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On the Irrelevance of Intelligence in Predicting Responsiveness to Reading Instruction

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ABSTRACT: *There is increasingly negative sentiment against IQ-achievement discrepancy as a method to identify children with learning disabilities (LD) and, more broadly, intelligence as an explanation of poor academic performance. The evidence for this latter view was examined by reviewing 13 studies involving 1,542 children who were at risk or reading disabled to determine whether IQ predicted responsiveness to reading intervention. In 8 of the 13 studies, it accounted for unique variance. It was a stronger and more consistent predictor among older students in interventions designed to strengthen reading comprehension; a weaker and less consistent predictor among younger children in phonological awareness training. Implications are discussed for the identification and treatment of students with LD and the LD construct.*

In this article, we report findings from a literature review directed at the question, What is the relevance of intelligence to learning among children at risk for school failure? To explain the importance and timeliness of this question for those with interest in learning disabilities (LD) and high-incidence disabilities generally, we use our introduction, first, to describe "responsiveness-to-intervention" (RTI) and, second, to explain reasons for its emergence as an alternate or supplement to conventional methods of LD identification. These reasons include longstanding, widespread dissatisfaction with IQ-achievement discrepancy and, among a smaller but influential group of policymakers and researchers, disapproval of the regular use of intelligence measures, apart from "discrepancy-making," to distinguish LD from mild mental retardation (MMR). Because this latter group of critics sees little connection between intelligence and responsiveness to instruction, it supports a "low-achievement" definition of LD, which, some claim, is a negation of the LD construct.

SEA CHANGE

We are witnessing a sea change in LD. For decades, in thousands of school districts, students were designated LD when there was a significant discrepancy between their performance on measures of intelligence and academic achievement. This practice is likely to change, however, as a result of Individuals with Disabilities Education Improvement Act (Public Law 108-446; IDEA; 2004), signed into law by President Bush on December 3, 2004. Although the newly reauthorized law neither encourages nor discourages the continued use of IQ-achievement discrepancy, it says for a first time that practitioners may use an alternative: RTI.

As we write, regulations to accompany the law and specify RTI have not yet been published. According to proponents, RTI starts with the teacher providing scientifically validated, or "generally effective," instruction; identifying at-risk students; and monitoring their academic progress. Those who do not respond to classroom instruction get something else or something more from the teacher, reading coach, or someone else. Again, progress is monitored. Children responsive to the more intensive instruction are returned to the classroom where practitioners continue to monitor their performance. Students still unresponsive either qualify for special education by virtue of their unresponsiveness or are provided a comprehensive evaluation to determine special education eligibility, depending on the version of RTI. Where chronic unresponsiveness is the necessary and sufficient condition for special-education eligibility (e.g., Heartland, Iowa, Area Education Agency and Minneapolis Public Schools), practitioners use a "low-achievement" definition of disability (e.g., Ikeda & Gustafson, 2002; Minneapolis Public Schools, 2001), circumventing hot-button issues like whether and how to measure students' learning potential.

Supporters believe that RTI can also solve more practical problems associated with IQ-achievement discrepancy. Foremost, RTI is described as providing help more quickly to a greater number of struggling students (e.g., Grimes, 2002; Lyon et al., 2001). A related expectation is that by providing more intensive instruction to these students, RTI distinguishes poorly performing students with disabilities from those who perform poorly because of inadequate instruction (cf. Compton, Fuchs, Fuchs, & Bryant, 2006; Fletcher, Coulter, Reschly, & Vaughn, 2004; Fuchs, Fuchs, & Compton, 2004; Vellutino et al., 1996). RTI backers reason that a successful separation of "true positives" (i.e., those truly disabled) from "false positives" (those who appear disabled but are not) will reduce special education enrollments and costs (e.g., Batsche et al., 2005).

RTI, then, should encourage serious and sustained early intervention with at-risk children, leading to stronger school performance and to fewer special education referrals, all of which enhances the validity of the disability-identification process. Such changes in service delivery would indeed be of substantial benefit to children, teachers, and schools. At the same time, important questions are being asked about (a) whether teachers will indeed implement scientifically validated instruction with fidelity; (b) whether they and their support staff will correctly identify at-risk students—those likely to be unresponsive to "first-tier" instruction—and will choose valid measures to regularly monitor their academic progress; (c) whether school districts will deploy more intensive, best-evidence, "second tier" instruction for the children unresponsive to first-tier instruction; (d) whether the children's performance will be monitored at this second tier and, for those deemed responsive enough to return to the classroom, whether practitioners will continue to monitor the children's performance there; and finally, (e) whether these many activities will lead to reductions in special education enrollments and cost.

"IQ-Achievement Discrepancy Is Invalid"

Notwithstanding such uncertainty, RTI is a "train that's left the station," prompting the question: How did a novel operationalization of LD get written into law to compete with widely observed conventions? One answer begins with the fact that the ubiquitous use of IQ-achievement discrepancy has belied many scholars' longstanding and profound dissatisfaction with it. More than 15 years ago, Siegel (1989, 1992), for example, identified and then rejected four common assumptions associated with its use. Assumption #1, she said, is that IQ tests measure intelligence. She wrote that "the term *intelligence* implies problem-solving skills, logical reasoning, and/or adaptation to the environment" (italics in the original, 1989, p. 469); and yet, she argued, no IQ tests explore those skills or abilities. Assumption #2: IQ and academic achievement are independent constructs. Siegel claimed that many poor readers are deficient in processing speed, short-term memory, and verbal skills and these weaknesses "can occur at any level, so that a particular IQ score should not be a requirement for the presence of a learning disability" (Siegel, 1988, p. 265).

Assumption #3 is that reading performance can be predicted from IQ scores. If this were true, she pointed out, then children with low IQ scores should be poor readers. Yet, she asserted, low IQ children "can learn to read, often as well as children with higher IQ scores and no reading disabilities" (Siegel, 1989, p. 472). And therefore, "children with low IQ scores who fail to read are genuinely reading disabled and do not fail to read because of low IQ scores" (p. 472).

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A last assumption is that the cognitive processes of high-IQ students with LD are different than those of low-IQ students with LD. To this, Siegel (1989) responded that emerging evidence suggests the two groups are more alike than not with respect to certain cognitive processes. More recently, Fletcher et al. (1994), Francis, Fletcher, Shaywitz, Shaywitz, and Rourke (1996), and Vellutino et al. (1996) compared young, poor readers with and without an IQ-achievement discrepancy and failed to obtain consistent between-group differences on cognitive and linguistic tasks closely related to reading. Moreover, these and other researchers found that phonological awareness was the most robust predictor of early reading performance, and that both discrepant and nondiscrepant poor readers tended to be equally deficient on this skill.

Others (e.g., Algozzine, Ysseldyke, & McGue, 1995; Coles, 1989; Lyon, 1987; Spear-Swerling & Sternberg, 1998; Stanovich, 1999; Willson, 1987) have expressed similar or related concerns about IQ-achievement discrepancy. Hence, the "sea change" in IDEA 2004 regarding LD has, at least for some, been a long time coming. In the last 5 years, influential policymakers such as Reid Lyon and colleagues have synthesized the various conceptual and methodological concerns and related research to offer a comprehensive and persuasive critique of IQ-achievement discrepancy (cf. Lyon et al., 2001). Lyon and associates' work has helped create what seems like a majority view on the issue, at least among academicians. To wit: Speece and Shekitka (2002) asked 218 members of the editorial boards of several scholarly journals how "reading disability" should be operationalized. Seventy percent responded that IQ-achievement discrepancy should play no role.

