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The Basis of Reading Skill in Young Adults with Down Syndrome

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Not long ago, reading skill was a rare and celebrated achievement among persons with Down syndrome. The diary written by Nigel Hunt (Hunt, 1966) was an exception to the more general rule that children with Down syndrome do not learn to read and write, and therefore should not be taught. For the past 20 years, however, there have been dramatic changes in the lives of people with Down syndrome that could make an important difference in reading outcome. There is better medical treatment, earlier and more professional language intervention, and greater access to systematic reading instruction in and out of school. Perhaps most importantly, the expectations of parents, teachers, society, and the young people themselves have changed dramatically. Consistent with these changes, it is now estimated that a substantial proportion (40%) of adolescents with Down syndrome acquire at least some reading skill; and there is a small but growing pool of documented success stories (see Buckley, 1985, for an extensive review). In the study presented here, we seek first to document the incidence of reading under these more nearly optimal conditions. We then go on to explore just what factors contribute to reading success. In particular, we investigate the claim that successful readers with Down syndrome somehow bypass the usual, phonological, route to reading.

We begin with the hypothesis that successful readers with Down syndrome should meet the same prerequisites for reading that have been established in extensive research involving children without Down syndrome. According to that research, children who more readily learn to read are not necessarily more intelligent than less-skilled readers of the same age (or even older); they do, however, show specific strengths in phonological awareness, in verbal short-term memory, and in the accuracy and speed of word retrieval. By phonological awareness, I refer to the oral language ability to consciously attend to the sound structure of the language without regard to meaning. Phonological awareness is required to detect rhyme (e.g., that *coat* goes with *goat*, but not with *bat*), to segment words into their phonemic segments (e.g., *fun* into ffff-uuuu-nnnn), or to categorize words on the basis of shared segments (e.g., *cat* and *cough*, ri*b* and cu*b*). In alphabetic languages, measures of phonological awareness correlate with reading success from kindergarten to adulthood, and serve as better kindergarten predictors of later reading success than almost any other measure (for a review, see Liberman et al., 1989). For children who lack phonological awareness, training programs that draw explicit attention to the internal structure of the word have significantly improved the prognosis for reading success. Although it is clear that reading instruction itself enhances phonological awareness (e.g., Morais et al., 1979), most research suggests that phoneme awareness is necessarily involved in achieving fully productive reading skill (Fowler, 1991). Phoneme awareness is most directly linked to decoding, the ability to apply letter–sound correspondences to sound out novel or unfamiliar words. Decoding skill is, in turn, an important component of word recognition, which refers to the ability to identify previously encountered, highly familiar real words (e.g., Gough and Walsh, 1991). Finally, although word recognition does not guarantee reading comprehension, it is, of course, an important component. Reading comprehension is a product of both decoding and listening comprehension; both must be in place for text to be understood (Gough and Tunmer, 1986).

Verbal short-term memory and facility with word retrieval are additional factors that co-vary with reading skill, although generally with less predictive power than phonological awareness. Verbal short-term memory refers to the ability to encode orally (or visually) presented material in a phonological store such that the material can be reproduced in exactly the same order that it was presented. A classic measure of phonological (or verbal short-term) memory is the digit span included on many intelligence tests. Word retrieval refers to the ability to rapidly and accurately retrieve the correct label when confronted with pictures of objects. Poor readers tend to respond more slowly and to make more errors (e.g., tornad*o* for volcan*o*). When assessed prior to reading instruction, both verbal short-term memory and word retrieval measures predict later reading skill (see Brady, 1991; Wolf, 1991, for an overview of these areas).

If phonological awareness is necessarily acquired prior to (or concomitant with) successful reading, successful readers with Down syndrome should be phonologically aware. Similarly, one should also expect that verbal short-term memory and word retrieval abilities would be important factors in reading success. Some investigators, however, argue that people with Down syndrome learn to read in a different way than most normal children. For example, Buckley (1985) suggests that phonological processes may not be relevant for the development of reading ability in those with Down syndrome because they learn to read words "as if they were an idiographic or picture language and had no print-to-sound relationships" (p. 327). As evidence, she points out that readers of her acquaintance never made phonological errors (e.g., *cat* instead of *car*), but did make semantic confusions (*go to bed* for *sleep*). She interprets these errors to suggest that children with Down syndrome, unlike typically developing children, go directly from the visual form to meaning. These findings, she suggests, cast doubt on the claim that "phonics" (i.e., explicit instruction in decoding) is essential to learning reading.

