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Reading, Laterality, and the Brain: Early Contributions on Reading Disabilities by Sara S. Sparrow

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Abstract

Although best known for work with children and adults with intellectual disabilities and autism spectrum disorders, training in speech pathology and a doctorate in clinical psychology and neuropsychology was the foundation for Sara Sparrow's long-term interest in reading disabilities. Her first papers were on dyslexia and laterality, and the maturational lag theory of developmental dyslexia proposed with Paul Satz, her mentor. The research program that emerged from this work had a wide impact on early neuropsychological models of reading disabilities. Although Sara went on to research focused on children with other developmental disabilities after she moved to Yale University, this initial research influenced her career-long interests in assessment, developmental models of disabilities, and early screening methods.

Keywords

Reading disabilities; Laterality; Maturational lag; Sara S. Sparrow

Sara S. Sparrow is best known for her contributions to research on children and adults with intellectual disabilities and autism spectrum disorders. She and her colleagues reformulated the assessment of adaptive behavior into a developmental, psychometric perspective with the revision and subsequent publication of the Vineland Adaptive Behavior Scales through two editions (Sparrow et al. 1984, 2005). However, Sara also had an early and enduring interest in reading and reading disabilities that emanated from her early training in speech pathology and her doctoral work in clinical psychology and neuropsychology. During her doctoral training at The University of Florida, Sara introduced her mentor, Paul Satz, to children with "dyslexia." Satz was primarily an adult neuropsychologist who nonetheless supported Sara's interest in children and disabilities. Her doctoral dissertation (Sparrow 1969a, b) was a neuropsychological study of different indices of laterality in children described in what was then contemporary language as "retarded readers." In addition to this and other studies focusing on language and cerebral dominance in poor readers (Sparrow and Satz 1970), Sara helped formulate a theoretical explanation of dyslexia (Satz and Sparrow 1970) that lead to a 6 year longitudinal study of kindergarten children known as the Florida Longitudinal Project (Satz et al. 1978; Fletcher et al. 1984). This study was the basis for the relationship of Sara with the two authors of this paper, who also worked on different

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phases of the Florida Longitudinal Project in their graduate training at The University of Florida under Satz. In this paper, we briefly review the Satz and Sparrow (1970) theory, focusing on why it was innovative at the time, and then discuss the long-term impact of this study.

Maturational Lag Theory of Developmental Dyslexia

Satz and Sparrow (1970) proposed that "developmental dyslexia" stemmed from a lag in the maturation of the left cerebral hemisphere. As stated in Satz et al. (1978), "the theory… postulates that reading disabilities reflect a lag in the maturation of the brain which differentially delays those skills which are in primary ascendance at different chronological ages. Consequently, those skills which develop ontogenetically earlier during childhood (e.g., visual-perceptual and cross-modal sensory integration) are more likely to be delayed in younger children who are maturationally immature. Conversely, those skills which have a slower rate of development during childhood (e.g., language and formal operations) are more likely to be delayed in older children who are maturationally immature (p. 319)."

Satz and Sparrow (1970) conceived of this theory as a reconciliation of conflicting research suggesting different neuropsychological explanations of reading disabilities. In a subsequent seminal review of the literature, Benton (1975) noted that multiple neuropsychological explanations of "developmental dyslexia" were available, including the idea of a maturational lag. He discussed multiple possible neuropsychological correlates of dyslexia, all based on single deficits from neuropsychological testing: visuoperceptual and audioperceptual functions, directional sense, right–left discrimination, finger recognition, and more generalized language deficiencies. Benton also discussed how these deficits might represent brain mechanisms underlying reading disorders, including specific problems in the development of the parietal lobes that represented an adult-like left hemisphere syndrome or problems with the organization of the cerebral hemispheres that might be manifested as a developmental problem with cerebral dominance (Orton 1925) or as a maturational lag (Satz and Sparrow 1970).