Similar sentiment was expressed in various policymaking documents in the run-up to the most recent IDEA reauthorization. The National Research Council's report on minority overrepresentation in special education (Donovan & Cross, 2002), the official proceedings from the Office of Special Education Programs' LD Summit (see Bradley, Danielson, & Hallahan, 2002), and the written recommendations of the President's Commission on Excellence in Special Education (2002) all conveyed concern about the continued use of IQ-achievement discrepancy as a method of LD identification. Such questioning in high-profile venues and reports bolstered a scientific stance against discrepancy, making it easier for policymakers to push for an alternative.

"Intelligence Is Unimportant"

For Siegel (1989, 1999), Fletcher et al. (2002), and others, the devaluation of intelligence as a construct extends beyond a rejection of IQ-achievement discrepancy as a method of LD identification. These authors argue that intelligence is relatively unimportant—if not irrelevant—to an understanding of poor school achievement and how to address it. To wit: "I would like to propose that we abandon the IQ test in the analysis of the child with learning disabilities. The time and money spent administering and analyzing [it] . . . could be far better spent on administering specific tests of achievement that might give a better idea of the child's actual functioning" (Siegel, 1989, p. 477). And "[t]he concept of IQ as it is applied to LD is outmoded and reflects an obsolete practice . . . IQ tests do not measure aptitude for learning or provide an index of response to intervention" (Fletcher et al., 2002, p. 234). And "IQ scores do not predict who is able to benefit from remediation" (Siegel, 1999, p. 312). In other words, these and other writers recommend that practitioners cease or curtail their use of intelligence tests, period.

It should be noted that some arguing against IQ-achievement discrepancy and against the routine use of IQ tests in the identification-eligibility process, have expressed support of IDEA's exclusionary principle that states that a child may not be considered LD if she or he is viewed as having mental retardation. Some, too, have recommended that, when practitioners cannot decide between LD and mental retardation designations on the basis of school performance or school behavior, achievement tests (e.g., Fletcher & Reschly, 2005) or brief measures of intellectual functioning (Gresham et al., 2005) may be administered.

Such support of IDEA and recommendations notwithstanding, Siegel's (1989, 1999) and others' devaluation of intelligence as an explanation of poor school performance is reflected in at least two implicit presumptions: first, that LD may be distinguished from mental retardation by most teachers most of the time without the use of intelligence or cognitive tests; second, that practitioners will indeed administer such tests when they cannot decide between the two designations. This second assumption is as dubious as the belief, appropriately questioned by Fletcher et al. (2004), that equal opportunity to learn is guaranteed by the IDEA exclusionary clause that reads in part, "a child shall not be determined [disabled] . . . if the determinant factor . . . is lack of instruction" (P.L. 105-17, see 614 (b) (5)). Fletcher et al. write, "without some RTI activities in place, this component of IDEA is merely surmised and not measured" (p. 312). Similarly, without the required routine use of a measure of cognitive functioning, the component of IDEA requiring an explicit separation of LD from mental retardation may be merely surmised and not measured. If one claims to view intelligence as relevant, then the use of appropriate cognitive measures to distinguish LD from mental retardation is too important to leave to chance.

Why Downgrading the Importance of Intelligence Is Provocative. The demotion of intelligence in the identification and treatment of children with special needs is provocative on at least four levels. First, minimizing the role for intelligence when explaining poor achievement is tantamount to rejecting LD as an explanation, too. The essence of a traditional understanding of LD, after all, has been "underachievement," or unexpectedly poor achievement despite average or better intelligence. Some RTI supporters' primary focus on low-achievement challenges the distinctiveness and validity of LD as a category of exceptionality (cf. Kavale, Holdnack, & Mostert, 2005). Many parents of children with the LD label, especially parents of children with relatively high achievement and relatively high IQ scores, may contest the notion that intelligence is unimportant in making sense of their children's inadequate learning.

Second, by reducing the importance of intelligence, some in effect are questioning the necessity of "LD" and "MMR" categorical labels. The thinking seems to be that whatever between-group differences may exist, none carries special import with respect to treatment: Effective instruction is effective instruction. Put differently, a noncategorical model of service delivery is not just reasonable but preferable to traditional categorical models that perpetuate divisions among students based on doubtful distinctions like "LD" versus "MMR" (cf. Reschly, Tilly, & Grimes, 1999). However, such a stance is at odds with research suggesting that students with LD and with MMR indeed learn differently (e.g., Hall & Day, 1982; Mastropieri, Scruggs, & Butcher, 1997; Scott & Greenfield, 1992; Scott, Greenfield, & Partridge, 1991; Van Luit & Naglieri, 1999; Wiss, 1986). If noncategorical service delivery becomes more widely accepted, and children with LD and MMR are routinely combined for instruction, three closely related outcomes may follow: (a) increased heterogeneity of instructional groups, (b) increased difficulty in teaching all children, and (c) increased concern among building-based practitioners who are accountable for closing the gap between children with and without disabilities.

Third, a well-known version of RTI implemented in Heartland (IA) Area Education Agency, Minneapolis Public Schools, and elsewhere, reflects a behaviorist paradigm. Key components of this approach are the use of effective instruction and valid measures to monitor students' level and rate of performance. Disability is defined as chronic unresponsiveness, the identification of which often leads directly to noncategorical special-education placement. Multidisciplinary evaluations are infrequent, as is the testing of children's cognition, language, and perception (e.g., Grimes, 2002; Marston, 2001; Minneapolis Public Schools, 2001). Whereas this approach to RTI has incontrovertible strengths, many academicians as well as numerous practitioners in schools and clinics may bristle at the implication that children's cognitive, linguistic, and perceptual performance is unnecessary to understand persistently poor school performance.

The attempt by some to belittle the value of such information also seems to conflict with programs of research and an emergent literature on nonresponders the aim of which is to understand the cognitive-linguistic (e.g., Compton et al., 2006; Fuchs, Compton, Fuchs, Paulsen, Bryant, & Hamlett, 2005; Torgesen & Davis, 1996; Torgesen et al., 1999; Vellutino et al., 1996) and neuro-behavioral (e.g., Eden, VanMeter, Rumsey, Maisog, Woods, & Zeffiro, 1996; Pugh et al., 2001; Shaywitz, et al., 2002; Shaywitz et al., 2003) underpinnings of literacy and numeracy performance.

Fourth, devaluing intelligence as an explanation of poor school performance ignores a well-known and largely well-respected scientific literature on the importance of intelligence to human behavior. Beck (1986); Ceci (1991); Clarren, Martin, and Townes (1993); Flynn (1980); Gottfredson (2002); Hunter and Hunter (1984); Jensen (1998); Lubinski (2004); McCall (1977); Schmidt and Hunter (1993, 2004); Schmidt, Hunter, McKenzie, & Muldrow (1979); Sternberg, Grigorenko, and Bundy (2001); and many others, have shown intelligence to be a powerful predictor of academic success, job performance, career status, and personal well-being.

Minimizing the Importance of Intelligence and Social Justice. By characterizing as provocative the assertion that intelligence is unimportant to an understanding of poor achievement, we are not saying provocation was the intent of those behind the claim. We believe their goals are loftier and nobler. By urging us to question the relevance of intelligence and the instructional validity of the LD construct and categorical service delivery to the identification and treatment of our most vulnerable children, these researchers and policymakers seem to be trying to facilitate an important redistribution of resources favoring low-income children and, particularly, poor children of color. For decades, many such children have failed to qualify as LD because, according to some, discriminatory IQ tests resulted in IQ scores insufficiently different from low achievement scores to produce a significant discrepancy. Commenting on this apparent class or race bias, Stanovich (1999) writes, "[I]t is rare for the advocates of discrepancy-based definitions to articulate the theory of social justice that dictates that society has a special obligation to bring up the achievement of individuals whose achievements fall short of their IQs, rather than simply to bring up the skills of those with low skills period" (p. 353). And whatever stock one puts in the foregoing, it is a matter of record that for decades in many urban school districts there was no other means beyond special education of securing such children the education they needed and were not getting in general education (e.g., Gottlieb, Alter, Gottlieb, & Wishner, 1994). By promoting a simpler low-achievement definition of LD, more children will get the services they need, say Lyon et al. (2001).