> Contrary to common beliefs that learning phonics is essential for successful reading, it seems that it is a useful trick, i.e., given that you know the rules for converting print to sounds, you can work out how to pronounce new unfamiliar words and, conversely, you can work out how to spell words, but that this coding system is not used for normal reading. The reading performance of these young children shows that mastering phonics is not necessary for reading" (p. 327).

Because reading skill commonly exceeded oral language skill in the children she studied, Buckley suggests that learning to read is a completely different process for the child with Down syndrome compared to normal children, who have developed language abilities to aid in their acquisition of reading skills.

Whereas Buckley's subjects could recognize hundreds of words without evidence of productive decoding skills, this was not the case for a sample of 10 Italian-speaking schoolchildren with Down syndrome studied by Cossu et al. (1993). In their group, well-developed word recognition abilities were accompanied by correspondingly well-developed decoding skill, although in the context of poor reading and listening comprehension. However, they argue that proficient decoding skills had been acquired in the complete absence of phoneme awareness. To support this argument, they matched the readers with Down syndrome to a control group of normal children reading at the same level (mean age = 7.3 years) and compared the two groups on several different measures of phoneme awareness (segmentation, deletion, oral spelling, and synthesis). The children with Down syndrome performed consistently worse on all measures. On the basis of these results, it was argued that phoneme awareness is not a necessary precondition for, or even a consequence of, acquiring productive decoding skills.

Although there is disagreement about whether successful readers with Down syndrome will possess the prerequisites to reading that have been identified in normal children, there is more consensus regarding the need for instruction. It is the case that some very young precocious readers (without Down syndrome) come to read after only minimal exposure to the written language. Such children are characterized by highly developed memory skills. For example, this is the case for hyperlexic children studied by Healy (1982). However, because children with Down syndrome are typically characterized as having especially poor memory abilities (see Fowler, this volume), one would not expect to find naturally occurring precocity in this sample. And, in fact, none is found. In discussing case studies of superior reading skill among young people with Down syndrome, Buckley (1985) points out that the only "common factor . . . is that all the children received intensive structured teaching" (p. 317). Cossu et al. did not focus on instruction, but they note that all of their subjects had received standard formal reading instruction. Even those children reviewed by Buckley who had acquired only word recognition skills had participated in intervention programs focussed on reading. We expect, therefore, that instruction is a significant factor in reading success among persons with Down syndrome. We remain intrigued, however, by the large variability among people with Down syndrome in how much intensive teaching is required to achieve that success and in how much skill is ultimately achieved, even under optimal conditions. This variability has been noted by both Buckley (1985) and by Cossu et al. (1993).

In a study summarized here (Fowler et al., in progress), we first sought to document levels of reading skill in a cohort of young adults who have grown up in more improved conditions for reading success. In this study we explored the relationship between reading and phonological skill within our sample, rather than making comparisons across groups. As noted earlier, we were unable to directly assess the significance of instructional strategies for reading success due to the wide variety of programs experienced over a 20-year lifetime and the inevitable failure to recall the details of even a small portion of these in hindsight. We have, however, sought to further refine, on the basis of our data, what it is instructional programs should incorporate.

METHOD

Subjects

The study included 33 young adults with Down syndrome, full trisomy-21, between 17 and 25 years old, recruited from private and public schools, and through parent groups, in the Northeastern United States. None presented untreated hearing problems and most reported no history of hearing difficulty; all were monolingual speakers of English. Because we made a special appeal for adults who could read, the results of this study should be interpreted as reflecting the upper end of a distribution of persons affected with Down syndrome.

Each young adult completed 4 hours of individual testing, conducted either at our clinic at Bryn Mawr College, in their home, or at their school. Individuals were assessed on reading, on general ability, and on phonological skill, including measures of phonological awareness, verbal short-term memory, and word retrieval. Although multiple measures were taken in order to improve reliability and to avoid concluding too much from a single, potentially inappropriate task, only one measure for each area of function is presented here for the sake of brevity. (Full details are provided in Doherty, 1993, where it is shown that the measures presented here correlate well with other similar measures.)

