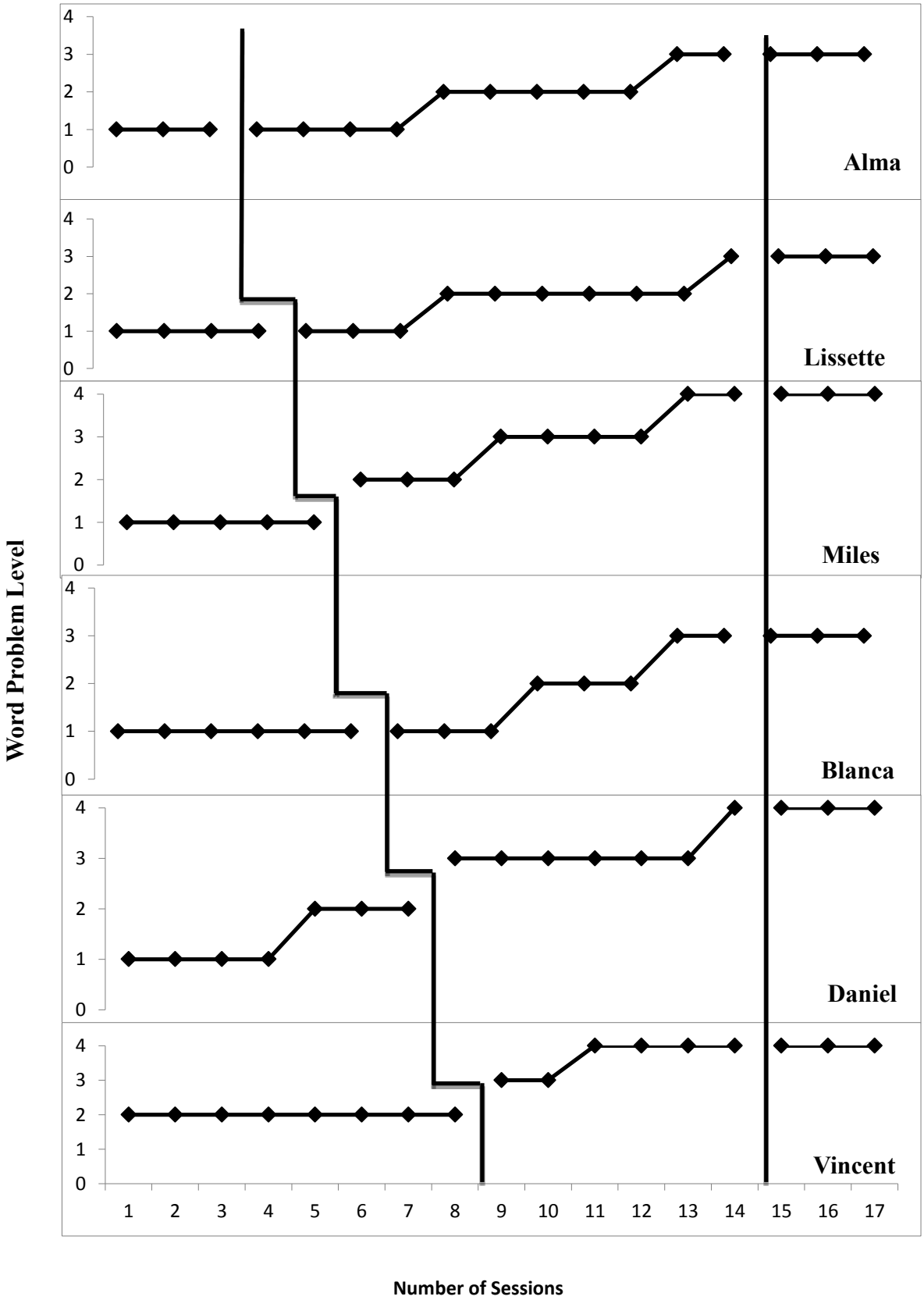

Figure 1. **Word problem level achieved**

Table 3

Word Problems Solved Correctly and Incorrectly per Student Session

	Alma							Lissette							Miles						
Session	B		I		M		APS	B		I		M		APS	B		I		M		APS
	IC	C	IC	C	IC	C	%	IC	C	IC	C	IC	C	%	IC	C	IC	C	IC	C	%
1	2	2					50	3	1					25	2	2					50
2	2	2					50	2	2					50	1	3					75
3	2	2					50	2	2					50	1	3					75
4			2	2			50	2	2					50	2	2					50
5			1	3			75			2	2			50	1	3					75
6			1	3			75			2	2			50			*1	3			75
7			0	4			100			0	4			100			1	3			75
8			*1	3			75			*2	2			50			0	4			100
9			2	2			50			0	4			100			*1	3			75
10			1	3			75			1	3			75			1	3			75
11			1	3			75			3	1			25			1	3			75
12			0	4			100			1	3			75			0	4			100
13			*1	3			75			0	4			100			*2	2			50
14			0	4			100			*1	3			75			1	3			75
15					0	4	100					0	4	100					0	4	100
16					0	4	100					1	3	75					0	4	100
17					0	4	100					0	4	100					1	3	75

	Blanca							Daniel							Vincent						
Session	B		I		M		APS	B		I		M		APS	B		I		M		APS
	IC	C	IC	C	IC	C	%	IC	C	IC	C	IC	C	%	IC	C	IC	C	IC	C	%
1	2	2					50	2	2					50	2	2					50
2	2	2					50	1	3					75	2	2					50
3	1	3					75	1	3					75	1	3					75
4	2	2					50	0	4					100	1	3					75
5	1	3					75	*1	2					50	2	2					50
6	1	3					75	0	4					75	1	3					75
7			1	3			75	0	4					75	1	3					75
8			0	4			100			1	3			75	2	2					50
9			0	4			100			1	3			75			1	3			75
10			* 1	3			75			1	3			75			0	4			100
11			2	2			50			0	4			100			*2	2			50
12			0	4			100			*1	3			75			0	4			100
13			* 1	3			75			0	4			100			2	2			50
14			1	3			75			*1	3			75			1	3			75
15					0	4	100					1	3	75					1	3	75
16					1	3	75					0	4	100					1	3	75
17					0	4	100					0	4	100					1	3	75

Note. B = baseline phase; I = intervention phase; M = maintenance phase; APS (%) = accuracy percentage score; IC = incorrect; C = correct; * = start of next level.

achievement scores in the native language. However, the low performance on more language complex and difficult word problems for all the participants at the baseline phase indicated a need for further intervention. Pretest scores on the Batería III Prueba 10 also indicated a need for further mediation.

Intervention

As compared with baseline scores, the intervention condition administered in the students' native language produced an increase in both accuracy and level of word problem difficulty solved while the treatment was in effect. After each intervention session, each participant was administered a set of four word problems based on the intervention language level received. Students' word problem solving accuracy during this phase is presented in Table 3, and word problem level achieved is shown in Figure 1.

Alma received 11 intervention sessions, her mean APS on word problem sets was 77%, and she demonstrated a gradual increase in word problem level performance (i.e., from Level 1 to Level 3) from baseline level. Lissette received 10 treatment sessions, her mean APS on word problem sets was 70%, and she also showed an increase in word problem level from Level 1 to Level 3. Similarly, Miles, received 9 intervention sessions with a mean APS of 78%, and obtained a word problem Level 4. Blanca received 8 intervention sessions; her 81% mean APS showed a gradual increase from level 1 to level 3. Finally, Vincent received 6 intervention sessions, and his mean APS was 75%.

In summary, all students benefited from intervention with increases in accuracy percentage scores after students were directly and explicitly taught math concepts and vocabulary that connected to everyday words.

Maintenance

To determine maintenance of intervention skills, all students were individually administered four math word problems similar to those used during the preassessment phase for three sessions. During this phase, all students sustained word problem solving accuracy (see Table 3) and word problem levels achieved (see Figure 1) similar to the end of their intervention phases. Examination of the outcomes shows that Alma maintained the highest level of performance (100% at Level 3), while, Lissette, Blanca, and Daniel maintained a mean APS of 92% at Level 3, and Miles a mean APS of 92% at level 4. Finally, Vincent's mean APS remained stable at 75% (Level 4).