Purpose of Review

Whereas there is evidence to believe that IQ-achievement discrepancy is an inappropriate index of LD, it is less clear whether the routine measurement of intelligence should be eliminated in eligibility and placement-related decision making, as some have recommended. Those who argue against its regular use do so because they believe that a low-achievement definition of LD will be cost effective, psychometrically justifiable, egalitarian, and inclusive. But a low-achievement definition means a very different LD, and the likely de-certification of a large number of low-achieving children with that label from special education. Moreover, a low-achievement definition, if widely embraced, may signal a retreat from promising efforts to understand the cognitive-linguistic underpinnings of student nonresponsiveness in the service of developing more individually tailored and potent instructional programs.

A pivotal question becomes, "How important is intelligence to learning?"

A pivotal question becomes, "How important is intelligence to learning?" In this article, we report on findings from a systematic review of studies exploring the importance of intelligence to at-risk and reading-disabled children's responsiveness to reading instruction. Does it predict responsiveness? If it plays an insignificant role, we say it should then claim an equally unimportant role in eligibility and placement-related decision making as well as in instructional planning. If, on the other hand, it proves an important predictor of instructional responsiveness, its influence in these decision-making contexts is strengthened, as is its importance in how we conceptualize LD.

METHOD

Inclusion Criteria

We used five criteria to select studies. Authors of these studies (a) published them in peer-review journals; (b) administered intelligence tests, or, in a few cases, proxies for an intelligence test, to each participating child; (c) applied well-defined, intensive reading interventions; (d) used reading or reading-related measures to index effects of the interventions; and (e) included children at risk for reading failure or students who had already been identified as reading disabled. We applied the first criterion—publication in peer-review journals—to ensure study quality and delimit our search. By requiring that selected studies involve intensive remedial interventions (our third criterion), we narrowed the focus of our search in a different way by excluding descriptive (often longitudinal) investigations of reading development during children's participation in general education (e.g., O'Malley, Francis, Foorman, Fletcher, & Swank, 2002; Scarborough, 1998).

The literature search was conducted in five steps. First, we entered the terms Intelligence and Achievement, IQ-Achievement Discrepancy, and Reading and Intelligence into a computer search, using the Educational Resources Information Center (ERIC) from 1966–2002; Psych Lit from 1967–2002; and Exceptional Child Educational Resources from 1969–2002. Second, we reviewed the abstracts produced by this search to determine which articles met the inclusion criteria. Third, articles were obtained and their respective reference sections were examined for other articles likely to meet the inclusion criteria. Fourth, two books were consulted: *Better Understanding Learning Disabilities: New Views from Research and Their Implications for Education and Public Policies* (Lyon, Gray, Kavanagh, & Krasnegor, 1993), and *Identification of Learning Disabilities: Research to Practice* (Bradley et al., 2002). Finally, the second author conducted a manual search of the following journals from January 1980 to January 2003: *Journal of Educational Psychology, Journal of Experimental Child Psychology, Journal of Learning Disabilities, Journal of Special Education, Learning Disabilities Research and Practice, Reading Research Quarterly, Remedial and Special Education,* and *Scientific Studies of Reading.* If the title of an article indicated that the study involved a reading intervention, the abstract was read to determine its usefulness for this review. As a result of this search (for which parenthetically but importantly there are no inter-rater agreement data), 13 articles were identified. We describe them principally in terms of study participants in our Table 1, and they are signified by asterisks in the reference section.

Organization of Review

Discussion of these studies is organized primarily by type of intervention implemented: Phonological awareness (PA) training versus more comprehensive reading instruction. "More comprehensive instruction" denotes interventions that included decoding, fluency-building, or reading

TABLE 1

Studies' Sample Size, Participants' Age and IQ, Type of Instructors, and Fidelity-of-Treatment Information by Nature of the Intervention and Whether IQ Predicts Responsiveness

Nature of Intervention/Study Authors	N	*Age/Grade*	*IQ Test*	*IQ Score*	*Instructor*	*Fidelity Data?*
Phonological Awareness						
IQ Predicts Responsiveness						
Hatcher & Hulme (1999)	124	7 years	WISC-R Short Form[a]	68–122	Teachers	Yes
O'Conner et al. (1993)	47	4–6 years	McCarthy[b]	50–112	Teachers	Yes
Wise et al. (1999)	122	Grades 2–5	WISC-R Full Scale	> 85	Teachers	Yes
IQ Does Not Predict Responsiveness						
O'Shaughnessy & Swanson (2000)	45	Grade 2	WISC-3 Full Scale[c]	> 85	Paraprofessionals	Yes
Schneider et al. (1999)	346	Kindergarten	Culture Fair Intelligence	$M = 105$	Teachers	No
Torgesen & Davis (1996)	100	Kindergarten	SB-IV Vocabulary[d]	$M = 89$	Research staff	No
Comprehensive Reading						
IQ Predicts Responsiveness						
Berninger et al. (1999)	48	Entering Grade 2	WISC-3 Short Form	$M = 91.6$	Research staff	Yes
Foorman et al. (1998)	285	Grades 1 and 2	WISC-R Verbal	> 85	Teachers	Yes
Stage et al. (2003)	128	Grade 1	WISC-3 Short Form	> 80	Research staff	No
Torgesen et al. (1999)	138	K–2	WISC-R Short Form	> 75	Research staff	Yes
Torgesen et al. (2001)	50	8-10 years	WISC-R Verbal	> 75	Research staff	No
IQ Does Not Predict Responsiveness						
Vadasy et al. (1997)	35	Grade 1	PPVT[e]	> 52	Community tutors	No
Vellutino et al. (2000)	74	Grade 1	WISC-R Full Scale	> 90[f]	Research staff	Yes

[a]Wechsler Intelligence Scale for Children-Revised (Wechsler, 1974). [b]McCarthy Scales of Children's Abilities (McCarthy, 1972). [c]Wechsler Intelligence Scale for Children-Third Edition (Wechsler, 1991). [d]Stanford-Binet Intelligence Scales-Fourth Edition (Thorndike, Hagen, & Sattler, 1986). [e]Peabody Picture Vocabulary Test (Dunn & Dunn, 1981). [f]> 90 on either Verbal or Performance scales.

comprehension components, usually in conjunction with PA training. Our presentation of the 13 studies is also organized by whether IQ reliably predicted participating children's responsiveness to the intervention. Finally, each section is divided by the children's age. "Early primary" is defined as preschool to first grade; "late primary," second through sixth grade. We organized our review in this manner for two reasons. First, we hypothesized that as an intervention becomes more comprehensive IQ may become a more important predictor of student responsiveness. Second, as students get older, the demands and expectations of reading become greater, moving beyond mastery of simple PA and decoding skills to an analysis and comprehension of text.

PHONOLOGICAL AWARENESS TRAINING

IQ Predicts Responsiveness to Treatment

Among the 13 studies, researchers in 6 studies implemented PA training. In one of these 6 studies, researchers used only PA measures to determine training effects. In 2, 1, and 2 additional studies, respectively, researchers relied on measures of PA and decoding; PA, decoding, and reading comprehension; and PA, decoding, reading fluency, and reading comprehension.

