PREFACE: Seven Dimensions of Time

Out in the middle of the wine-dark sea
there is a land called Crete,
a rich and lovely land,
washed by the sea on every side;
and in it are many peoples, and ninety cities.
And there one language
mingles with another.
Among the cities is Knossos, a great city;
and there Minos was nine years king
the boon companion of mighty Zeus

—Homer, Odyssey, Book Nineteen

In the year 2000 on the legendary island of Crete, a small group of researchers from around the world came to discuss a relatively new set of ideas: how the time it takes for the brain to process written language may impede the development of reading. Beginning with this introduction, seven dimensions of time are considered within this volume 1) as an historical factor in the evolution of writing; 2) as a basic property of neurological function; 3) as a developmental component of all cognitive and linguistic processes; 4) as a potential source of disruption in developmental disorders of reading and language; 5) as an outcome in reading fluency; 6) as a critical aspect of psychometric measurement; and 7) as a key dimension of intervention in reading fluency. This book represents a first approximation of what an approach to dyslexia might be that emphasizes multiple dimensions of time.

In the preface, I introduce the reader to the underlying questions that motivated this effort and the themes that emerged from it. But first, I would like to use the unique history of Crete to place the themes of the book within the first dimension of time discussed here: that is, the broader context of the history of written language—in particular, the contributions of Crete and the ancient Greek world to the evolution of writing.

In so doing, I hope to ground the relatively new questions about time, dyslexia, and the human brain that are raised in this volume within the sweeping, humbling context of the history of efforts the species has made to become literate. In addition, within this history, I wish the modern reader to confront and be reminded of the reasons one of the foremost apologists of oral lan-

guage, Socrates, felt written language would irrevocably change our species—to its detriment.

The historical facts that connect the island of Crete to any study of written language continue to unfold. We now know that Crete was the home of at least three ancient writing systems. Linear A, a hieroglyphic system, was used in 19th-18th centuries BCE and continues to elude decipherment. Linear B was used around 1450 BCE and was discovered at Knossos at the turn of the twentieth century by Sir Arthur Evans. Evans spent more than 40 years of his life trying to decipher it, only to fail. At last deciphered by a young scholar named Michael Ventris, the elaborate story of the decipherment of Linear B is one of the great intellectual tales of the 20th century (see Coe 1999; Daniels and Bright 1996).

But the real story in the history of written language is the creation of the Greek alphabet, that was traced back at least to the eighth century BCE in Crete and two other sites. Until recently, many scholars (myself included) believed the Greek alphabet was the first "true alphabet" (Havelock 1976), an argument still made by some classicists. More recent archeological evidence changes our whole understanding of early alphabets (see Daniels and Bright 1996) and comes from places whose very names evoke a sense of the ominous (e.g., Wadi el Hol in Egypt physically looks like and linguistically translates as the Gulch of Terror). This evidence makes it far more probable that the first alphabet was a Semitic system, used by scribes in and out of Egypt in the 19-18th Century BCE, at least a full millennium before the Greeks!

That acknowledged, there is probably no people in the history of the world who came closer to being the world's first speech-perception researchers than the scholars who created the first Greek alphabet. To be sure, the concept of letters was something the Greeks borrowed from the Phoenicians, who had, in turn, borrowed their system from Semitic scripts. But, to accomplish what the Greeks attained required an unimaginably precise analysis of the Phoenician sound system and the Greek sound system (Swiggers 1996). The result was a system capable of matching every Greek sound (i.e., phoneme) with a letter. The extraordinary alphabet that the early Greek scholars on Crete produced was an achievement of a millennium, reflected in the fact that the Greek alphabet is the basis of most alphabets today, including our own (Threatte 1996).

The stunning cognitive and linguistic breakthroughs that the Greek alphabet represented have been historically underappreciated, beginning with the time of its creation. For the Greeks gave

more complex twists to the history of writing than the creation of the Greek alphabet; they raised timeless and deeply critical questions about written language that are as thought-provoking now as then. It is a good thing for the modern reader to pause and be quietly astounded not only by the intellectual and epistemological revolution that the first Greek alphabet represented for our species' evolution, but also by their reasons for initially rejecting it. It took, in fact, more than three and a half centuries for the Greek alphabet to come into regular use in the schools.

This is because the Homeric-driven Greece of the first half of the first millennium BCE possessed one of the most highly developed oral cultures that the world has ever known. Plato's Dialogues were one of the most perfect examples of orality captured in text (that is, they were neither speech nor prose) (Klein 1965). Paradoxically, The Dialogues recorded the most prescient arguments against literacy that have ever been made, before or since (see Nussbaum 1997). Within the Dialogues, Socrates scorned written language and tried, unsuccessfully, to limit its use.