Reading Measures

Woodcock Reading Mastery Tests—Revised (WRMT-R). All participants were given the Word Identification, Word Attack, and Passage Comprehension subtests of the WRMT-R (Woodcock, 1987). The WRMT-R is a widely used and highly reliable reading measure with age and grade norms from 5 years of age to adulthood. The Word Identification subtest consists of a series of real words (e.g., *is, sleep, gasoline,* and *spectacular*) to be read aloud; the Word Attack measure includes nonsense words that must be decoded using knowledge of letter–sound correspondences (e.g., *dee, plip, adjex,* and *monglustamer*). The Passage Comprehension measure includes sentences or a short paragraph missing a word or phrase; the participant must select from several (written) choices how best to complete the sentence.

General Cognitive Measures

Peabody Picture Vocabulary Test—Revised (PPVT-R). The PPVT-R is a widely used measure of receptive vocabulary with norms for persons from 2–18 years of age; it provides an age equivalent and a standard score, which correlates roughly with verbal IQ measures (Dunn & Dunn, 1981). In this test, the person points to which of four pictures best depicts a spoken word.

Kaufman Assessment Battery for Children—Mental Processing Composite (K-ABC). The K-ABC (Kaufman and Kaufman, 1983) is an individually administered instrument designed to assess mental processing (as opposed to acquired knowledge) in children between 2.5 and 12.5 years of age. We relied on age equivalent scores, to allow for meaningful comparisons across subtests. (Full details on modifications to the K-ABC testing and scoring procedure are presented in Doherty, 1993.)

Phonological Measures

Phoneme Awareness. To assess phoneme awareness, we relied on the Auditory Analysis Test (Rosner and Simon, 1971), for which participants are asked to repeat a whole word (e.g., "belt") and then to say only a portion of it—"Now can you say belt without the t?" Answer: bel(l). The test consists of 40 items, preceded by two practice items. The test is highly reliable (Yopp, 1988) and correlates with reading from kindergarten to adulthood. It yields a raw score and an approximate grade equivalent up to grade 6.

Verbal Memory Spans. To obtain verbal memory spans, we expanded the Number Recall subtest of the K-ABC, in which participants listen to a string of two or more digits and repeat them back in the same order. In our augmented version, participants had five opportunities to repeat strings at each length, after some practice with feedback. Subjects were given credit for a span of *x* when they could accurately reproduce *x* digits in the correct order in three out of five trials.

Word Retrieval. In the Boston Naming Test (Kaplan et al., 1983), originally developed for use with aphasic individuals, participants are presented with a line drawing and asked to provide, as quickly as possible, the name for the item depicted (e.g., *bed, toothbrush, harmonica,* and *abacus*). The number correct was compared to approximately age equivalents available in Guilford and Nawojczyk (1988).

Other Measures

Additional measures presented to young adults with Down syndrome were expected to be associated with reading, but not after controlling for general ability.

Visual Memory Span. The first of these was the Corsi Block Test, a nonverbal measure of sequential memory designed by Milner (1971) and often used as a measure of right-brain function in neuropsychological research. Variation in nonverbal visual memory has not proven to be a significant correlate of reading ability in normal IQ schoolchildren (e.g., Gould and Glencross, 1990; Rapala and Brady, 1990). In the Corsi Block test, the individual watches the examiner touch a sequence of randomly scattered identical blocks and then attempts to reproduce the same sequence. Calculation of a span paralleled procedures for verbal short-term memory.

Test of Auditory Comprehension of Language—Revised (TACL-R). The TACL-R (Carrow-Woolfolk, 1985) is a picture-pointing test standardized on children from 2–12 years. The test includes three sections, emphasizing individual lexical knowledge, grammatical morphology, and syntactic structures; we present the total age-equivalent score across all sections. This measure was included as a measure of oral language comprehension, predicted to be an important factor in reading comprehension, but not in decoding.