Early Primary. Only one PA training study was found in which IQ reliably predicted responsiveness among young children. O'Connor, Jenkins, Leicester, and Slocum (1993) examined the usefulness of teaching phonological skills to 47 four-to-six-year-old students with developmental delay before formal reading instruction. Eighty percent of the students were language impaired. The McCarthy Scales of Children's Abilities (McCarthy, 1972) was administered, and IQ scores ranged from 50 to 112 ($M = 71$). None of the students had received instruction in letter sounds or reading. They were placed in one of four groups: "blenders," "segmenters," "rhymers," or a control group. "Blenders" were taught to blend continuous sounds, onset rimes, and phonemes. "Segmenters" were taught to segment phonemes, onset rime, and first sounds. The rhyming group was taught rhyme recognition, rhyme production, and rhyme oddity. PA training occurred four times per week for 7 weeks in groups of three to five children. Each session ran 10 min. Total training time was approximately 5 hr.

Pretest measures were developed to evaluate the three skills taught within each treatment (e.g., segmenting phonemes, segmenting onset-rime, and segmenting the first sound, etc.). Hence, there were nine phonological subtests. Students were also given a letter recognition test. Using multiple regression, IQ accounted for a statistically significant amount of the variance on three of nine posttests (i.e., blending onset-rime, segmenting first sound, and rhyme oddity); for the controls, on six of the nine tests (i.e., all blending and rhyming tests). This suggests PA training weakened the importance of IQ to those phonological measures. No r^2 value was reported.

Late Primary. Whereas young students with disabilities, such as many of those in O'Connor et al.'s (1993) study, may be expected to master only select PA skills, older students are expected to decode words, read many words by sight, read with increasing fluency, and comprehend what they read. A small group of researchers have explored whether PA training affects reading skills more complex or advanced than PA and what if any role IQ plays in mediating these training effects.

Wise, Ring, and Olson (1999) explored how such training should be conducted for children with LD. Participants were 122 students in second through fifth grade. All had severe word identification problems (lowest 10th percentile in each classroom) despite mean full scale IQ scores greater than or equal to a standard score of 85 on the Wechsler Intelligence Scale for Children-Revised (WISC-R; Wechsler, 1974). None had sensory deficits or emotional/behavioral disorders. Wise et al.'s identification criteria were consistent with the contemporary federal definition of LD.

The students with LD were assigned to three PA training conditions and a control group. In the "sound manipulation" treatment they learned to explicitly manipulate sounds; in the "articulation" treatment they focused on articulatory awareness concepts; and in the "sound manipulation and articulation" treatment they were taught both explicit manipulation of sounds and how articulatory concepts relate to sounds and spellings of those sounds. The same teachers taught every condition, and they taught for an equal amount of time in groups of one to three students. Across conditions, students were encouraged to perform well and were granted time on a computer. Total training time was approximately 40 hr over 6 months. Control students received general classroom instruction with no modifications.

No differences were reported among the three treatment groups in word reading or reading comprehension, and all three groups outperformed controls. Multiple regression analyses determined that the WISC-R full-scale score was a statistically significant predictor of gains in word recognition as measured by The Wide Range Achievement Test-Revised (WRAT-R; Jastak & Wilkinson, 1984; r^2 = .08), and of gains in untimed nonword reading (r^2 = .048), nonword repetition (r^2 = .08), and comprehension (r^2 = .19). The WISC-R full-scale score did not predict growth on PA measures. When IQ was entered into the regression with grade and PA, Wise et al. (1999) indicated that IQ was the most important predictor of growth on the Peabody Individual Achievement Test (PIAT; Dunn & Markwardt, 1970) measure of reading comprehension (no r^2 reported). Its r^2 decreased from 8% to 5.7% on the WRAT.

In a second study, Hatcher and Hulme (1999) conducted a longitudinal investigation of the importance of PA and IQ to responsiveness to reading instruction. Participants were younger that those in the Wise et al. (1999) study. A total of 124 seven-year olds were assigned randomly to one of four conditions: reading, PA, reading and PA, and controls. Students were given pre- and posttreatment tasks. Reading tests included examiner-made tests of word and nonword pronunciation, accuracy in text, and comprehension. PA tasks included nonword repetition, phoneme deletion, phoneme blending, nonword segmentation, and sound categorization. The researchers used recall of digits to measure short-term memory. A general IQ score was derived from the object assembly, block design, similarities, and vocabulary subtests of the WISC-R.

Each student was tutored for forty, 30-min. sessions over a 20-week period (20 hr of total training time). Thus, Hatcher and Hulme's (1999) students were tutored for less time than those in Wise et al.'s (1999) study. But, unlike Wise et al.'s children, they received individualized instruction. Hatcher and Hulme's teachers were trained over 3 days and monitored by the authors on an ongoing basis. PA training included rhyming, segmenting syllables, discrimination of sounds within words, blending, segmenting, and deletion of phonemes. Children were graduated to a next level of difficulty after achieving 80% success on the previous skill. In the reading and PA group, the main reading intervention was Reading Recovery (Clay, 1985) with a phonological component. Activities were also conducted to connect reading and phonology. The reading group received the same reading curriculum without explicit references to PA or phonology.

The PA group made the most progress in PA; the PA and reading group demonstrated the greatest gains in reading and spelling. Hatcher and Hulme (1999) hypothesized IQ would be a strong predictor of reading comprehension even if it were a weak predictor of reading accuracy, and results were consistent with their hypothesis. Hierarchical regression analysis indicated that, whereas IQ did not add unique variance to reading accuracy, it was a unique predictor of reading comprehension (r^2 = .05). Phoneme manipulation was the better predictor of reading accuracy (r^2 = .07).

IQ Does Not Predict Responsiveness to Treatment

Three studies involved PA training in which IQ failed to predict responsiveness to instruction. Two of the three studies involved students in the early primary grades.

Early Primary. Torgesen and Davis (1996) analyzed individual differences that predicted responsiveness to PA training. One hundred kindergarten students from two low-socioeconomic status and minority schools who scored below the 80th percentile on the Test of Phonological Awareness (Torgesen & Bryant, 1993) were assigned randomly to either a PA training program or a no-treatment control group. The training was conducted in groups of three or four students in 20-min sessions four times a week for 12 weeks (total training time was approximately 16 hr). Students were trained in both synthetic and analytic skills. Pretests included measures of phoneme segmentation and sound isolation (test of analytic skills), phoneme blending (synthetic awareness skill), naming rate for digits, digit span test, letter-name knowledge, letter-sound knowledge, reading nonwords, spelling nonwords, and the vocabulary subtest of the Stanford-Binet Intelligence Scales-Fourth Edition, (SB-IV; Thorndike, Hagen, & Sattler, 1986). The tests of segmenting and blending were administered at three different points to determine growth over the training period.

Growth curve analysis indicated that the best predictors of responsiveness to treatment were spelling nonwords at pretest (r^2 = .23 for segmenting; r^2 = .40 for blending) and general verbal ability (r^2 = .20 for segmenting; r^2 = .18 for blending). Although these contributions were independent of one another, the best model predicted only 26% of the variance for segmenting. For blending, virtually all of the variance was accounted for by the best model. When the Test of Phonological Awareness was added to the model, general verbal ability no longer explained any of the variance for blending.

The second PA training study was conducted by Schneider, Ennemoser, Roth, and Kuspert (1999) who included all kindergarten children in 11 classes in Franconia, Germany. A total of 191 children were pretested in December of their kindergarten year. Pretests included deletion of initial phonemes, blending, alliteration and rhyming, phonological memory, letter knowledge, and rapid naming. The intervention was Lundberg's (1988) six metalinguistic exercises: Listening games, identifying rhymes, spoken sentences and words, syllable segmentation, onset-rime segmentation, and phoneme analysis and synthesis. The training consisted of daily lessons in each classroom over 6 months lasting 10 to 15 min each. Students were tested at the end of kindergarten, first grade, and second grade. These tests included the Diagnostic Spelling Test (Mueller, 1982), and German reading and spelling tests.