In summary, during the maintenance phase, visual inspection of the data on students' word problem solving accuracy and word problem difficulty level achieved indicates that they were able to maintain a higher level of performance due to EDM treatment. Posttest scores on the Batería III Prueba 10 also indicated that students showed improvement from the intervention.

Social Validity

Qualitative interview data indicate that the majority of the participants were in agreement (83%) that the intervention procedures were reasonable and effective. Several students commented around the theme “Me gustó mucho la enseñaza de matemáticas, nosotros podríamos hablar. (I like the teaching, we could talk).” Only one student, Vincent, said he did not like it because “Fue muy lento. (It goes too slow).” The homeroom teacher commented, “La intervención es bastante sencilla enfoque que permite integrar el vocabulario y la comprensión de estrategias de la lectura con la instrucción de matemáticas. (I really liked the simplicity of the strategy, and how easily it integrated vocabulary and reading comprehension strategies with math instruction.” The students recommended “mas juegos de matemáticas (more math games),” while the teacher would have liked more writing in Spanish for each student to help them solidify their word problem solving literacy: "Un diario de matemáticas para cada uno de los estudiante que le podrían ayudar a solidificar sus conocimientos de matemáticas por medio de la escritura. (A math diary for each student that would help them reflect on their own math learning through the medium of writing.)"

Discussion

The purpose of this study was to investigate the effects of a math intervention in Spanish, called Estrategia Dinámica de Matemáticas (EDM), on Latino ELLs’ word problem solving achievement. This study addressed the following two questions:

1) To what extent does EDM facilitate student’s word problem solving accuracy when compared to the baseline conditions?

The results of visual analysis and examination of graphed accuracy percentage scores supported the hypothesis that EDM facilitates an improvement in word problem solving accuracy from baseline conditions. The results indicated a functional relationship between EDM and increased word problem solving performance because the intervention was able to provide scaffolding instruction that positively mediate word problem skills and language over time, It gave instructional feedback based on students’ current performance levels (known) and students’ assisted performance (potential) levels. Posttest scores on the Batería III Prueba 10 also confirmed this improvement. In summary, as students’ knowledge of EDM increased, their ability to accurately solve increasingly complex word problems improved during intervention in comparison with the baseline phase.

2) To what extent does EDM maintain word problem solving skills’ accuracy in follow-up sessions?

The follow-up results of EDM indicated that students were able to maintain knowledge of the EDM process during three follow-up sessions after intervention and relevant to the baseline phase. All subjects demonstrated generalization of the DA strategy to more complex verbal math problems by maintaining their word problem solving performance

at the intervention level. Overall, the results indicate support for the two questions that motivated this pilot study.

The findings from this study lend support to the current literature in this area in three key areas. First, dynamic assessment (DA) theory suggests that scaffolding instruction can positively mediate math comprehension over time because it can give performance-contingent feedback based on students' independent performance (known) and students' assisted performance (potential) that promotes cognition. The EDM results demonstrated this mediation during intervention. Although students in this project had the number sense and calculation skills to perform word problem solving computations adequately, when facing word problems, they needed assistance with understanding the math vocabulary and reading comprehension tasks in order to decipher the meaning of the sentences, and to apply this meaning to selecting suitable algorithms in order to solve word problems. These findings are consistent with DA theory and provide further evidence that DA may be an effective framework for improving word problem solving skills in ELL students.

Second, the findings of this study provide additional support for reading comprehension strategies instruction (CSI) as an effective method for teaching ELLs math problem solving skills. Results from the current study suggest that CSI may be an effective instructional tool for teaching students at risk for MD because it prompts them to consider their background knowledge on the topic they are reading, to summarize key ideas, and to self-question while they read. In addition, it may be critical for ELLs at risk for MD to acquire skills that help them understand word problems because: (a) word problems become increasingly more abstract and complex beyond the second grade level, and (b) ELL students are unlikely to receive extra intervention support as math content becomes more challenging.

Finally, this study contributes to the math literature because EDM delivers a Dynamic Assessment Comprehension Strategy Instruction (DA-CSI) model in the native language. Results indicate that this may be an effective model because EDM was able to teach students math concepts, knowledge, and skills through the language they knew best. Because this intervention was developed in the native language, it may have provided a more efficient language medium to express thought, which is critical to students' comprehension development. In addition, the emphasis of the native language stressed the importance to students that mathematical proficiency is built upon the activation of prior knowledge and applying what has been learned to the acquisition of new math concepts and skills related to word problem solving development. As a result, EDM may be an effective instructional method for ELLs because it incorporates comprehension strategies in the native language that allows them to understand word problems so that they can access the general math curriculum.

Limitations

Although the results of this multiple baseline study demonstrate the effect of a word problem solving intervention that positively mediated ELLs' word problem solving skills, there were limitations to this study. First, intervention data were collected on an

individualized basis over a duration of 17 sessions. Therefore, the extent to which the intervention may improve word problem solving skills in other students with similar learning challenges for this time duration is unknown. Next, this pilot study suffers from a small sample size (six students), and because of this, generalizing intervention effectiveness to other populations is limited at this time and further replication is required with larger samples. Finally, to date there have been few math studies conducted in the native language of ELLs. Although EDM was developed based on research that promotes evidence-base instruction, focusing on the native language (e.g., math vocabulary) may have influenced students' performance, rather than solely on DA or CSI. Clearly, additional research on a larger and longitudinal scale on the properties of DA and CSI is needed, especially studies linking the effectiveness of these two constructs to students' native language in math.

Implications

The findings from this study have implications for ELLs at risk for MD and their elementary math curricula. Although participants had a fundamental understanding of numbers in their native language, achievement data collected prior to the study indicated that the participants' skill was limited to number calculations (simple math problems) and heavily influenced by the context in which the numbers appeared. This below-basic proficiency meant that EDM provided students with extensive opportunities to learn and practice math concepts and content in their native language, while learning to use their background knowledge in improving math comprehension skills. Word problem solving data indicated that the students could acquire proficiency (i.e., solve a word problem correctly) with Level 1 Spanish word problems once given appropriate vocabulary and comprehension strategies. As an example, once students were taught basic math vocabulary and concepts and given time to practice with math problems, they could solve these problems quite easily. However, it was only when they moved on to more complex word problems that solving these types of word problems became more challenging because these students needed more instruction that emphasized comprehension strategies, vocabulary, and oral language practice.

In summary, results from this study indicate that comprehension strategy training situated within a dynamic assessment framework could satisfy the learning needs of certain ELLs, particularly those who may be struggling with math disability at the elementary level. The DA-CSI based EDM intervention strategy employed in this study can be an effective learning tool for teachers with ELL students because it helps define (a) what the ELL student demonstrated independently (present ability), and (b) what the ELL student could achieve with systematic assistance (potential ability), giving teachers an appropriate instructional tool where they can create a baseline to work from and a stronger idea of expected progress. Additionally, when ELL students learn to use the strategy effectively and efficiently, they should become more independent learners, allowing them to progress further on their own.

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Appendix A

Estratégica Dinámica de Matemáticas (EDM) Probe Sheet (English Translation in Parenthesis)

Examinador, "Un problema de palabras hace una pregunta. ¿Puedes encontrar la pregunta en el siguiente problema de palabras?"

(Examiner, "A word problem asks a question. Can you find the question in the following word problem?")

Examinador, "En cada pregunta siempre hay palabras importantes. ¿Puedes subrayar las palabras en esta pregunta que piensas que son importantes para resolver este problema?"

(Examiner, "In each question there are always important words. Can you underline words in this question that you think are important to solving this problem?")

Examinador, "En cada problema de matemáticas siempre hay números que necesitas para resolver el problema. Puedes círcular los números que necesitas para resolver este problema?"

(Examiner, "In each math problem there are always numbers that you need to solve the problem. Can you circle the numbers that you need to solve this problem?")

Examinador, “Los números se utilizan para formar y resolver un problema de matemáticas. ¿ Puedes utilizar estos números para formar el problema de modo que puedas resolver el problema de la palabra?”

(Examiner, “Numbers are used to set up and solve a math problem. Can you use these numbers to set up the problem so that you can solve the word problem?”)