K-ABC Arithmetic. This subtest of the K-ABC Achievement Scales samples a student's knowledge of counting, ordering, terminology, and basic computation (addition, subtraction, multiplication, division). All questions are presented orally, and include a number of word problems. The task is designed to be appropriate for children 2.5–12 years. Although not as in-depth a measure as our extensive reading battery, it was a developmentally appropriate measure for this sample. We presented it to explore how school-based achievement measures would differ.

RESULTS

Reading Measures

Young adults with Down syndrome ranged widely in their reading skill, from kindergarten to 12th grade levels. They were classified into "reader groups" on the basis of their decoding scores on the Word Attack measure. Although every individual could recognize at least a few familiar words, those who could decode no more than two pseudowords were classified as "novice readers." Those who could decode 3–10 pseudowords had skills that were clearly "emerging" (first grade level), and those who could decode 11–29 pseudowords (second to fourth grade level) were considered to be "developing." Finally, those who could read at or above the 5th grade level (>29 pseudowords) qualified as "skilled" or productive decoders.

As can be seen in Table 1, these classifications based on decoding predicted performance on both Word Identification ($F(3,29) = 67.13$, $p < .0001$) and Passage Comprehension ($F(3,29) = 36.41$). Although the overall mean scores for Word Attack and Word Identification were close, the advantage for Word Identification was significant ($F(1,29) = 5.02$, $p < .05$). Of particular interest was a significant group-by-test interaction ($F(3,29) = 16.25$, $p < .0001$): whereas the less-skilled decoders showed a clear advantage for Word Identification, this pattern was reversed for the most skilled group.

As is often the case for persons with general cognitive impairment, reading comprehension lagged significantly behind single-word identification ($F(1,29) = 67.56$, $p < .0001$). This disparity became even more pronounced as decoding skill improved, as indicated by the significant task × reader group interaction ($F(3,29) = 10.76$, $p < .001$). Although decoding is clearly necessary for Passage Comprehension, it is not sufficient.

Table 1. Mean Age Equivalent Scores on Reading and Cognitive Measures for Four Groups of Adult Readers with Down Syndrome

		Reading Measures			Cognitive Measures			
Reader Group	*n*	Word Attack	Word Identification	Comprehension	PPVT-R	TACL-R	K-ABC	Arithmetic
Novice	12	5.7	6.7	5.6	6.1	5.1	5.0	5.7
Emerging	10	6.6	8.1	7.1	8.1	6.1	6.3	6.5
Developing	6	8.0	9.3	7.7	9.3	6.4	6.2	7.0
Skilled	5	16.0	12.7	8.4	11.1	7.8	7.1	9.0
Overall mean	33	7.9	8.5	6.9	8.1	6.1	5.9	6.7
(Standard deviation)		(3.8)	(2.3)	(1.3)	(2.3)	(1.4)	(1.2)	(1.4)

Association between Reading and Cognitive Measures

It can be observed by looking at Table 1 that reader group significantly predicts variation in vocabulary [PPVT-R, $F(3,29) = 12.74$, $p < .0001$], receptive language ability [TACL-R, $F(3,20) = 6.03$, $p < .01$], general cognitive ability [K-ABC, $F(3,29) = 7.16$, $p < .001$], and arithmetic achievement ($F(3,29) = 14.88$, $p < .0001$). It is especially interesting to observe the close correspondence in age equivalent scores for the Word Identification and the PPVT-R (both single-word measures) and for Passage Comprehension and the TACL-R (both sentence-level measures). Whereas decoding skill may, and in some individuals does, exceed either language comprehension measure, reading comprehension does not (cf. Gough and Tunmer, 1986, for the normal case). On the other hand, despite this apparent link between reading and acquired verbal intelligence, it is clear that our general ability measure (K-ABC) underestimates ultimate reading levels; this is consistent with findings from other studies of successful readers with Down syndrome and demands some explanation.

Although arithmetic function was not a major focus in our study, the link between arithmetic and reading is obvious. Indeed, looking at the adults on an individual basis, we observed some cases where reading exceeded arithmetic, but no cases of the opposite. The association may, of course, be exaggerated by the heavy reliance on language in the arithmetic measure.