At the heart of Socrates' protestations was his fear and belief that the appearance of permanence in written text would give readers the false "conceit of wisdom" (Plato, Phaedrus, 275b) and lead them away from a rigorous, ongoing examination of the essence of words. That is, the learner would confuse the permanence of print with truth and not feel the need either for the ongoing examination of words or the storage of oral passages in memory. To Socrates, only "living speech" could be questioned, probed, and then transformed into human memory, personal knowledge, and the earnest pursuit of wisdom. This entire process—from the examination of word and thought through its embodiment in the learner's memory—was considered the basis of virtue in the individual and society. Socrates' deep-seated concerns over his society's shift to the mode of literacy were profound and deserving of our attentiveness today, as we make our own shift from text to the visual, image-dominated mode of a technologically based society.

To those of us who spend our lives in the service of words and their accessibility to all young humans, Socrates may be an unusual ally and "gadfly." I would like to invoke and re-fashion three of Socrates' objections to literacy and use them as guideposts for the reader before encountering the material in this book: first, that the earnest examination of words should be vigilantly attended to (in this case, specifying with care to the terms related to time); second, that there are critical ways of learning from "living speech" that may increase our understanding and teaching of

written language (as in our intervention); and third, that many human beings (for example, children and adults who are dyslexic) may have greater access to other ways of learning than text-based knowledge. With these Socratic admonitions as the backdrop, I will move to a more recent, historical context for the ongoing work represented in this book.

Some years ago, Gerald Holton described what he called "paradigm shifts" or discernible changes in emphases that mark the history of science. The field of dyslexia research mirrors this development, with each new paradigm's explanation for dyslexia supplanting the preceding one (see Wolf and Ashby in press). In the last 25 years, dyslexia research has been largely characterized by a psycholinguistic approach; this approach replaced all previous perceptual-based explanations with a new emphasis on the linguistic basis of developmental dyslexia (Vellutino, 1979). Based largely on the long, systematic investigations by Don Shankweiler and Isabelle Liberman and their colleagues (Shankweiler and Liberman 1972), this work rests on the assumption (and the evidence) that learning to read requires a knowledge of the letter-sound or grapheme-phoneme correspondence rules of the language. This knowledge, in turn, is based on a tacit awareness by the child of the sounds or phonemes in language. Such a view resulted in what has been called the phonological-core deficit (Stanovich 1988) paradigm, and there is large consensus that a primary source of reading failure is the lack of development of phoneme-awareness skills.

What may be unique about the present moment in dyslexia research history is that there is not so much a shift away from the phonological paradigm, but rather, an attempt to integrate that knowledge base, both with new findings about a second core-deficit in time- and fluency-related processes, and also with new approaches from the neurosciences.

The recent attention to time- and fluency-related deficits in reading breakdown is the result of a convergence of three factors. First, the systematic research on the role of phonological processes in dyslexia and intervention has proven both successful and yet insufficient in dealing with the heterogeneity of reading disabilities and the complexity of reading breakdown— especially in the area of fluency. (For a recent comprehensive review, see Meyer and Felton 1999; also see Breznitz and Share 1992; Torgesen, Rashotte, and Wagner 1997; Torgesen et al. 1999; Rashotte and Torgesen 1985; Young and Bowers 1995.) The wish to address the needs of children who do not completely respond to phonological-based treatment is a motivating impulse in turning to additional explanatory principles like fluency (Lyons and Moats 1997; Torgesen et al. 1999).

The second factor is an increased awareness of the multiple, underlying sources that can contribute to or impede fluency development. An example is the concerted effort to understand the predictive ability of naming speed in reading failure, as indexed through "rapid, automatized naming" or RAN tasks (Denckla and Rudel 1976; see reviews in Wolf and Bowers 1999; 2000). So also are extensive studies that explore a range of time-related deficits in reading-disabled children in various perceptual and motor areas (see reviews in Farmer and Klein 1995; Nicolson and Fawcett 1994; Wolf, Bowers, and Biddle 2000; Wolff in press).

The third factor is related to naming-speed research and involves cumulative evidence from subtype research in developmental dyslexia. There is a growing body of work demonstrating that there are discrete groups of reading-impaired children who can be characterized by single deficits in either naming speed or phonological processes or combined deficits in both areas (Badian 1996; Lovett, Steinbach, and Frijters 2000; Manis, Doi, and Bhada 2000; Wolf et al. 2000). Known as the Double-Deficit Hypothesis, this conceptualization has several fluency-related implications (Wolf and Bowers 1999; 2000). For example, children with single naming-speed deficits are frequently difficult to diagnose in early primary years, but go on to develop fluency and comprehension problems by the end of grade 3. Further, children with both phonological and naming-speed deficits are consistently found to possess the most severe problems in reading and reading fluency. The most important implication of this conceptualization is that it provides a theoretical rationale and foundation for intervention that specifically addresses issues of speed of processing and fluency. Until very recently intervention was largely directed to treatment for phonologically based decoding problems. Children with either single processing-speed deficits or combined deficits would be only partially served by such a focus, thus fueling the ranks of children who do not respond to treatment.