Examinador, “Después de resolver el problema de matemáticas, debes de revisar la respuesta. Puedes comprobar tu respuesta?”

(Examiner, “After solving the math problem, you need to check your answer. Can you check your answer?”)

Appendix B

English Vocabulary Translation

This is the vocabulary word *sum*. The word sum can mean *more*, *to add*, *to combine* and can be represented with the math sign (+). (On the chart board the teacher interventionist wrote +, *to add, to combine.* Next, the teacher interventionist contextualized this vocabulary.) "Julio went to the market and bought 5 packets of red rocks and 5 packets of blue rocks for his fish bowl. What is the sum of the products? What does the word sum mean (writing *sum* on the chart board)? *Sum* means to combine (+). What is the sum of all the products? 5+5 = 10. Now can you give an example?” Student, “I went to the store and I bought three packets of red rocks and three packets of blue rocks for my fish bowl.” Teacher interventionist, "What is the sum?" Student, "Sum means to combine. Three plus one equals four (3+3 = 6)." Teacher interventionist, "Very Good!"

Appendix C

Estratégica Dinámica de Matemáticas Cue Sheet (abbreviated example)

Ejemplo de problema de palabras: Dora tiene $17.00 en su alcancía de cochinito. Para su cumpleaños, sus abuelos le dieron $10.00. ¿Cuál es la cantidad *total* de dinero que Dora tiene en su alcancía de cochinito?

Examinador, “Un problema de palabras hace una pregunta (apunta a la pregunta): ¿Cuál es el *total* de dinero qué Dora tiene en su alcancía de cochinito? Después, subrayaré las palabra(s) importantes en la pregunta.

Examinador, Sé que Dora tiene *dinero en su* alcancía de cochinito. ¿Qué significa la palabra *total*? No entiendo esta palabra *total*. Vamos a ver si voy a la tienda y quiero comprar dulces, el cajero me dará el *total* de lo que tengo que pagar. *Total* significa todo junto o *suma* o *agregar*. Si puedo reemplazar o sustituir la palabra *total* con *suma* tiene esto sentido?¿Cuál es la suma de dinero que Dora tiene en su alcancía? Sí, esto tiene sentido. Total también puede significar *suma* o *agregar*(+).

Examinador, ¿Cuál es el total de dinero que Dora tiene en su alcancía de cochinito? El problema de palabras, dice que Dora tiene $17 dólares en su alcancía de cochinito. Para su

cumpleaños, sus abuelos le dieron $10.00. ¿Cuál es el *total* de dinero que Dora tiene en su alcancía de cochinito? Voy a circular estos números, ya que estos son los números que necesito para resolver este problema. Bueno, vamos a resolver este problema. Necesitamos *agregar* o *sumar* $17.00 + $10.00 = $27.00. Mi respuesta es $27.00; Dora tiene $27.00 dólares en alcancía de cochinito.

Examinador, "Bueno, necesito revisar mi respuesta. Si comienzo con 17 y cuento de un dólar (diezveces), yo cuento 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, mi respuesta es 27 dólares. Esto es correcto. Dora tiene 27.00 dólares en su alcancía de cochinito. Ahora es.

Appendix D

Estratégica Dinámica de Matemáticas Cue Sheet (English translation)

Word Problem Example: *Dora has $17.00 in her piggy bank. For her birthday, her grandparents gave her $10.00. What is the total amount of money that Dora has in her piggy bank?*

Examiner, "A word problem asks a question (point to the question): What is the total amount of money that Dora has in her piggy bank? Next, I will underline the important word(s) in the question."

Examiner, "I know that Dora has money in her piggy bank. What does the word *total* mean? I do not understand this word *total*? Let's see if I go to the store, and I want to buy candy, the cashier will give me a *total* amount to pay. *Total* means *all together* or *sum* or *to add*. If I replace or substitute the word *total* with *sum* does this make sense? What is the *sum* amount of money that Dora has in her piggy bank? Yes, this makes sense. *Total* can also mean to *sum* or to *add* (+).

Examiner, "What is the <u>total</u> amount of money that Dora has in her piggy bank? The word problem says *Dora has $17.00 in her piggy bank. Her grandparents gave her $10.00. What is the <u>total</u> amount of money that Dora has in her piggy bank?* I am going to circle these numbers, as these are the numbers I need to solve this problem. Okay, let's solve the problem. We need to add or sum $17.00 + $10.00 = $27.00. My answer is $27.00; Dora has $27.00 in her piggy bank.

Examiner, "Okay, I need to check my answer. If I start with 17 and count by one dollar (ten times), I count 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, my answer is 27 dollars. This is right. Dora has $27.00 dollars in her piggy bank. Now it is your turn."

Rodriguez, R. J. & Cavendish, W. (2013). Cultural differences in the relationship between perceived family environments and self-determination among students with disabilities. *International Journal for Research in Learning Disabilities, 1*(2), 110-134.

Cultural Differences in the Relationship between Perceived Family Environments and Self-determination among Students with Disabilities

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Abstract

This study examined the potential role of cultural variables in the relationship between perceived family environments and levels of self-determination among students with disabilities. Participants were 190 Latino, African-American and Euro-American students with disabilities enrolled in six high schools within a large urban school district in the United States. Self-determination was measured using the Arc's Self-Determination Scale (SDS, Wehmeyer & Kelchner, 1996). Students' perceptions of their family environment were measured using seven subscales from the Family Environment Scale (FES, Moos & Moos, 2009) that reflected environments that are expected to nurture self-determination according to Self-Determination Theory (SDT; Deci & Ryan, 2007). The family environment subscales were statistically significant predictors of levels of self-determination, and suggested that cultural variables may moderate the relationship between family environments and self-determination. Implications for how parents and schools can enhance self-determination and successful transition among students with learning disabilities from different cultural groups are discussed.

The concept of self-determination has been studied extensively as it relates to the provision of services for persons with disabilities (Perrin & Nirje, 2004; Wolfensberger, 1972) and in the field of special education (Algozzine, Browder, Karvonen, Test, & Wood, 2001; Field & Hoffman, 2002; Mithaug, 1996; Wehmeyer, 2001). An underlying assumption in this research is that if individuals with disabilities are to enjoy a high quality of life, they must have the ability and opportunity to make their own decisions and be in charge of their destinies. However, there is evidence that the meaning of self-determination varies from one culture to the next (Kagitcibasi, 2005; Matsumoto, 1999; Oyserman, Coon, & Kemmelmeir, 2002; Zhang, 2005; Zhang & Benz, 2006). If people from different cultural backgrounds

have different meanings for self-determination, one implication is that the conditions most likely to foster self-determination may also vary depending on the cultural context.

The Historical and Political Context for the Concept of Self-determination

In the United States, the meaning of self-determination has become associated with the idea of *individualism.* Musgrave (2002) traced the legal and political antecedents of the concept of self-determination to the establishment of dozens of nations since the Enlightenment. In this account, self-determination is said to occur whenever a group of people is able to freely determine its own political status. His analysis recounted the relationship between self-determination and the preservation of minority groups throughout the world, from the eighteenth century until the end of World War II. He distinguished between the notion of self-determination in Western Europe and the United States, which was based on nationalistic ideals that did not take ethnic considerations into account, and the notion prevalent throughout Eastern and Central Europe, which emphasized ethnicity. The Western European view of self-determination was rooted in the writings of John Milton, with references to popular sovereignty, civil liberties and natural rights. These ideas were further shaped in the United States by Thomas Jefferson in his emphasis on the importance of individual liberty and representative government. Because of these influences, self-determination in Western Europe and the United States became rooted in the idea of *individualism*.

According to Musgrave (2002), in many other countries such as those in Central Europe, states were made up of heterogeneous cultures and each ethnic group developed a nationalistic sentiment. For example, states like the Russian and Austro-Hungarian empires were composed of a multitude of ethnic groups. In such circumstances, *ethnic identity* became the issue of primary importance, and a notion of self-determination evolved that was sensitive to a minority voice.