For Satz and Sparrow (1970; Satz et al. 1978), the reconciliation occurred in a developmental explanation based on hypothesized differences in the development of the skills summarized by Benton (1975). In contrast to prevailing explanations of dyslexia as a unitary deficit in a specific skill that had cascading effects on other skills and on reading, dyslexia was viewed as a multifactorial disorder, with varying patterns of age-related neuropsychological deficits depending on the maturation of the child's brain. Although the deficits displayed by children would resemble those of adults with aphasia and acquired disorders, there was little evidence of structural alterations of the brain in children with dyslexia, so an adult-based explanation could not be correct. Rather, Satz and Sparrow argued that the patterns of deficits were age-related. If assessed earlier in development, skills that developed more rapidly early in development related to visual perception and auditory perception, as well as finger identification, right-left discrimination, directional confusion, and other signs of parietal lobe dysfunction, would more robustly discriminate good and poor readers. As the brain matures, the earlier deficits in visual and auditory perception, and the signs of parietal lobe dysfunction, would recede. However, measures of language (e.g., vocabulary) that have a slower and more gradual rate of development would more robustly discriminate older good and poor readers because there would be a lag in development of brain regions related to more complex skills. Thus, Satz and Sparrow (1970) embraced a multiple deficit, developmental view of dyslexia, and rejected an explanation based on damage or injury to the brain and comparisons with adult alexics. Reading disorders were developmental, emerging because the maturational lag affected the capacity of the brain for acquiring the necessary skills as opposed to loss of skills or injury to the brain. In addition,

the maturational lag would be manifested as age-related differences in cerebral organization and laterality.

From this theory, Satz and Sparrow (1970) generated hypotheses about developmental differences in the neuropsychological correlates of reading disabilities and difference in the lateralization of language and cerebral dominance that were tested in several early cross sectional studies (Satz et al. 1971; Sparrow and Satz 1970). In addition, because the skills underlying reading were linked through development of the brain, they speculated that it may be possible to predict which children would develop reading disorders prior to the onset of the problem by screening children in kindergarten. If screening was successful, intervention programs could be initiated prior to the manifestation of the disorder at a time when the brain had more plasticity and thus prevent secondary problems associated with reading difficulties (loss of motivation, poor self-esteem).

Sparrow (1969a, b) and Sparrow and Satz (1970) tested components of the theory in a cross sectional design focusing on sensory, motor, and language indices of laterality, while Satz initiated other cross-sectional research (Satz et al. 1971) and a major longitudinal study in a direct test of the hypotheses generated by the theory that also evaluated the possibility of early screening for reading disability (Fletcher et al. 1984; Satz et al. 1978). The studies were deliberately conducted in public schools and outside of clinics because of concern about sampling bias and a desire to assess the prevalence of “developmental dyslexia.”

Laterality and Dyslexia

In Sparrow’s early work, she administered indices of lateralized sensory, motor, and language functions to large samples of older good and poor readers. For example, Sparrow (1969a), her first published paper, reported on comparisons of manual preference, strength, and dexterity, visual preference, finger differentiation, lateral awareness, ear asymmetry (dichotic listening), and verbal IQ. The sample of 80 9–12 year old children was recruited directly from the schools and half were poor readers. Sparrow predicted smaller differences on sensorimotor aspects of development that emerge earlier and larger differences on perceptual-cognitive skills that become consolidated later in development. She found no differences in hand preference (i.e., no raised incidence of non-right-handedness), manual strength and dexterity, or visual preference. However, the poor readers were less likely to show a right ear advantage on dichotic listening (historically interpreted as evidence of incomplete dominance of language in the left hemisphere), more errors on finger differentiation tasks (identifying unseen and tactilely stimulated fingers by a number code), and a lower verbal IQ. She concluded that,

> “The present results strongly suggest that many normal intelligence children with reading problems are exhibiting a maturational lag in the development of laterality. Thus, a potential picture emerges of the experimental group resembling younger normal children. The lack of findings for the sensorimotor measures can be attributed to the relatively early lateralization of these manual and visual functions. Since the youngest [participants] were already 9 years old, one might hypothesize that sensorimotor laterality, although delayed initially, had by that time matured. On the other hand, the higher level and later developing perceptual-cognitive aspects of laterality strongly differentiated the retarded from the normal reader. Lateralization generally refers to representation or control of a function primarily in one hemisphere. Delay in this lateralization to one of the hemispheres can result in deficits which interfere with learning to read (Sparrow 1969a, p. 674).”