This book, and the conference that preceded it, were organized to confront critical unanswered questions about time, fluency, and intervention in dyslexia. The most persistent and difficult questions have defied every effort within a phonological paradigm to answer them and are the questions that underlie this conference.

What are the nature and extent of rate-of-processing, time-, and fluency-related deficits in developmental dyslexia?

What are the hypothesized source(s) of these deficits?

Are time- and fluency-related deficits amenable to change? If so, what theoretical principles should guide intervention in these areas?

This book is organized into sections around these three, related questions, followed by a chapter by Ginger Berninger than spans all three topics.

The framework for the book has been constructed to bring several levels of evidence and types of research to bear on the questions. In the first section, evidence is presented on timing deficits in dyslexia at the behavioral level by cognitive, clinical, and experimental psychologists. The second section contains evidence, largely by neuroscientists, at three levels: neuronal, brain structure, and genetic. The third section contains research on the emerging intervention in reading fluency.

SECTION 1. THE NATURE AND EXTENT OF TIME-RELATED DEFICITS IN DEVELOPMENTAL DYSLEXIA

The papers in the first section frame the above question along behavioral, developmental, and cross-linguistic axis. There is considerable evidence and consensus that at least one type of time-related problem—naming-speed deficits (NSD)—represents a very strong predictor of reading disabilities across every language tested to date. Heinz Wimmer demonstrates that in languages like German whose orthography is relatively regular, that naming-speed deficits are even stronger predictors than in English. He uses this information to question the primacy of phonological deficits in other languages. (In a later section, Ginger Berninger states that NSD are the single most prevalent deficit among her severely impaired subjects.)

A central unresolved question explored by many in this volume is: Why would this be so? What is the underlying relationship between naming speed and reading? More specifically, are there particular relationships between processes underlying naming speed and particular forms of reading? One compelling hypothesis, first raised in work by Patricia Bowers during the nineties, is the relationship between NSD and orthographic skills. In their separate chapters Patricia Bowers and Frank Manis explore and find different forms of support for this working hypothesis. Manis' long history of research on different aspects of orthographic skills has enabled his new work to become more specific about this line of investigation. In a different section, however, Don Compton and Dick Olson do not find naming speed clearly connected to orthography, as measured in their battery's orthographic tasks. There is consensus among this book's participants that we need to continue to examine these questions in ever more differentiated ways.

In her chapter, Deborah Waber uses her extremely large database of children with multiple forms of learning disabilities to pose questions about whether NSD primarily predicts reading disabilities or also broader forms of learning disabilities (LD). In the first database exploring this same question, Denckla and Rudel (1976) found that only reading disabled children were classified by NSD, and other learning disabled children were not. Waber's data show the converse pattern. There is a critical need for this question to be pursued with careful attention to the classification of both LD and dyslexic sub-groups, potentially the putative Double-Deficit subgroups.

John Stein moves arguments about time-related deficits outside naming speed to other domains. In his essay chapter, he presents evidence showing both visual and auditory speed-of-processing differences among dyslexic children; that is, well beyond language-based deficits. This broader range of time-related deficits is supported and extended by work from the lab of Angela Fawcett and Rod Nicolson, who present, in their first chapter in this volume, an overview of the multiple time-related deficits (including auditory, visual, and motoric) found in their subjects over the last decade. A theme that occurred first in Peter Wolff's (see review, in press) early work and now in Fawcett and Nicolson's work is the finding that at the lowest level of processing (like the detection of a flash or tone), there are no speed differences; rather, when tasks require the first hint of choice, there are differences in time. John Stein speculates in his chapter that the wide range of time-related findings in dyslexia might be parsimoniously explained by a magnocellular deficit, a hypothesis strongly supported by work reported by Glen Rosen and his colleagues, Al Galaburda, and Gordon Sherman in the second section.

The upshot of the first section is that there is a convergence of evidence across several perceptual, motor, and linguistic areas and several orthographies that many dyslexic children have rate of processing differences, particularly in naming speed tasks, but also on tasks well beyond the linguistic domain. Less consensual and less resolved are questions about how these differences interfere with reading and whether they are found in children with more general learning disabilities.