If the concept of self-determination has different meaning to different persons depending on their cultural heritage, it stands to reason that factors that may enhance self-determination, such as a person's family environment, may also vary depending on the person's cultural background. This may be particularly true when one considers that the ways in which family members relate to each other are greatly influenced by cultural factors. Therefore, the purpose of this study was to examine the ways students from varying cultural backgrounds, particularly students with learning disabilities, perceive their family environments, and the ways in which these family environments may differ with respect to levels of self-determination.

Self-determination in Cultural Context

In the landmark study *Culture's Consequences* (1984), Geert Hofstede outlined a system of classification of countries throughout the world on the basis of several dimensions that the author suggested were descriptive of each country's culture. One of the most enduring of these dimensions is the notion that countries vary according to the extent to

which they are *individualistic* or *collectivistic* (IND-COL). The study defined this dimension as the extent to which members of a society are expected to look out for themselves individually as opposed to remaining integrated into groups. Oyserman et al. (2002) conducted a meta-analysis of cultural studies examining the IND-COL dimension and found that these studies did not support the idea of IND-COL as a dimension. Rather, they found that some cultures had elements of both individualistic and collectivistic practices and that it was therefore more appropriate to view the concept orthogonally. They also found that while there was a tendency for US and Canadian samples to score higher on individualistic practices, much variation existed in other geographic areas; collectivistic practices were observed in Western European samples and individualistic practices were observed in Asian and Latin American samples. Nevertheless, the meaning of concepts such as self-determination may vary in accordance with the extent to which a person comes from a culture that values individualistic or collectivistic practices.

Additional studies have pointed to other cultural differences that may impact on the meaning of self-determination. Kagitcibasi (2005) found that differences in subsistence and economic systems can lead to differences in the extent to which family practices promote autonomy (individualistic values) or relatedness (collectivistic values). Theories that have attempted to explain the development of self-determination, such as Deci and Ryan's theory on the development of self-determined motivation, have identified autonomy and relatedness as two of three necessary conditions for the development of self-determination, the third being "competence" (1985, 2000). However, according to Kagitcibasi (2005), the extent to which these conditions occur in family relationships may depend on cultural norms.

Other studies have examined self-determination through a cultural lens (Frankland, Turnbull, Wehmeyer, & Blackmountain, 2004; Zhang, 2005; Zhang & Benz, 2006). Zhang (2005) compared special education students from Anglo, Asian and African American backgrounds in the US and found that Anglo children were more involved in activities that reflected personal independence in the home than were children of Asian or African American backgrounds. In a review of the self-determination literature with culturally diverse students, Zhang and Benz (2006) suggested that though the concept of self-determination is rooted in Western European values, it has applicability to persons from diverse cultures. However, the authors pointed out that if the principles of self-determination are imposed on individuals from diverse cultures without regard to their own cultural values, they may feel that these values are not their own, and be less likely to internalize them. Frankland et al. (2004), in a study of self-determination with people of the Navajo culture, concluded that though the Navajo valued self-regulation and autonomy, these concepts were operationalized more in terms of interdependence and group cohesion.

In spite of research indicating that the meaning of self-determination may vary depending on cultural context, there is also research indicating that self-determination is associated with increased well-being and improved quality of life across a variety of cultural groups (Chirkov, Ryan, Youngmee, & Kaplan, 2003; Chirkov, Ryan & Willness, 2005; Deci

et al., 2001; Nota, Soresi, Ferrari & Wehmeyer, 2010; Ryan et al., 1999). These studies, conducted in Canada, Brazil, Russia, Turkey and Korea, upheld the notion that self-determination and autonomy may also be important constructs among people from backgrounds other than those of Western European descent. However, there is little research on the environmental conditions most suitable for fostering self-determination among people of different cultures, especially among people from Latino cultures.

Most theories of self-determination agree that self-determination is both intrinsic to the individual and enhanced through environmental factors (Abery & Stancliff, 1996; Deci & Ryan, 1985, 2000, 2007; Mithaug, 1996; Wehmeyer, 2001). Many researchers agree on the conditions that should be present to nurture the development of self-determination. These include providing support for autonomy, feelings of competence, and a sense of relatedness with others. However, the impact of cultural variables that may affect the ways in which environments enhance the development of self-determination is less clear.

The Role of Family Environments and the Development of Self-Determination

Deci and Ryan's (1985, 2000) theory of self-determination proposes that extrinsic goals become self-determined to the extent that environmental conditions facilitate a person's ability to satisfy the needs of *autonomy, relatedness* and *competence*. *Autonomy* means contexts that foster autonomous regulation. According to SDT, family environments that promote autonomy are more likely to yield self-determined goal-pursuing behavior. *Relatedness* means that since extrinsically motivated behaviors are not inherently interesting, the primary reason people initially perform such actions is because the behaviors are prompted, modeled, or valued by significant others to whom they feel, or want to feel, attached. Family environments that promote relatedness are more likely to lead to self-determined behavior. *Competence* means that people are more likely to adopt activities that relevant groups value when they feel efficacious with respect to those activities. Family environments that promote feelings of self-efficacy are expected to lead to higher levels of self-determined behavior.

Several studies have demonstrated a connection between family environments that provide autonomy support, their impact on the development of self-determined behavior, and positive school outcomes. Grolnick, Krurowski, and Gurland (1999) studied the relationship between parenting practices, children's motivations, and school achievement and found that parents who provided autonomy support had children who performed better and who demonstrated higher levels of intrinsic motivation. In a related study, Joussemet, Landry, and Koestner (2008) conducted parent observational studies and interviews to determine the correlates of children's self-determined motivation. They found that a family environment where structure is provided in a democratic manner, with respect for the child's feelings and interests, is associated with higher self-determination and more positive educational and socio-emotional outcomes.

The Role of Culture in the Relationship between Family Environments and Self-Determination

The potential role of culture as a moderator of the conditions that can enhance self-determination has not been closely examined in the literature, though research has shown that cultural background is associated with differences in family interaction patterns (Roth, 2008; Suarez-Orozco, 1989; Suarez-Orozco & Suarez-Orozco, 1995; Valdes, 1996). If cultural differences affect family interaction patterns, these differences may also be associated with the development of self-determination.

Suarez-Orozco (1989) elaborated on Ogbu's work (1987, 1992) on the dual frame of reference in an ethnographic study of Central American immigrant families and their children who attended two low socioeconomic status (SES) high schools in Southern California. According to Ogbu, voluntary minorities, like many Latino immigrants, develop a *dual frame of reference.* Unlike African-American minorities, who are descendants of immigrants who were brought to the United States involuntarily as slaves, the vast majority of Latino immigrants have entered the United States voluntarily. This means that even though these voluntary immigrants may not have assimilated into the cultural mainstream of the country and may live in poverty, they still consider themselves to have greater educational opportunity relative to their countries of origin. This dual frame may be a source of self-determined motivation in that students may internalize the need to work hard from their parents, in order to avoid returning to the conditions of poverty in their country of origin.

Suarez-Orozco (1989) and Suarez-Orozco and Suarez-Orozco (1995) conducted an ethnographic study comparing first generation Mexican immigrants and second generation Mexicans to Euro-American non-Hispanics born in the United States. They examined a variety of issues impacting on the development of the youths' self-identity, including the concept of *familism*. Familism is defined as a "strong identification and attachment of individuals with their families, strong feelings of loyalty, reciprocity, and solidarity among members of the same family" (1989, p. 113-114). They found that this attitude toward the family stood in stark contrast to the pervasive attitude of individualism among youth from Euro-American families. Euro-American adolescents scored lower than any of the other groups studied on a familism scale. The authors also examined youths' responses to the Thematic Apperception Test and found differences in the prevailing themes when comparing Mexican and Latino youth. Stories told by Mexican youth tended to contain a higher proportion of themes related to family conflict, romance, parents sacrificing themselves so their children can pursue an education, and parents who are nurturing and supportive. Themes from Euro-American youth respondents tended to focus on individualism and pursuing an education to move away from parents.