Students in the PA training group outperformed the control group on PA tests and reading and spelling tests. Additional analyses were conducted to determine whether at-risk, average, and advanced children benefited similarly from the training; whether there were individual differences in response to the instruction; and whether the training reduced the risk of later reading disabilities. Schneider et al. (1999) concluded that all students benefited from the PA training. Regression analyses revealed that neither the Culture Fair Intelligence Test (Weiss & Osterland, 1980) scores nor PA scores significantly predicted training gains in reading or spelling. There was no effort to teach or measure reading comprehension.

Late Primary. The final PA training study in which IQ did *not* predict responsiveness to treatment was conducted by O'Shaughnessy and Swanson (2000). They compared the effects of two interventions for at-risk second graders. Participants were referred by their teachers for reading below grade level. All students had full-scale IQ scores greater than 85 on the Wechsler Intelligence Scale for Children-Third Edition (WISC-3; Wechsler, 1991). They also scored in the bottom quartile on Woodcock Reading Mastery Tests-Revised (WRMT-R; Woodcock, 1987) Word Identification, Word Attack, and Passage Comprehension, as well as in the bottom quartile on the Test of Phonological Awareness. The authors excluded students if they had sensory impairments, English as a second language, behavior problems, brain damage, or a chronic medical condition. The final sample consisted of 45 participants with a mean IQ score of 89.6.

Pretest measures included WRMT-R Word Identification, Word Attack, and Passage Comprehension; the PIAT spelling subtest; CBM measures; the Test of Phonological Awareness, and the Wechsler Individual Achievement Test (WIAT; Wechsler, 1992) numerical operations and math reasoning. Resource teachers' assistants were trained to implement the interventions for 10 hr across 6 weeks. They received ongoing supervision and training and there was a 1-hr weekly meeting with the principal investigator. Students were assigned randomly to the two interventions or to a control group. The first intervention, PA training, included rhyming, sound blending, sound segmenting, and reading and spelling activities. The second intervention, Word Identification by Analogy, included 90 key words with high frequency spelling patterns. In each training session, 5 key words were presented within the context of sentences, and students practiced the words. The control group was given the same amount of instructional time in math. Both reading interventions lasted 30 min each session, 3 days a week for 6 weeks. Total training time was 9 hr.

The two interventions strengthened students' capacity to decode words, but this did not generalize to improved isolated-word reading. The best predictor, according to individual growth curve estimates, was initial word recognition. IQ did not predict growth in reading fluency or reading accuracy, whereas it did predict growth for controls, with prediction increasing with older children (r^2 = .15 at pretreatment; r^2 = .27 at posttreatment). As in the O'Conner et al. (1993) study, PA training appeared to weaken the importance of IQ as a predictor.

SUMMARY

Six studies examined how well IQ predicted responsiveness to treatment, which was primarily PA training. In three studies, IQ was a statistically significant predictor. Study features that may explain these inconsistent findings are participants' age, study measures, and treatment fidelity.

Participants' Age. Two of three studies (Hatcher & Hulme, 1999; Wise et al., 1999) in which IQ predicted responsiveness to treatment were implemented with older children (Grade 2 and above). In the one study in which IQ did *not* predict responsiveness among older students (O'Shaughnessy & Swanson, 2000), study participation was restricted to those with IQ scores greater than 85. This restriction of range may have influenced results.

Dependent Measures. In Torgesen and Davis's (1996) PA training study, IQ predicted 18% and 20% of the variance in blending and segmenting, respectively. When pretreatment levels of PA were added to the regression equation, however, IQ no longer accounted for unique variance. O'Connor et al. (1993) reported similar results. Wise et al. (1999) investigated the importance of IQ to word attack skills (indexed by the Word Attack subtest of the WRMT-R) and word-level reading (measured by the WRAT-R and PIAT). IQ accounted for unique variance on the WRMT-R Word Attack subtest (4.8%), and it explained unique variance on the WRAT-R (8%), but not on the PIAT. When Wise et al. combined IQ with PA and grade level, IQ continued to account for unique variance on the WRAT-R (r^2 = .057).

Wise et al. (1999) also explored the importance of IQ to reading comprehension by combining it with PA and grade level. It was the strongest influence on children's growth on the PIAT reading comprehension measure (r^2 = .19). In Hatcher and Hulme's (1999) study, IQ accounted for 5% of the variance on the Neale Analysis of Reading Ability (Neale, 1988). Hence, in PA training studies, it appears IQ tends to account for a statistically significant portion of the variance on word-level and reading-comprehension measures, but not on PA measures. In addition, its predictive validity is more modest when combined with PA and other variables. And PA training appears to weaken the importance of IQ to responsiveness to instruction, with IQ scores tending to be more predictive of control group gains than training group gains.

Fidelity of Treatment. In each of the three studies in which IQ predicted responsiveness to treatment (Hatcher & Hulme, 1999; O'Connor et al., 1993; Wise et al., 1999), researchers determined the fidelity with which the instruction was conducted. According to the researchers, fidelity data were collected in only one of three studies in which IQ did not predict responsiveness (O'Shaughnessy & Swanson, 2000). Treatments for which there is an absence of fidelity data may or may not have been implemented correctly and may or may not have been effective, thereby complicating interpretation of study outcomes.

COMPREHENSIVE READING INTERVENTIONS

Researchers in seven studies conducted comprehensive reading instruction. In one of these studies, this meant a decoding-only intervention. In two more studies, researchers implemented a combined PA and decoding treatment. And in four studies, instructional components included PA, decoding, fluency-building, and reading comprehension. IQ was a statistically significant predictor of instructional responsiveness in five of the seven investigations.

IQ Predicts Responsiveness to Treatment

Early Primary. Torgesen et al. (1999) conducted a 2.5-year longitudinal investigation to determine the effects of different types of instruction on reading growth. They used a two-tier screening process to select study participants. All kindergartners in 13 elementary schools were asked to name the uppercase letters of the alphabet. Those scoring in the lowest 30th percentile were then administered a test of elision, a measure of rapid naming, and the vocabulary subtest of the SB-IV. Students were excluded if they had an estimated verbal IQ of less than 75. Torgesen et al. (1999) chose 180 students with the lowest combined score on the letter-naming and elision tasks. They were assigned randomly to four study groups: no treatment control, regular classroom support, embedded phonics, or PA plus synthetic phonics.

A kindergarten pretreatment battery included measures of PA, verbal short-term memory, rapid naming, expressive and receptive language, verbal ability, nonverbal ability, visual processing skill, decoding, word identification. In second-grade, the study participants were administered four subtests of the WISC-R. They were also given measures of reading comprehension and spelling. Students were tutored four times per week for 20 min per session from kindergarten through second grade for a total of 67.5 hr. Instruction was conducted one-on-one. Certified teachers conducted two sessions per week, and teacher aides led an additional two sessions each week.

Individual growth curve analysis indicated that general IQ alone was a significant predictor of word attack (r^2 = .07) and word identification (r^2 = .11). However, when PA was added to the equation, IQ no longer accounted for unique variance on either measure. For reading comprehension, regression was used because there were only 2 measurement points. General IQ was a unique predictor of comprehension after tutoring even when phonological variables were entered first in the regression equation. No r^2 value was reported.