Association between Reading and Phonological Skill

Whereas the overall mean age equivalent for Word Attack and Word Identification was 7.9 and 8.5 years respectively, participants were functioning at or below the 6-year-old level on the various phonological measures presented (see Table 2). At first blush, these results seem to support the claim that phonological factors are not relevant to reading acquisition in Down syndrome. These low scores, however, mask considerable variability in performance. In fact, when variation on the phonological measures was compared to variation in the reading measures, the correlations were highly significant, as evident in the third column. Most importantly, when we statistically controlled for the already high association between general ability and reading, the association between phonology and reading remained strong. For example, performance on number recall accounted for approximately 39% of the variance in decoding, and 38% of the variance in word recognition, over that accounted for by a general cognitive ability composite made up of the K-ABC and the PPVT-R. Similarly, performance on phoneme awareness accounted for 36% of the variance in word recognition, and 49% of the variation in decoding skill, after accounting for the variance accounted for by general cognitive factors. This means that phonological factors play an important role in predicting and explaining variation in reading skill beyond what can be attributed to general ability. Even the word retrieval measure explains variation in reading not explained by general cognitive factors; the fact that the association is somewhat smaller is consistent with findings from the general population.

The one unexpected result was the strong association between visual memory and

Table 2. Performance on Selected Phonological and Memory Measures

Phonological Measure	Raw Score Mean (Standard deviation)	Mean Age Equivalent (years)	Correlation with Decoding/Recognition	Partial Correlation with Decoding/Recognition
Phoneme awareness (AAT)	10.4 (10.4)	6.0	0.78*/0.72*	0.72†/0.60†
Verbal Span (K-ABC)	3.2 (0.76)	5.0	0.73*/0.72*	0.63†/0.62†
Visual Span (Corsi)	3.5 (0.90)	est. 6.4	0.65*/0.59*	0.50†/0.40†
Lexical Access (BNT)	28.5 (9.4)	est. 5.5–6	0.75*/0.77*	0.46†/0.49†

*$p < .001$.
†$p < .01$

reading evident from Table 2, suggesting that visual memory also explains reading variation not explained by general cognition. Indeed, even when verbal span was entered first together with general cognition, visual span explained an additional 8% of the variance in reading. At the same time, when visual span was entered together with general cognition; verbal span explained a unique 17% of the variance. This suggests that visual and verbal memory are both important, but distinct, contributors to reading skill in this group of young adults with Down syndrome. It does remain to be determined, however, just how visual memory plays a role.

A high correlation alone does not rule out the possibility, put forth by Cossu et al. (1993) that some persons acquire productive decoding skills without meeting the hypothesized phonological prerequisites. To explore this question more directly, we examined the actual scatterplot of how decoding skill maps onto phoneme awareness. The results, depicted in Fig. 1, indicate that no person in our study achieved decoding skills beyond the first grade level without answering at least 10 items correctly on our phoneme awareness measure, a feat that cannot be achieved by chance alone. More-