Valdes (1996) conducted an ethnographic study with ten firs- generation Mexican families and found consistent differences between Latino and Euro-American family environments. First, Latino families were organized "hierarchically". Each member understood his or her role, and their primary responsibility was to the family. This contrasted

with commonly held views of Euro-American families that encouraged equality and independence. Second, family members did not raise their voice and tended to stay close to the family most of their lives. This contrasted with Euro-American family patterns that encouraged assertiveness and an emphasis on social mobility. Third, and consistent with Suarez-Orozco's findings, for Latinos, showing gratitude and respect for parents' sacrifices was a deeply held value. In contrast, the more commonly held value among Euro-Americans was that individual effort and merit were more important. Fourth, these differences in family patterns translated to differences in behavior patterns in the classroom. Latino parents did not expect their children to raise their hands or be among the first to answer questions, since these actions might be viewed as disrespectful. This contrasted with the Euro-American view that it was important to demonstrate personal initiative and decisiveness.

These studies, conducted with Latino immigrants in the US, suggest that Latino family interaction patterns may be different from Euro-American family interaction patterns. If Euro-American and Latino family interaction patterns differ, it is also possible that the conditions in the family environment that are most associated with the development of self-determined motivation also differ.

Self-determination and Positive Educational Outcomes among Students with Learning Disabilities

Research findings related to both differential levels of self-determination and long-term educational and post-school outcomes for youth with intellectual disabilities (ID) and learning disabilities (LD) have been unequivocal in their findings that youth with ID and LD demonstrate lower levels of self-determination and poorer academic achievement and graduation outcomes than youth without disabilities (Newman, Wagner, Cameto, & Knokey, 2009; Wehmeyer & Kelchner, 1995). Recent research has examined goal attainment (a subdomain of self-determination) of diverse middle and high school youth with LD and ID and found no significant difference in goal attainment scores (pre-treatment) between youth with LD and ID (Shogren, Palmer, Wehmeyer, Williams-Diehm, & Little, 2012). This finding supports the current study's focus on an examination of family environment factors that may support the development of self-determination for students with LD in particular.

Therefore, this study examined the relationship between perceived family environments and self-determination among students with disabilities by asking the following questions:

1. Do students who self-identify as Latino, African American, or Euro-American differ in levels of self-determination?
2. Do students who self-identify as Latino, African American, or Euro-American differ in how they perceive their family environments?
3. In what ways are students' perceived family environments associated with levels of self-determination?

4. Is the association between perceived family environments and self-determination moderated by self-reported cultural identity?

Method

Participants

Participants in this study were recruited from six high schools in an urban Florida school district. The sample consisted of 190 high school students identified by the school district to receive special education services. The demographics of the sample approximate the demographics of the school district, where 62% of the youth are Latino, 27% African-American, 9% Euro-American, and 2% other/multiracial. The participant demographics were 58% Latino, 27% African-American, and 15% Euro-American. These groupings were based on student self-report. Students were coded as Latino if they self-reported as Latino or if they reported one or both of their parents were born in a Latino country or Puerto Rico, or described one or more of their parents' ancestries as Latino. Hispanic countries were defined as Spanish-speaking countries in the Caribbean, Central and South America.

Students' race was coded as Euro-American if they reported that they and both of their parents were born in the US and they identified their race as "White". Students were coded as "African-American" if they reported having been born in the US and if they self-declared as Black or African-American. A small number of students who self-identified as Black but also indicated that their backgrounds were Haitian or from other non-Latino Caribbean countries were not included as participants in this study. Thus, the Latino group reflects youth from 1st to 3rd generation immigrant status and therefore, group comparisons made in all analyses must be interpreted with this in mind. Exclusion criteria for participation in the study, however, did include English language learner (ELL) status. The mean age for the overall sample was 17.5 years. The mean age for Latinos was 17.4 years, Euro-Americans was 17.2 years, and African-American was 17.9 years. Males comprised 67% of the sample; 33% were females. The ratio of males to females was similar for each sub-group. Males comprised 67% of the Latino group, 69% of the Euro-American group and 64% of the African-American group.

As noted, all of the students in the sample were district-identified as meeting the criteria for special education services. Of these, 74 % were students with learning disabilities, 7% were other health impaired, 4% were emotionally/behaviorally disabled, 4% were intellectually disabled, 2% were "other" low incidence disabilities and disability category data were unavailable for the remaining 9%.

According to school records, 60% of the students in the sample were receiving free or reduced-priced lunch. Eighty-two percent of the African-American students were receiving free or reduce-priced lunch, as compared to 60% of the Latino students and 25% of the Euro-American students. During the time data for the study were collected, however, many schools in the district were offering a free lunch program to all students, so the percentage of students receiving free or reduced-price lunch may not be a reliable indicator of socioeconomic status.

Procedure

This study was conducted within the context of a larger study with both general and special education youth within the local school district. Permissions were granted by school district and school site administrators prior to the start of the study. Once parent consent and student assent were obtained, the research team administered the survey measures to students individually or in small groups in the school media centers. All items were read aloud to students to account for different reading levels. The measures administered were the Arc's Self-Determination Scale (SDS) (Wehmeyer & Kelchner, 1995) and the Family Environment Scale (Moos & Moos, 2009).

Measures

The Arc's Self-Determination Scale (SDS). The Arc's Self-determination Scale (Wehmeyer & Kelchner, 1995) is a measure of students' levels of self-determination. The SDS is a student self-report measure designed for adolescents with disabilities. The scale is divided into four subdomains:

(1) Autonomy measures a sense of personal control over one's life. It involves the belief that one is acting according to one's own preferences, interests or abilities. Respondents are asked to indicate how frequently they perform a variety of activities associated with autonomy: for example, "I do free time activities based on my interests." There are 32 items comprising this subdomain.

(2) Self-Regulation includes self-management strategies such as self-monitoring, self-instruction, self-evaluation and self-reinforcement. Goal-setting and problem-solving are also associated with this scale. The self-regulation section consists of two subscales with nine questions that require that students write their answers. The first subscale involves story-based items that require that students indicate how they would solve a problem. Each response is scored on a scale of 0-2 points, depending on how thoroughly the student's response brings the situation to a successful conclusion. In one question, a scenario is presented where the student is in a planning meeting with parents and teachers and he/she has to convince them of the desire to take a particular course instead of the one preferred by the parents and teachers. Section II of the self-regulation subdomain asks students to identify goals in several life areas and indicate the steps needed to achieve those goals. These items are scored on a scale ranging from 0 to 3 points, depending on how well the student has planned the steps needed to achieve a goal. The responses to these questions were scored by the authors, who achieved 100% consensus on the number of points that should be assigned to each student's responses to the questions.

(3) Psychological empowerment involves the perception that one has control over circumstances that are important, that one has the skills and efficacy necessary to achieve desired outcomes, and that identified outcomes will result from one's actions. This sub-domain consists of 16 questions asking students to choose, from two options, the one that best describes them. Answers that reflect psychological empowerment are scored a "1" and those that do not are scored a "0." For example, students can choose between the options "I

usually do what my friends want" and "I tell my friends if they are doing something I don't want to do." The second option reflects psychological empowerment.

(4) Self-realization involves having reasonably accurate knowledge of one's interests, abilities and limitations and the capacity to fulfill one's potential. Like the previous section, items are scored either "1" or "0" depending on the direction of the answer. For example, the student may either agree or disagree with the statement, "I do not feel ashamed of my emotions." Agreement reflects self-realization, since it indicates valuing of one's feelings.

The scale was normed on 500 general and special education students aged 14-22 across five states. Students in general education represent 14% of the norm sample and students in special education represent 86% of the sample. The norm sample students who were served in special education primarily represented the learning disability, emotional/behavior disorder, and intellectual disability categories (83%). Fifty-six percent of these youth were Euro-American, 18% Latino, 23% African-American, and 3% other. The scale was validated concurrently against three previously validated measures of internal-external locus of control, intellectual achievement and self-efficacy. The internal consistency measure for the instrument yielded a Cronbach's alpha of .90.

The Family Environment Scale (FES). The FES (Moos & Moos, 2009) was developed to measure social and environmental characteristics of families. The FES consists of 90 items and is scored on a dichotomous scale based on the respondents' true or false answers. The measure consists of 10 subscales of 9 items each. The seven subscales of interest in this study were:

Cohesion – the degree of commitment, support and help family members provide for one another. An example of an item on this scale is "Family members really help and support each other."

Expressiveness – the extent to which family members are encouraged to express their feelings directly. An example of an item on this scale is "We tell each other about our personal problems."