Foorman, Francis, Fletcher, Schatschneider, and Mehta (1998) examined the effects of explicit instruction on reading growth among at-risk first and second graders. Participants were 285 children receiving Title I services who scored in the lowest 18th percentile on a survey of emergent literacy skills. They were placed in one of four conditions: (a) direct instruction in letter-sound correspondence practiced in decodable text using the *Open Court* reading basal ("direct code"), (b) less direct instruction in systematic spelling patterns using onset-rime embedded in connected text ("embedded code"), (c) indirect and incidental instruction in the alphabetic code embedded in connected text taught by research staff ("implicit code research"), or (d) indirect and incidental instruction in the alphabetic code embedded in connected text taught by the classroom teacher ("implicit code standard"). Instruction was conducted 30 min each day in a classwide format. Each student was tutored an additional 30 min each day in Title I in a one-to-one or small group format using the same methodology used in the classroom (i.e., direct code, embedded code, implicit code research, or implicit code standard). There was no information on the total number of hours of instruction, but it continued throughout the school year.

Individual growth curve analysis was conducted to explore changes in students' PA and word reading. Verbal IQ was a statistically significant predictor of posttreatment PA and posttreatment word recognition (both intercept and slope). However, Foorman et al. (1998) did not examine whether PA, instructional group, age, or ethnicity moderated the predictive utility of verbal IQ.

Whereas Torgesen et al. (1999) and Foorman et al. (1998) implemented treatments for 1 to 2 years, Berninger, Abbott, Zook, Ogier, Lemos-Britton, and Brooksher (1999) and Stage, Abbott, Jenkins, and Berninger (2003) provided one-to-one tutoring for 4 hr to 8 hr. Berninger et al. investigated a connectionist approach to teaching word recognition: Instruction focused on connections between written and spoken words with no explicit phonics instruction. First grade teachers in 10 schools referred 119 poor readers who were given WRMT-R Word Identification and Word Attack subtests. Those scoring at least 1 standard deviation below the mean on one subtest and .33 standard deviation below on the other were chosen to participate. Forty-eight students were selected and assigned randomly to one of three treatments: whole word training, sub-word training, or whole word and sub-word training. There were no controls. Each tutoring session ran 30 min, one to two times a week. Total training time was 4 hr. Growth curve analysis indicated that verbal IQ and rapid naming predicted slopes for Word Identification and the 48 words taught during tutoring. Verbal IQ did not predict growth in Word Attack. No r^2 values were reported.

Stage et al. (2003) explored the predictive utility of Verbal IQ, PA, rapid naming, orthographic skills, and attention variables. First-grade teachers in eight schools identified their poor readers who also spoke English as a first language, demonstrated a scaled score of 6 or higher on the WISC-3 Vocabulary subtest (equivalent to an estimated Verbal IQ score of 80), and performed at least 1 standard deviation below the mean on the WRMT-R Word Attack or Word Identification subtests. Applying these criteria, 73 boys and 55 girls were chosen. For each session, they were given 5 min of explicit instruction in the alphabetic principle, 10 min of teacher modeling of speech to print conventions, and 5 min. of repeated reading of first grade books. Total training time was 8 hr. The children were assigned randomly to one of seven treatments, which varied in terms of the unit of language in which the teacher modeled during the 10 min section of the tutoring.

The researchers used Hierarchical Linear Modeling to determine growth curves on the Word Identification and Word Attack subtests. Then with multiple regression, they determined which of the following predictors contributed to growth in Word Identification: Verbal IQ; PA (Rosner Test-syllable and phonemic deletion); orthographic skills (writing as many letters as possible in 15 s and choosing a correctly spelled word from a pair of words pronounced the same); attention (teacher ratings of students' attention during tutoring); and rapid naming (cf. Wolf, Bally, & Morris, 1986).

Verbal IQ predicted growth on Word Identification (r^2 = .09) and Word Attack (r^2 = .04). RAN accounted for 12% of the growth on Word Attack, 30% Word Identification. Attention: 16% on Word Attack, 32% on Word Identification. A combination of Verbal IQ and PA predicted 17% of the variance on Word Identification and 10% on Word Attack. Verbal IQ plus orthographic performance, 19% and 6% on Word Identification and Word Attack, respectively. Verbal IQ and attention: 37% and 19% on the two subtests. Each of these combinations accounted for unique variance on both subtests.

Late Primary. Whereas participants in the research of Berninger et al. (1999), Foorman et al. (1998), Stage et al. (2003), and Torgesen et al. (1999) were at risk and in the early primary grades, Torgesen, Alexander, Wagner, Rashotte, Voeller, and Conway (2001) involved children with severe reading disabilities in the late primary grades. Torgesen et al. (2001) examined the effects of the Auditory Discrimination in Depth Program (Lindamood & Lindamood, 1984) and embedded phonics on the reading performance of children between 8 to 10 years. Both reading programs were conducted in two 50-minute one-to-one tutoring sessions, 5 days a week for 8 weeks. Total training: about 68 hr. Immediately following treatment, general verbal ability (i.e., Clinical Evaluation of Language Fundamentals-Third Edition [CELF-3; Semel, Wiig, & Secord, 1995] Expressive Language) explained unique variance on word identification (r^2 = .14) and reading comprehension (r^2 = .10). At 2-year follow-up, it predicted children's growth on word identification (r^2 = .12), reading comprehension (r^2 = .16), and reading rate (r^2 = .12).

IQ Does Not Predict Responsiveness to Treatment

Vadasy, Jenkins, Antil, Wayne, and O'Connor (1997) hired community tutors and trained them for 5 hr to provide instruction to first-grade students at risk for reading failure. Students were chosen from four elementary schools in a large urban district in which 40% to 50% of children received free or reduced lunch. All first graders were screened using examiner-made tests that measured early decoding, word recognition, verbal memory, rapid naming, and onset-rime segmentation. The 65 students scoring lowest on the screening measures were given the WRAT-R Reading and Spelling subtests and the PPVT-R.

Students were assigned randomly to treatment or control groups with 20 students in each.

Treatment consisted of 100 lessons that included the following elements: (a) instruction in letter names and sounds, (b) sound categorization, (c) rhyming exercises, (d) onset-rime segmentation, (e) phonogram exercises and spelling words on magnetic boards, (f) writing, and (g) storybook reading. Each of the 100 lessons lasted 30 min and was conducted after school in a one-to-one setting. Nonresponsiveness to treatment was defined as 8 points or less gain on the WRAT-R Reading and Spelling subtests. Responsive and nonresponsive students did not differ in terms of growth indexed by PPVT-R standard scores. The most obvious between-group difference was behavior during tutoring. The six students with the smallest gains were rated by their tutors as difficult to manage because of frequent off-task and uncooperative behavior.

Vellutino et al. (1996) asked first-grade teachers to nominate their poorest readers at the beginning of the school year. Those who became study participants scored in the lowest 15th percentile on either the Word Attack or Word Identification subtests of the WRMT-R. These students were then tutored daily for 30 min over one or two semesters (spring semester in first grade, fall semester in second grade). Instruction was individualized and it incorporated phonemic awareness, decoding, sight word practice, comprehension strategies, and reading connected text. No fidelity-of-treatment data were reported.

The students were administered the Word Attack and Word Identification subtests of the WRMT-R five times between winter of first grade and spring of second grade. Students' responsiveness to treatment was based on slopes derived by linear regression analyses. Vellutino et al. (1996) described for levels of treatment responsiveness: "very limited growth," "limited growth," "good growth," and "very good growth." Two thirds of the tutored readers demonstrated "good growth" or "very good growth." They did not perform significantly worse than normal readers after one semester of tutoring. Vellutino et al. suggested that these children were not reading disabled but "instructionally" disabled. By contrast, one third of the tutored readers remained in the lowest 30th percentile on the two subtests of the WRMT-R. These children were termed "difficult-to-remediate."