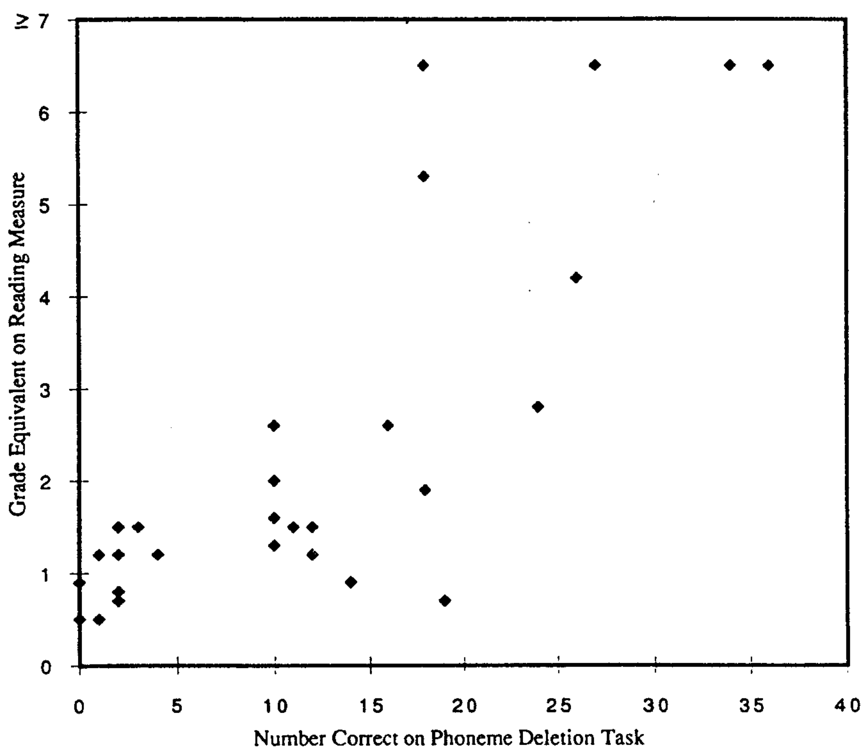

Fig. 1. Reading scores plotted against phoneme awareness scores.

over, no one achieved beyond the third grade decoding level without responding correctly to at least half of the phoneme awareness items. Although there are certainly cases of phoneme awareness that are not accompanied by reading skill, the opposite does not hold, as evidenced by the blank space in the upper left portion of the scatterplot. This result is consistent with the view that phoneme awareness is necessary but not sufficient for decoding success. In this group of English-speaking young adults, as in many groups of schoolchildren without Down syndrome, decoding skill does not develop in the complete absence of phoneme awareness.

As can be seen in Fig. 2, a surprisingly similar story can be told about verbal short-term memory. The plot indicates that all young adults with decoding skills at or above a grade level of 1.3 achieved a digit span of at least 3.0; and all six individuals decoding above the fourth grade level achieved a digit span of at least 4.0. As with phoneme awareness, it would appear that a minimum digit span is not sufficient for decoding skill (see data points in lower right), but is necessary (as evident in the lack of data points in the upper left).

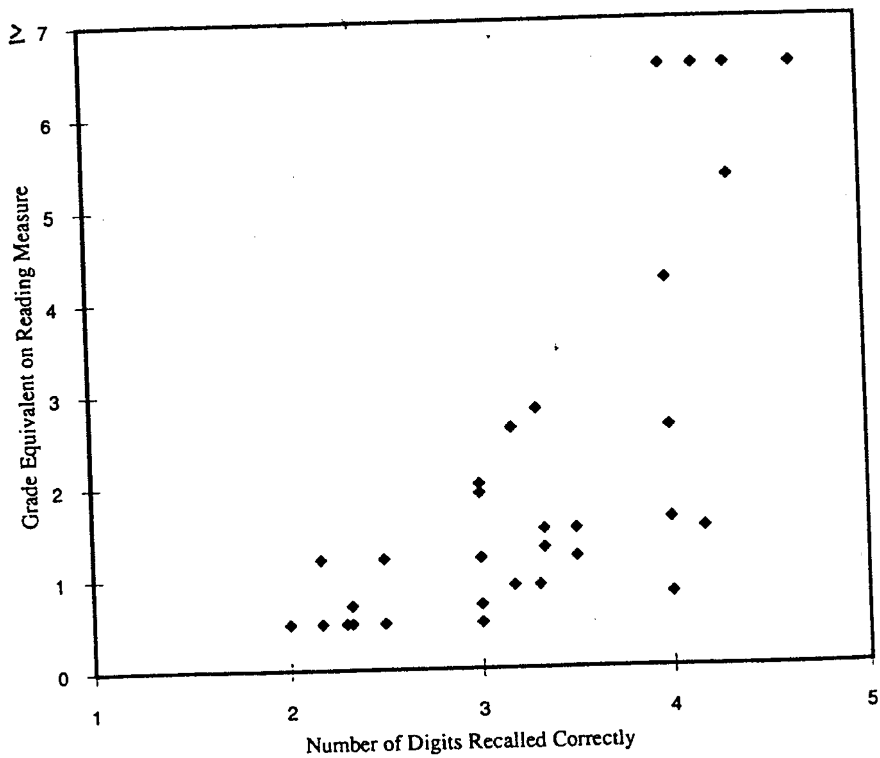

Fig. 2. Reading scores plotted against digit span measure.

DISCUSSION

In the study presented, young adults with Down syndrome varied greatly in reading skill, with scores ranging from kindergarten to adult levels. Although reading scores were linked with general levels of intellectual function, our results suggest that phonological skill explains additional variance that cannot be wholly explained by general ability. Below, we try to relate our findings to the questions raised earlier.