These two subscales are conceptually related to Deci and Ryan's notions of *relatedness* as an important condition for the development of self-determination.

Independence – the extent to which family members are assertive, self-sufficient and make their own decisions. An example of an item on this scale is "In our family, we are strongly encouraged to be independent."

Control – how much set rules and procedures are used to run family life. An example of an item on this scale is "There is one family member who makes most of the decisions."

These subscales are conceptually related to Deci and Ryan's notion of *autonomy* as an important condition for the development of self-determination in opposite ways. "Independence" was expected to be positively associated with higher levels of self-determination, whereas "Control" was expected to be inversely related to higher levels of self-determination among Euro-Americans, but not necessarily Latinos. This subscale was reverse coded, where "no" answers received a point instead of "yes" answers.

Achievement Orientation – how much activities are cast into an achievement-oriented or competitive framework. An example of an item on this subscale is "Getting ahead in life is very important in our family."

Organization – the degree of importance of clear organization and structure in planning family life. An example of an item on this subscale is "Being on time is very important in our family."

Intellectual/Cultural Orientation - the level of interest in political, intellectual, and cultural activities. An example of an item on this subscale is "Learning about new and different things is very important in our family."

These last three scales are conceptually related to Deci and Ryan's notion of *competence.* Family environments that promote achievement, organization and an intellectual orientation were considered to also promote a sense of competence among family members.

The norm groups for the FES consisted of 2,220 family participants including both adult and adolescent groups. The group represented a culturally and ethnically diverse sample, with 68% Euro-American and 32% Latino or Black. The FES manual contains only these two broad groups in the description of the scale development (Moos & Moos, 2009). Internal consistency estimates for the Form R ranged between .61 and .78. Inter-correlations between the subscales ranged from -.53 to .45. Additional validity evidence is provided through summaries or references to approximately 150 research studies. Many of these present convergent validity for the measure's 10 subscales.

Analyses

The data were analyzed using analysis of variance procedures (ANOVA), post-hoc comparisons of means, multiple analysis of variance procedures (MANOVA) and ordinary least squares multiple linear regression design (OLS). In this study, the seven subscales of interest on the FES are continuous independent variables and ethnicity or race is a categorical independent variable. These variables were coded into two "dummy variables", where Euro-American = 0 and Latino = 1 and where Euro-American = 0 and Black = 1. By including both of these dummy variables in the same regression analysis, Euro-American remained the comparison group.

Overall means were obtained for SDS total score and subscales, and FES mean scores for the seven subscales of interest. Mean comparisons were conducted between Euro-American, Latino and African-American students. These analyses addressed the first two research questions: (1) Do students who self-identify as Latino, African American, or Euro-American differ in levels of self-determination? and (2) Do students who self-identify as Latino, African American, or Euro-American differ in how they perceive their family environments?

A simultaneous multiple regression analysis was conducted, regressing SDS total score on the seven FES subscales of interest. This analysis addressed question (3): In what ways are students' perceived family environments associated with levels of self-

determination? An additional multiple regression analysis was conducted regressing SDS on the six FES subscales with the addition of two dummy variables (Latino/Euro-American dummy variable and African-American/Euro-American dummy variable) to retain Euro-American as the reference group. The purpose of these analyses was to determine if Latino group membership and/or African-American group membership contributed significantly to the prediction of levels of self-determination after controlling for the seven family environment variables. Finally, based on the finding that Latino but not African-American group membership was a significant predictor of self-determination, a final sequential regression analysis was conducted adding interaction terms combining Latino membership with each of the FES subscales to further investigate research question number (4): Is the association between perceived family environments and self-determination moderated by self-reported cultural identity?

Results

A preliminary analysis was performed comparing the mean scores of students identified with LD on the Self-determination Scale (SDS) to the mean scores of students in the remaining disability categories in the sample in order to determine whether the scores of students not identified as LD were statistically different from the students with LD. The analysis revealed no statistically significant difference between the two groups of students, suggesting that the inclusion of a small number of students not identified as LD in the sample did not significantly affect the results on the SDS (Total SDS; F (1, 185) = 1.91, p = .169, η^2 = .010).

Comparisons of Means on the Self-determination Scale (SDS) Based on Cultural Group Membership

The analyses described in this section address the research question, "Do Euro-American students differ from Latino or African-American students in their levels of self-determination?" Latino and African-American students scored higher in total SDS than Euro-American students. In order to further examine these differences, a one-way ANOVA was conducted to determine if the mean differences between the groups were statistically significant. These analyses are presented in Table 1. The results of the ANOVA indicated there were significant differences between the groups on at least one of the pairs of group comparisons (Total SDS; F (2, 182) = 3.06, p = .049, η^2 = .033).

In order to test for further differences among the three groups, a post-hoc analysis was conducted using Tukey's honest significant difference (HSD). The results revealed that the difference between the Latino and Euro-American means was statistically significant, whereas the comparisons between the means for Euro-American students and African-American students, as well as African-American students and Latino students, were not ($M_{Latino} - M_{Euro\text{-}American}$ = 10.30, p = .043; $M_{African\text{-}American} - M_{Euro\text{-}American}$ = 9.77, p = .102; $M_{Latino} - M_{African\text{-}American}$ = 0.53, p = .988.

Comparisons among the three groups on each of the four subscales of the SDS revealed significant differences on the Autonomy subscale (Autonomy; F (2, 182) = 5.75, p = .004, η^2 = .059).

Comparison of Means on Family Environment Subscales (FES)

A multivariate analysis of variance was conducted to address question two, "Do students who self-identify as Latino, African American, or Euro-American differ in how they perceive their family environments?" The results revealed no statistically significant differences among the means of the Latino, Euro-American and African-American student groups on any of the FES subscales, Wilks' Lambda F(12, 362) = .691, p = .798.

The Role of Cultural Identity as a Factor in the Relationship between Perceived Family Environments and Levels of Self-determination

In order to explore potential differences between self-determination and perceived family environments for each of the sub-groups, correlational analyses were performed examining the association between total SDS and the seven FES subscales for each sub-group. The results are presented in Table 2.

The results indicate that while there is overlap among the three groups in the relationship between SDS and the FES subscales, there are also differences among the groups. For example, Intellectual/Cultural Orientation was significantly correlated with SDS among the Latino and African-American groups, but not in students from Euro-American backgrounds. In addition, Independence was significantly correlated with SDS among African-American students, but not among Latino or Euro-American students. Expressiveness had a small to moderate correlation with SDS among Euro-American and African-American student, but was unrelated to SDS among Latino students. Control was negatively correlated with SDS among Euro-American students, but unrelated to SDS among Latino students and slightly positively correlated with SDS among African-American students.

Table 1.
Comparison of Total Self-Determination Scores and Subscale Scores between Groups

Self-Determination Measure	*M*	*SD*	*n*
Autonomy			
Euro-American	55.41*	24.90	29
Latino	65.81	12.99	107
African-American	67.12	15.06	49
Self-regulation			
Euro-American	12.72	4.41	29
Latino	12.44	4.09	107
African-American	12.04	4.55	49
Psychological Empowerment			
Euro-American	14.41	1.86	29
Latino	14.30	2.16	107
African-American	14.45	2.15	49
Self-realization			
Euro-American	11.52	2.15	29
Latino	11.97	1.99	107
African-American	11.88	2.43	49
Total Self-determination			
Euro-American	94.41*	25.64	29
Latino	104.71	16.29	107
African-American	104.18	24.33	49

* *M* for Euro-American students significantly lower than *M* for both Latino and African-American students ($p < .05$). $R^2 = 0.06$.

An ordinary least squares (OLS) multiple regression (MR) design was used to further examine the ways in which cultural identity might play a role in the relationship between students' perceptions of their family environments and levels of self-determination. In order to address the question of whether perceptions of the family environment are associated with changes in levels of self-determination, a simultaneous MR was conducted, regressing total self-determination on the seven FES scales. The results of the regression analysis are shown in Table 3.

Table 2.