Vellutino et al. (1996) looked for differences in performance between the groups with very limited growth and very good growth on a broad range of measures administered in the fall of kindergarten and spring of first grade. Three of seven measures that reliably differentiated the two groups reflected phonological processing. The remaining four were syntactic awareness, visual-verbal learning, counting, and number identification.

Vellutino, Scanlon, and Lyon (2000) revisited the data from the Vellutino et al. (1996) study to examine whether IQ predicted reading achievement. Whereas IQ was significantly correlated with reading comprehension and word identification among average readers, good-growth, and very-good-growth groups did not score significantly higher on IQ tests than limited-growth or very-limited-growth groups. The predictive utility of IQ was not explored.

Summary

In seven studies, researchers examined how well IQ predicted responsiveness to treatment, when treatment involved a comprehensive reading program. In five studies, IQ predicted responsiveness to treatment. Four were conducted with early-primary children (Berninger et al., 1999; Foorman et al., 1998; Stage et al., 2003; Torgesen et al., 1999); one with students in the later primary grades (Torgesen et al., 2001). In the five studies in which IQ predicted responsiveness to treatment, r^2 values were .16 for reading comprehension, .09 to .12 for word identification, and .04 to .07 for word attack. (These ranges reflect coefficients produced when IQ was a single predictor and when it was one of several predictors. Table 2 disaggregates this mix by presenting, study by study, the exact unique variance explained by IQ when used alone and in combination with other variables.) These values are higher than those found in the PA training studies, suggesting that as the reading intervention becomes more comprehensive and challenging (i.e., requiring recognition of orthographic patterns, text comprehension, and writing), the predictive utility of IQ increases.

In one of the two studies in which IQ did not predict responsiveness, researchers (Vadasy et

TABLE 2

Variance in Reading Explained by IQ Alone or in Combination With Other Variables

Nature of Intervention/ Study Author	*Reading Skill*	*Does IQ Alone Explain Unique Variance?*[a]	$R^{2\ b,c}$	*Does IQ With Other Variables Explain Unique Variance?*	$R^{2\ b,c}$ *for IQ*
Phonological Awareness					
Hatcher & Hulme (1999)	Reading comprehension			Yes	.05
	Reading accuracy			No	.00
O'Conner et al. (1993)	Blending onset rime	Yes			
	Segmenting first sound	Yes			
	Rhyme oddity	Yes			
O'Shaughnessy & Swanson (2000)	Reading fluency	No	.00		
	Reading accuracy	No	.02		
Schneider et al. (1999)	Reading	No			
	Spelling	No			
Torgesen & Davis (1996)	Segmenting phonemes	Yes	.20	No	
	Blending phonemes	Yes	.18	No	
Wise et al. (1999)	Word recognition	Yes	.08	Yes	.057
	Untimed nonword reading	Yes	.048		
	Nonword repetition	Yes	.08		
	Comprehension	Yes	.19		
	Phoneme awareness	No			
Comprehensive Reading					
Berninger et al. (1999)	Word identification			Yes	
	48 taught words			Yes	
Foorman et al. (1998)	Phonological processing	Yes			
	Word reading	Yes			
Stage et al. (2003)	Word identification	Yes	.09		
	Word attack	Yes	.04		
Torgesen et al. (1999)	Word attack	Yes	.071	No	–.038
	Word identification	Yes	.109	No	–.003
	Reading comprehension	Yes		Yes	
Torgesen et al. (2001)	Word identification			Yes	.12
	Comprehension			Yes	.16
	Reading rate	No		Yes	.12
Vadasy et al. (1997)[d]					
Vellutino et al. (2000)[d]					

[a]"Yes" indicates researchers explored the question and IQ by itself explained significant variance; "no" signifies the researcher explored the question and IQ did not account for a statistically significant portion of the variance; blank means that the researchers did not explore the question. [b]Cohen (1988) encourages thinking about r^2 in terms of *ES*s. A small *ES* = .10 with a corresponding r^2 = .002; a medium *ES* = .50 with an associated r^2 = .059; large *ES* = .80 (or greater) and an r^2 equivalent of .138 (see his Table 2.2.1, p. 22). [c]Blank indicates that an r^2 was not computed. [d]Authors did not predict reading skill.

al., 1997) used community tutors with little experience or training, and did not appear to use fidelity measures to determine whether instruction was implemented correctly. In addition, Vadasy et al. and Vellutino et al. (2000) did not use regression or growth curves to determine the predictive utility of IQ. Rather, they simply compared IQ scores of responders to those of non-responders prior to reading instruction. Although this method of analysis seemed appropriate for the use to which it was put, it does not address the predictive importance of IQ.

DISCUSSION

We wish to underscore that this review was based on only 13 studies. As indicated in our Tables 1 and 2, they varied considerably in terms of (a) participants' chronological age (or grade) and IQ, (b) whether the interventions focused narrowly on PA training or more broadly on reading comprehension, (c) whether the researchers claimed to have documented the fidelity with which the interventions were conducted, (d) how IQ and reading were operationalized, and (e) whether the predictive utility of IQ was explored by combining it with other variables or not. Because of this variation in method and analysis, as well as the small number of studies, whatever confidence the reader may have in our conclusions must be tempered by the possibility that, with more studies, more nuance will be required—maybe different conclusions. There is yet another reason for caution: Because of differences among the 13 studies in sample size, the reliabilities of predictor and outcome measures, and, in some cases, the restriction of range of the predictors, we should have used "corrected *r*" to strengthen the comparability of the *r* statistic across studies. Insufficient psychometric information made it impossible for us to do this.

Our purpose was to determine whether the IQ scores of students who were at risk and reading disabled predict responsiveness to reading instruction. Among our 13 studies, results were mixed. But in a majority of studies (eight, or 62%), IQ reliably explained unique variance in children's responsiveness. Specific study features appear to shed light on why IQ was important in the eight studies and unimportant in the remaining five. These study features include type of instruction, type of IQ test, type of dependent measure, participants' age or grade, and whether fidelity of treatment implementation was determined.

Important Study Features

Type of Intervention. Of the 13 investigations reviewed, 6 involved implementation of PA training; 7, more comprehensive reading instruction. In 3 of the 6 PA training studies (O'Shaughnessy & Swanson, 2000; Schneider et al., 1999; Torgesen & Davis, 1996) and in 5 of the 7 more comprehensive reading instruction studies, IQ reliably predicted responsiveness to instruction. That is, researchers in only 2 studies of comprehensive reading interventions (Vadasy et al., 1997; Vellutino et al., 2000) failed to find intelligence predictive of responsiveness to instruction and, in neither study, did the researchers directly measure IQ's predictive utility. Rather, Vadasy et al. and Vellutino et al. (2000) compared pretreatment IQ scores of students eventually identified as responders and nonresponders.

Type of Dependent Measure, Participants' Age, and Fidelity of Treatment. Across the 13 studies, IQ became an increasingly important predictor of responsiveness to instruction as the reading measure became more complex (i.e., from phonological skills to word recognition and comprehension). Indeed, in every study in which reading comprehension was measured, IQ was a statistically significant predictor of growth on this outcome. In the 5 studies in which IQ failed to predict responsiveness, reading comprehension was not measured. For reading comprehension, the average amount of unique variance explained by IQ was 15% for children in the more comprehensive interventions; 12% for those in PA training. For word identification: 6.77% for those in more comprehensive interventions, 6.85% for those in PA training. For word attack: 4.96% for comprehensive interventions, 4.80% for PA training. Averaging across the PA training studies and more comprehensive intervention studies, IQ explained 13.33%, 6.81%, and 4.88% of the variance in reading comprehension, word identification, and word attack measures, respectively. (These averages do not distinguish between studies in which IQ was a single predictor and those in which it was one of a set of predictors. As indicated previously, our Table 2 makes this distinction.)