First, like Buckley, we find that even in today's more supportive educational climate, most persons with Down syndrome have not progressed beyond the early stages of reading. These early stages may, in any group, be achieved almost wholly via sight-word recognition, and it is clear that our less skilled readers relied almost exclusively on this strategy. However, in this group, as in any group, the lack of decoding skill severely restricts the reader's sight-word vocabulary.

The fact that many adults do not advance beyond the early stages of reading does not mean that different skills are required for reading success in persons with Down syndrome, only that they have not yet acquired the skills (or received the appropriate instruction) necessary to move forward. In fact, the third of our subjects who had made substantial progress in mastering orthographic decoding strategies were characterized by better-developed phonological skill. Although, as Cossu et al. (1993) found, productive decoders possessed less phoneme awareness than would be expected on the basis of grade-level norms, it was not the case that they possessed no phoneme awareness at all. Looking within the sample with Down syndrome, there was a direct correlation between phoneme awareness and decoding skill. These results suggest that young adults with Down syndrome can and do acquire productive decoding skills, and that their success depends on the same prerequisites implicated in any other group attempting to read. It is, in fact, promising that a little phoneme awareness goes such a long way. It should be acknowledged, too, that the fact that older people with Down syndrome possess so much less phoneme awareness than younger normal readers may have predictive implications: the younger normal readers stand a far better chance of rapidly becoming fully productive and automatic decoders.

In the present study, verbal short-term memory also proved to be a crucial component of reading success, even more so than in normally intelligent populations who vary in reading success. It may be that in most school-aged children, the minimal level of verbal short-term memory has already been met, and further variation does not have nearly as great an effect. Consistent with this interpretation, it can be seen in Fig. 2 that once the necessary prerequisite for decoding is met (here estimated at a digit span of 4.0), there is no longer any correlation with reading: those individuals with a digit span of 4.0 display the full range of reading skill evident in the sample. A higher span does not guarantee success, but a lower span apparently precludes it.

Although our evidence regarding instruction is necessarily limited, there are many reasons to believe that instruction was also a crucial component of the success achieved by our most skilled readers. Instruction could, for example, account for the variability among those young adults obtaining the highest digit span. Just as there is substantial evidence for the role of instruction in normally intelligent children with weak phonological skills, it would follow that the same kind of instruction would be equally, if not more, important for persons with Down syndrome. The most effective instruction focusses attention on the internal structure of the syllable (phonemes) before or simultaneous with the introduction of letters, which merely represent these phonemes (e.g., Bradley and Bryant, 1983; Lundberg et al., 1988; Ball and Blachman, 1990; see Adams, 1990; or Clark, 1988, for a review). Given the important association between phoneme awareness and reading in our group, the same instruction should prove helpful here as well. It is important, from a developmental perspective, to note that phoneme awareness training programs have been successful at the kindergarten level, yet retain their utility into adulthood; the programs can vary significantly without losing their effectiveness. Consistent with this, we were interested to learn that several of our most successful readers had spent several years beyond the preschool level in Montessori schools; the Montessori program does focus on the structural analysis of the syllable (Wilkinson, 1990).

The call for explicit and systematic instruction in phoneme awareness and decoding does not rule out the utility of other, additional, forms of instruction. Clearly, many factors contribute to reading success in this population. For example, Buckley (1985) focusses her attention on sight-word vocabulary in very young children (3–5 years of age). This could readily be combined with phonics instruction once a small repertoire of sight words is established. Sight-word training may, for example, be especially useful for helping children learn letter sound correspondences.

Finally, we wish to point out that our results provide no evidence that reading could not be introduced in adolescence and beyond; it may in fact be the optimal time. We observed considerable growth in reading skill in one young man first observed at 19 and later seen at 21 years of age; his family had recently hired a tutor. Although there is evidence from typical and atypical populations that oral language is most readily acquired in the first decade of life, reading differs importantly from speech and can be acquired at any time. If we are correct that minimal prerequisites in phonological memory must be achieved in order to experience real success in reading, it may be that many schools are giving up on reading instruction at just the time when it might actually prove effective.

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