Pearson Correlations of Total SDS and FES Subscales by Cultural Group

Cultural Group	Total SD	Cohesive-ness	Expressive-ness	Indepen-dence	Achievement Orientation	Int. Cult. Orienta-tion	Organiza-tion	Control
Euro-American SD	1	-.013	.258	.163	-.097	.085	.068	-.221
Latino SD	1	.160	.012	.138	.174	.282**	.097	.089
African-American SD	1	.228	.211	.377**	.216	.294*	.197	.181
Total Sample SD	1	.140	.141	.204**	.130	.241**	.113	.043

*$p < .05$, two-tailed test; ** $p < .01$, two –tailed test

The results indicate that the seven FES subscales were statistically significant predictors of total self-determination score ($R^2 = .105$, F (7, 179) = 2.988, $p = .005$). The FES subscales Independence (β = .165, $p = .034$) and Intellectual/Cultural Orientation (β = .205, $p = .012$) were statistically significant individual predictors of total SDS, after controlling for the other FES subscales.

Table 4 shows the additional amount of variance explained by the addition of the categorical group membership variables for Latino and African-American group membership. This model (Model 2) consisted of adding dummy variables for Latino and African-American. For the first dummy variable, Latinos were coded as "1" and European-American and African-Americans were coded as "0." For the African-American dummy variable, African-American students were coded as "1" and Latinos and European-American students were coded as "0.". Therefore, the reference group was the group of European-American students. The addition of these variables approached but did not meet statistical

significance (ΔR^2 = .027, p = .069). This model explained 13.2% of the variance in self-determination and was statistically significant (R^2= .132, p = .003).

Table 3.

Simultaneous Multiple Regression of Total Self-determination on Seven FES Subscales

	Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
Model	*B*	*SE*	β	t	Sig.	Tolerance	VIF
1 (Constant)	66.021	9.887		6.677	.000		
FES Cohesiveness	-.067	.930	-.006	-.072	.942	.672	1.488
FES Expressiveness	1.493	1.043	.116	1.432	.154	.768	1.301
FES Independence	2.091	.980	.165	2.134	.034	.833	1.200
FES Achievement Orientation	.055	1.066	.004	.051	.959	.775	1.291
FES Intellectual/ Cultural Orientation	2.322	.918	.205	2.531	.012	.762	1.312
FES Organization	.237	.863	.023	.274	.784	.725	1.378
FES Control	.792	.933	.067	.850	.397	.805	1.242
R^2	.105						
F	2.98						
P	.005**						

***p < .01*

Table 4.

Amount of Variance Explained in Sequential Regression of SDS on FES Subscales, Latino and African-American Cultural Identity

				Change Statistics			
Model	*R*	R^2	ΔR^2	F Change	df1	df2	Sig. F Change
1	.32	.105	.105	2.965	7	177	.006
2	.363	.132	.027	2.709	2	175	.069

Note: Model 1 predictors = Seven FES scales; Model 2 predictors = seven FES scales, cultural identity categorical variables; Both Model 1 and Model 2 were statistically significant; Model 1 (p = .006); Model 2 (p = .003).

Table 5 shows the individual contributions of each of the predictors. The addition of the Latino membership variable was statistically significant (β = .234, *p* = .021) but African-American group membership was not (β = .159, *p* = .117). In addition, Independence (β = .179, *p* = .022) and Intellectual/Cultural Orientation (β = .210, *p* = .012) were statistically significant predictors of self-determination, when other variables in the model were controlled for.

Table 5.
Sequential Regression of SDS on FES Subscales, Latino and African-American Cultural Identity

	Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
Model	*B*	*SE*	β	*t*	Sig.	Tolerance	VIF
(Constant)	60.370	10.144		5.952	.000		
Cohesiveness	-.134	.943	-.012	-.142	.887	.654	1.528
Expressiveness	1.236	1.047	.096	1.180	.239	.754	1.327
Independence	2.262	.981	.179	2.306	.022*	.826	1.211
Achievement Orientation	-.139	1.072	-.010	-.130	.897	.761	1.314
FES Intellectual/ Cultural Orientation	2.376	.936	.210	2.537	.012*	.725	1.379
Organization	.205	.863	.020	.237	.813	.719	1.391
Control	.765	.936	.064	.817	.415	.804	1.244
Latino Membership	9.711	4.174	.234	2.327	.021*	.489	2.045
AA Membership	7.362	4.679	.159	1.573	.117	.487	2.052
$R^2_{Model\ 2}$	.132						
F	2.953						
p	.003						

*$p < .05$

Table 6 shows the variance explained in the final regression analysis, consisting of a sequential MR of SDS using the previous two groups of variables with the addition of seven interaction terms created as the cross-products of the Latino group dummy variable and the seven FES subscales, as described in Keith (2006), added as a third step. The interaction terms were included only for the Latino sub-group for two reasons. First, the main effects for each of the dummy variables entered in Model 2 were significant for the Latino sub-group but not the African-American subgroup. Second, the entry of a large number of independent

variables would greatly reduce the power of the analysis to detect an effect when there was one, particularly given the relatively small sample size.

Table 6.
Amount of Variance in SDS Scores Explained by each Regression Model in Final Model

				Change Statistics			
Model	R	R^2	ΔR^2	F Change	df1	df2	Sig. F Change
1	.278	.077	.077	1.535	7	129	.161
2	.377	.142	.065	4.849	2	127	.009
3	.452	.204	.062	1.330	7	120	.242

Note: Model 1 predictors = Seven FES scales; Model 2 predictors = seven FES scales, cultural identity categorical variables; Model 3 predictors = seven FES scales, cultural identity categorical variables and seven FES scales X Latino group interaction terms. Both Models 2 and 3 were statistically significant; Model 2 (p = .018); Model 3 (p = .024).

In the final model (Model 3), perceived family environments explained 7.7% of the variance in self-determination and was not statistically significant, $R^2 = .077$, F (7, 129) = 1.54, $p = .161$. The addition of the Latino and African-American group membership variables increased the amount of variance explained by 6.5% and this change was statistically significant, $\Delta R^2 = .065$, F (2, 127) = 4.85, $p = .009$. The addition of the Latino by family environment subscales increased the amount of variance explained by 6.2%, and this change was not statistically significant, $\Delta R^2 = .062$, F (7, 120) = 1.33, $p = .242$. Both Model 2 (p = .018) and Model 3 (p = .024) were statistically significant overall. The final model explained 20.4% of the variance in self-determination ($R^2 = .204$, F (16, 120) = 1.92, $p = .024$).

Table 7 displays the coefficients for the individual predictors in the final model. In this model, only African-American group membership was statistically significant when controlling for the other variables in the analysis ($\beta = .282$, $p = .010$). It should be noted that the interaction terms show considerable collinearity, since they all share Latino group membership as a component and are therefore highly correlated with each other. This collinearity is associated with high standard errors for each coefficient, which lower the F values and reduce the likelihood of demonstrating statistical significance for any one coefficient.

Table 7
Results of Full Model Regression of SDS on Perceptions of Family Environments, Cultural Identity Variables, and Latino- Family Environment Interaction Terms

		Unstandardized Coefficients		Standard-ized Coeffi-cients			Collinearity Statistics	
	Model	*B*	*SE*	β	t	*p*	Tolerance	VIF
Model 3	(Constant)	68.217	13.112		5.203	.000		
	Cohesiveness	-3.298	2.419	-.340	-1.364	.175	.106	9.399
	Expressiveness	5.027	2.848	.413	1.765	.080	.121	8.269
	Independence	3.035	1.992	.264	1.524	.130	.220	4.541
	Achievement Orientation	-.037	3.464	-.003	-.011	.992	.080	12.468
	Intellectual Cultural Orientation	.013	3.206	.001	.004	.997	.071	14.103
	Organization	2.399	2.276	.267	1.054	.294	.104	9.649
	Control	-1.509	2.226	-.139	-.678	.499	.159	6.298
	Latino Membership	20.418	13.371	.441	1.527	.129	.080	12.577
	AA Membership	45.059	17.168	.282	2.625	.010*	.573	1.744
	Cohesiveness ethnicity interaction	3.707	2.662	.584	1.393	.166	.038	26.478
	Expressiveness ethnicity interaction	-4.969	3.112	-.619	-1.596	.113	.044	22.694
	Independence ethnicity interaction	-2.310	2.284	-.336	-1.011	.314	.060	16.652
	Achievement ethnicity interaction	-.027	3.657	-.004	-.007	.994	.020	48.902
	Model	B	*SE*	β	t	*p*	Tolerance	VIF
	Intellectual/Cultural ethnicity interaction	1.889	3.408	.257	.554	.580	.031	32.437
	Organization ethnicity interaction	-2.935	2.554	-.445	-1.149	.253	.044	22.579
	Control ethnicity interaction	2.074	2.556	.270	.812	.419	.060	16.630
	$R^2_{Model\ 3}$	.204	*F*	1.924	*p*	.024		

* $p < .05$

Discussion

The findings from this study provide some support for the idea that family environments are associated with levels of student self-determination. Students' perceptions of their family environments, based on descriptions that are conceptually related to Deci and Ryan's concepts of autonomy, relatedness and competence, were related to higher levels of self-determination for the sample as a whole. However, these associations also appear to be moderated by factors involving cultural identity.