2. THE HYPOTHESIZED SOURCES OF TIME-RELATED DEFICITS: NEURONAL, STRUCTURAL, AND GENETIC LEVELS

Glen Rosen colorfully describes in his essay, current work at the neuronal level from the extensive work of the Beth Israel Hospital

lab where he, Al Galaburda, and Gordon Sherman have worked over the last decade and a half. Rosen and his colleagues have used an animal model to study how specific neuronal anomalies (similar to those found in autopsied brains of dyslexic individuals) can result in slower auditory processing.

Guinevere Eden and Tom Zeffiro were participants of the conference and presented evidence there at the structural level that summarized much of the cumulative fMRI imaging evidence on brain structures involved in reading and reading failure, and most recently, in naming speed. A surprising finding in their conference presentation that receives support from several authors in the second section concerns the possible role that the right cerebellum might play in dyslexia and time-related deficits. Indeed questions about the cerebellum represent an unexpected subtheme in this section.

Rod Nicolson and Angela Fawcett in their second chapter discuss evidence from dyslexic subjects on a new battery of cerebellar tasks. They hypothesize that the cerebellum should be considered as one potential source of time-related disruption in dyslexia.

Rich Ivry provided the conference participants with their most startling discovery: upon close examination, he concluded that the famous, to-date undeciphered, Disk of Phaistos in Crete is actually the first RAN! His chapter takes a decidedly more serious note. He and his colleagues, Timothy Justus, and Christina Middleton, present an important overview for dyslexia researchers on the role of the cerebellum in regulating precise timing in the brain; they argue for a slow, cautious perspective on hypotheses linking dyslexia to cerebellar dysfunction at this time.

Frank Wood's chapter throws caution to the winds, as he provides an avowedly unconventional neuroanatomical description of brain structures used in reading and fluency. An important contribution in his chapter is a new emphasis on the concept of "anticipatory facilitation" in timed processes like the RAN and reading.

Zvia Breznitz has written an equally surprise-filled chapter that discusses an unusual method of using evoked potentials for looking at the gap or discrepancy between visual and auditory rates of processing. She sees this gap as an index of the dysynchrony between visual and auditory systems in dyslexia, and a future predictor of dyslexia. Russ Poldrack uses another conceptually exciting and promising new imaging method—diffusion tensor imaging—to examine in dyslexic adults the level of white matter (essential for speed of information processing) in areas used in reading. Results involving the angular gyrus region, long hypothesized by Norman Geschwind to be implicated in dyslexia, are particularly noteworthy.

Mentioned earlier, Don Compton and Richard Olson extend our explanations of possible sources of dyslexia to the genetic level. Of considerable importance to researchers who continue to conceptualize naming speed as a phonological process, they provide compelling genetic evidence on 500 twins that there are independent relationships of both naming speed and phonological processes to reading.

3. THE QUESTION OF INTERVENTION

The third section of the book concerns fluency and intervention. Fittingly, the first two chapters stress the importance of early detection and prevention of fluency problems. Ed Kameenui and his colleagues Deborah Simmons, Roland Good, and Beth Harn, stress a new conceptualization of fluency: that is, that fluency is not simply an outcome of reading, but rather a developmental continuum of processes that need to be addressed before reading ever begins, along with phoneme awareness work. This developmental view of fluency with its implicit emphasis on fluency prevention programs is a major sub-theme in this volume.

Similarly, based on his extensive history of intervention research with Rick Wagner, Carol Rashotte, and their colleagues, Joe Torgesen makes an equally strong case for fluency prevention programs. Highlighted in this chapter are some of the most important principles of fluency instruction, including the role of anticipatory facilitation, repetition, practice, and outside reading.

The role of repeated practice is amplified in Betty Ann Levy's overview of her important, experimental fluency-intervention studies. She emphasizes in her chapter a new factor, orthographic visibility, and its importance for facilitating processing speed in children with dyslexia. Such an emphasis echoes earlier questions raised in the first section concerning the potential relationship between naming speed and specific orthographic processes in reading.

The final chapter by Ginger Berninger and her colleagues Robert Abbott, Felix Billingsley, and William Nagy, is a broad-sweeping account of several topics: naming speed and its puzzle; the "morphological fluency hypothesis" within Berninger et al's connectionist framework; and a new view of fluency. This wide-ranging paper and the questions it raises provides an ideal coda for the book.

Plato wrote that once begun, there is no real end to a "dialogue." That is what I have come to think about the Crete Dialogues that make up this book. It is my hope that the questions about time, fluency, and intervention raised first at the Crete con-

ference and now in this book will elicit for the reader new thoughts about dyslexia and ancient questions about the role of time in human language. There is no end to such thoughts.

Maryanne Wolf
Cambridge, Massachusetts
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