When study participants were in second grade and higher, authors of six of eight studies determined IQ to be a statistically significant predictor of responsiveness. Only Stage et al. (2003) found IQ predictive of reading growth among students below second grade.

Of the eight investigations in which IQ was a significant predictor, authors of six either produced fidelity of treatment data or claimed to have collected such information. Of five studies in which IQ did not predict reading growth, authors of only two investigations claimed to have determined fidelity-of-treatment. Treatment fidelity information is pivotal because without it one does not know whether unresponsiveness is due to child characteristics or intervention features.

Type of IQ Test. In the eight investigations in which intelligence explained unique variance, it was measured by the WISC-R, WISC-3, or McCarthy Scales of Children's Abilities. Reliability and validity of these tests are well established (e.g., Sattler, 1992). Conversely, reliable and valid tests of intelligence were used in only two of five studies in which IQ did not predict responsiveness. In the remaining three studies, The Culture Fair Intelligence Test (Schneider et al., 1999), the vocabulary subtest of the SB-IV (Torgesen & Davis, 1996), and the PPVT (Vadasy et al., 1997) were used as intelligence measures. The PPVT is a measure of receptive language, and the vocabulary subtest of the SB-IV is generally viewed as an estimate of vocabulary knowledge, not overall intelligence. It is reasonable to assume that a less comprehensive and less valid measure of IQ would not adequately assess overall cognitive ability. Greater measurement error is also associated with such tests. In short, the use of un-validated, or invalid, measures of general intelligence may help explain why, in several studies, IQ was not an important predictor of responsiveness.

Interpreting the Magnitude of R^2

Our findings indicate IQ often reliably predicts responsiveness to reading instruction—especially when instruction is relatively comprehensive, when reading comprehension is a measure of student performance, when investigators indicate fidelity-of-treatment information was collected, and when IQ is assessed with a valid measure. As reported, IQ explained 15% of the variance in reading comprehension when the reading intervention was comprehensive; 12% when it was PA training. Cohen (1988) provides help in thinking about the importance of these proportions (as well as those displayed in our Table 2). He writes that whereas researchers in the physical sciences frequently account for as much as 99% of the variance in the dependent variable, researchers in the behavioral sciences often account for only half that amount. Thus, Cohen (1988) says, proportions of variance should be interpreted in a relative, not absolute, sense. "The question, 'relative to what?' is not answerable concretely," he writes (p. 79). "The frame of reference is the writer's subjective averaging of [proportions of variances] from his reading of the research literature" (p. 79).

Cohen (1988) suggests thinking about r in terms of effect sizes (ESs), and offers the following rule of thumb: $r = .10$ ($r^2 = .01$; $d = .20$) is the equivalent of a small ES; $r = .30$ ($r^2 = .09$; $d = .50$), medium *ES*; $r = 50$ ($r^2 = .25$; $d = .80$) large *ES*. Our 15% and 12% of the variances explained in reading comprehension correspond with *ES*s greater than .80 and .70, respectively (see Cohen, 1988, Table 2.2.1, p. 22). Elsewhere, Cohen (1977) encourages behavioral researchers to regard an r^2 greater than .01 as noteworthy; Rosenthal (1990) reminds us that medical researchers view r^2 values as important when they are as low as .001.

Implications for Research and Practice

So, findings from our review suggest that IQ frequently predicts responsiveness to reading instruction, and it can explain important variance in such responsiveness. Put differently, IQ often mediates or influences the effectiveness of reading instruction such that it is more or less effective for children with higher versus lower IQ scores. By extension, children's more specific cognitive, linguistic, and perceptual characteristics, as well as their attentiveness and behavior in school, may help predict instructional responsiveness. Indeed, an emerging literature, recently summarized by Al Otaiba and Fuchs (2002), suggests the importance of phonological awareness, phonological encoding and discrimination, naming speed, attention and behavior, orthographic processing, and level of English proficiency to poor readers' responsiveness to reading instruction.

A Multifactorial Approach to Intelligence. Consonant with this developing literature is a multifactorial view of intelligence, which is different from the traditional little "g" approach that yields a single global IQ score. Rejecting the traditional approach as simplistic, advocates of a multifactorial approach say attention should be directed at "the specific cognitive and linguistic processes [that] are accessed and used by individuals to collect, sort, process, store, and retrieve various types of information" (Mather & Gregg, 2006, p. 99). And "[b]y analyzing the pattern of strengths and weaknesses that exist within a person or the intraindividual discrepancies, one can begin to determine how specific differences influence functioning and academic performance" (Mather & Gregg, p. 100). Most of the researchers whose work is the basis of our review used traditional measures of intelligence, and all derived a single global IQ score. Future research should explore the utility of a multifactorial view of intelligence in predicting children's responsiveness to intensive reading instruction.

Continuing to explore the importance of children's cognitive, linguistic, and perceptual characteristics would seem important for another reason. As indicated by Kavale et al. (2005), policymakers did not change the definition of LD in the 2004 reauthorization of IDEA. It continues to signify a disorder within basic psychological processes. Thus, say Mather and Gregg (2006), "documentation of cognitive and linguistic processes . . . [should be] of great concern" (p. 101).

Differentiated Instruction. The "instructional validity" of these cognitive and linguistic processes—or whether strengthening them affects academic performance—should also be of concern, we believe. Mather and Gregg (2006) and others may disagree, arguing that if an evaluation of such processes strengthens the identification of children with LD as defined by statute, then they have proven their worth. We encourage those with this perspective to make an argument for the importance of diagnostic testing that serves identification but not necessarily treatment. Aptitude-Treatment-Interaction (ATI) is a means of conceptualizing and researching the relevance of cognitive and linguistic processes to instruction. ATI may refer to a situation in which one child's aptitude X moderates (i.e., facilitates or impedes) her performance in program A but not her functioning in program B, whereas her classmate with aptitude Y performs similarly across the two programs, or responds more strongly to, say, program B.

Results from our review suggest an ATI, whereby IQ is more likely to moderate responsiveness to comprehensive reading instruction (with decoding, fluency-building, and reading comprehension objectives) than to PA instruction. This is consistent with others' research on intelligence, in which performance on less g-loaded tasks like PA correlates poorly with IQ because easier tasks produce ceiling effects on performance (e.g., L.S. Gottfredson, personal communication, January 22, 2006). This apparent ATI is subject to all the caveats and admonitions we have offered throughout this article. Another cautionary note: Findings from the 13 studies in our review are correlational. Rigorous randomized control trials are necessary to appropriately explore ATIs. We are aware, too, that ATI work has a checkered history in educational psychology and special education, and that it is difficult to meaningfully conceive and rigorously implement. (See Fuchs, 2006, for a discussion of current ATI work.) Yet, high-quality ATI research is necessary, we believe, to help practitioners work successfully with chronically unresponsive students with and without mental retardation, probably the bottom 5% or so of the general population.

CODA

We are not promoting here IQ-achievement discrepancy. Nor, in a different vein, are we implying that education should be for some but not for all, or that there should be high expectations and ambitious goals for only those students with higher IQ scores. Schools should set ambitious goals and provide rigorous instruction for all children, and everyone with a stake in public education must insist on nothing less. We applaud that part of No Child Left Behind that encourages practitioners to close the achievement gap between traditionally enfranchised and disenfranchised groups. But to accomplish this, teachers will need to take students on different routes to the same end. Results from this review suggest that select child characteristics like IQ may help teachers provide this differentiated instruction—through various grouping arrangements, perhaps, or by modifying their pace or explicitness of instruction. And if student characteristics like intelligence have implications for instruction, then they should be assessed regularly during the special-education eligibility and instructional-development processes.

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