One possible explanation for the finding that Latino students demonstrated higher levels of self-determination than Euro-American students may lie in the research that explains academic motivation in recent immigrants. Some research has suggested that students who are immigrants, or the children of recent immigrants (second generation), report a strong desire to do well academically due to guilt associated with their parents' sacrifices in immigrating to the US (Suarez-Orozco, 1989; Suarez-Orozco &Suarez-Orozco, 1995). It is possible that this undercurrent of motivation also explains these Latino students' perceptions of their self-determination. Latino students may want to perceive themselves as self-determined in order to believe they are going to meet their parents' expectations of success. On the other hand, these factors cannot be said to operate among students of African-American backgrounds, who showed similarly high levels of self-determination compared to their Euro-American counterparts.

However, there is another potential explanation for the higher self-determination scores among both Latino and African-American students. The higher self-determination scores for Latino students may also have to do with the demographics of the community from which the sample was drawn. Within the public school system, 64% of the population is Latino, 25% is African American, 9% is white of non-Latino origin, and 2% is multi-racial/other (Miami Dade County Public Schools, 2009). Within this context, both Latino and African-American students represent the majority and Euro-American students are in the minority. Teachers and administrators reflect this distribution as well. It may be that in this particular environment, students from Euro-American backgrounds encounter fewer opportunities to become self-determined as they are, in this case, the minority in a literal sense. Latino and African-American students may be able to more readily access available community and school resources that can support their goals if those resources are more tailored to the majority of students in the school system.

The Relationship between Perceptions of the Family Environment and Level of Self-determination

The regression of SDS on the seven FES subscales yielded a statistically significant effect size, suggesting that perceptions of the family environment are associated with variability in levels of self-determination. This finding supports Deci and Ryan's theoretical model, as well as other research suggesting that environments that promote *autonomy,*

relatedness and competence nurture the development of self-determination. However, the relationship between these perceived family environments and self-determination changed considerably when cultural identity was taken into consideration.

While the patterns of correlations between FES variables and self-determination provide some support for the idea that family environments that foster autonomy, relatedness and competence may enhance self-determination, these vary according to cultural background. As predicted by SDS theory, family environments that encourage Independence were associated with increased self-determination, but this association was stronger among African-American students. Similarly, environments that foster an Intellectual/Cultural Orientation were also positively associated with self-determination, but the relationship did not hold for students of Euro-American backgrounds. The notion that environments that are less controlling should foster self-determination only held true for students of Euro-American descent. This is consistent with the idea that for students of Western European decent, self-determination is associated with individualism. This relationship did not hold true for members of Latino or African-American descent, however.

Cultural Differences in the Relationship between Perceptions of the Family Environment and Self-determination

While perceived family environments showed a small but significant effect on self-determination, the addition of the cultural group membership variables in the regression equation further explored the question of whether cultural background may have an additional effect independent of family environments. Before considering the interactions between Latino membership and perceived family backgrounds, Latino background alone was a statistically significant predictor of self-determination.

The addition of the interaction terms for Latino background and perceived family environments reveal that compared to Euro-American students, the kinds of family environments that may enhance self-determination for Latino students may be different. Examination of the standardized β coefficients for the interaction terms reveals that Latino group membership may serve as a moderator of the relationship between perceived family environments and self-determination. The Expressiveness term, for example, was negatively associated with levels of self-determination in Latino students, whereas Expressiveness was a positive predictor of self-determination in the comparison group, the Euro-American students. Similarly, Cohesiveness was a negative predictor of self-determination for the Euro-American students but interacted with Latino background in a positive direction. For Latino families, it appears that more structured, cohesive environments serve to enhance self-determination, whereas the opposite would seem to hold true for Euro-American students.

Similarly, the positive association between Independence and self-determination was reversed for students from Latino backgrounds, as evidenced by the negative interaction between Latino group membership and Independence. Here again, family environments that foster independence may not necessarily be as conducive to enhancing self-determination

among Latino students as they are among African-American or Euro-American students with disabilities.

Finally, while perceived low control in the family environment was associated with self-determination in Euro-American students, it was positively associated with self-determination among Latino students, as evidenced by the negative interaction term. These differences, while not statistically significant, may still reflect a possible moderating effect of cultural identity as the lack of robustness in the findings may also reflect the caveat noted by Oyserman et al. (2002) that cultures may reflect elements of both individualistic and collectivistic practices and values.

The findings described in this paper support the general theoretical position posited by Deci and Ryan (1985, 2000, 2007) that perceived conditions in the family that support needs associated with autonomy, relatedness and competency may promote increased levels of self-determination among student with disabilities. However, the findings also suggest that cultural background may be a variable of interest in evaluating the conditions that support self-determination. Thus, schools may need to be sensitive to the possibility that conditions that foster self-determination and successful transition among Latino students may differ from school-related normative expectations. Latino students' self-determination may be enhanced, for example, by continuing to live with their families after graduation, since cohesive family environments may be more associated with self-determination in this population.

Limitations of the Study

This study had several limitations that must be taken into consideration when drawing conclusions from the data and generalizing to a broader population. First, the analyses were run with a specific sample of Latino, African-American and Euro-American students with disabilities. Generalizations made from the data are limited to these groups as the population was drawn from a community where Latinos and African-American students are the de-facto majorities compared to students from Euro-American backgrounds. Second, generational immigration status must be considered a potential confound when interpreting findings related to differences reported for the Latino group.

Third, as with any research on cultural differences, the grouping of individuals from a variety of different countries, each with its own nuances, into a categorical grouping blurs what may be real differences between these cultures. Finally, other factors known to be associated with self-determination, such as age, gender, and school environments, were not taken into consideration in this study. The addition of these variables into the regression equations may have altered some of the correlations and effect sizes, and coefficients obtained from the analyses.

Implications for Further Research

Much of the research on psychological constructs such as self-determination is conducted without regard to the potential effects of cultural identity. This study suggests that cultural background may be associated with levels of self-determination, and that it may moderate the impact of other factors, such as family environment, on self-determination.

One direction for future research is to conduct a follow-up study with a larger sample of students that takes into account the variables of gender, age, and immigrant generational status. Another area for further research is to conduct qualitative studies with students, parents and teachers to identify factors they may consider important in the development of self-determination that may not have been previously considered relevant.

Perhaps most importantly, the question remains as to whether self-determination is equally important to the successful transition of all students with disabilities, irrespective of cultural background. Even though Latino students perceived themselves as more self-determined, it does not necessarily follow that self-determination is an important cultural value for Latino students. Further research is needed with students with learning disabilities from other cultural backgrounds to examine possible differences in the meaning of the concept of self-determination among people from different backgrounds. This research can also examine potential differences in perceptions of the conditions that support the development of self-determination.

Additional cross-cultural research is critical to a meaningful continuation of self - determination research inquiry and an expansion of qualitative research is also needed to identify cultural beliefs about what parents and students consider important for "successful" academic achievement and post-school transition. If the concept of self-determination is to have meaningful implications for students across a variety of countries and cultures, schools must be sensitive to the meaning self-determination has for students in those cultures. Finally, the relative importance of providing conditions that nurture autonomy, relatedness and competence may also vary if culture has a moderating effect on the conditions that enhance self-determination.

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