Impact of the Theory

As she completed this work, Sparrow had begun a post doctoral fellowship at the Child Study Center at Yale University, working closely with Edward Zigler and others, and eventually became a faculty member and Chief Psychologist at the Yale Child Study Center. She did not continue her work with Satz, although she maintained a lifelong relationship with Satz and his family. Sara moved on to other areas of research involving children and adults with intellectual and developmental disabilities, and the assessment of adaptive behavior. However, the impact of this early work on her subsequent career is apparent. Sara was always highly interested in assessment, focusing on the need for reliable and valid measures of cognitive functions and adaptive behavior. She trained many people rigorously in psychological assessment. Her developmental perspective clearly emerged early, especially in the idea that the strengths and weaknesses in older children would resemble those of younger children with no developmental difficulties. Her support of early intervention programs and her long term interest in screening methods that promote early detection are clearly evident in her early work (e.g., Sparrow et al. 1983). Finally, her commitment to people with disabilities of all kinds emerged from her early interests in children with language and reading difficulties.

The early work was prescient in promoting the idea of mass screening of children for reading problems, which was implemented by Satz and colleagues (1978) on a large scale based in the 1970s. It emanated in publication of a 20 min kindergarten assessment (Satz and Fletcher 1982) that included equations for predicting the risk of a reading problem in Grade 2. Now this technology has continued to develop, with many approaches to screening in kindergarten and Grade 1 requiring 3–5 min per child and embedded in service delivery systems described as “Response to Intervention (RTI)” models used in many schools across the country. In an RTI model, universal screening for reading, math, and behavior problems is a fundamental component of the implementation and the identification and assessment of progress of the at risk students are fundamental to the effort to match the intensity of intervention to student needs (Fletcher and Vaughn 2009).

The idea that the brain is involved in reading and reading disability was certainly not a new idea, nor was the focus on cerebral dominance and brain organization. The idea that the difference was not an injury or stroke-like defect, but rather a difference in developmental progression, organization of function, and lack of specialization of key regions that support reading, is a major tenet of contemporary models of learning disabilities. With the advent of contemporary neuroimaging, the differences between good and poor readers can be expressed as differences in how the brain is organized for reading, with underactivation of some areas and possible compensatory involvement of others.

The areas most consistently implicated include the basal temporo-occipital region in the base of the brain, the temporo-parietal region (including the posterior portion of the superior temporal gyrus, and the angular and supramarginal gyri), and inferior frontal regions, predominantly in the left hemisphere (Fletcher et al. 2007; Shaywitz et al. 2004; Simos et al. 2002). Depending on the task and modality, individuals with reading difficulties are more likely to show underactivation of the left hemisphere regions in the temporo-occipital and temporo-parietal regions, sometimes showing more activity in the right hemisphere than the left hemisphere. Intervention does exert a largely normalizing influence on this network and supports the idea of plasticity (Shaywitz et al. 2004; Simos et al. 2002). However, this plasticity is not obviously agedependent and seems to occur whenever intervention is successful. Thus, as Satz and Sparrow (1970) suggested, the differences in the brains of children with and without reading problems can be understood in terms of organizational differences and lack of specialization for left hemisphere regions critical for reading.

Less Enduring Aspects of the Theory

The differences in brain organization for reading in good and poor readers do not appear to represent a maturational lag (Rourke 1976; Satz et al. 1981). Indeed, much of the longitudinal research on children with reading problems shows that the cognitive and reading differences are highly persistent and show little evidence of spontaneous "catching up" (Rourke 1976; Francis et al. 1996). Many of the tasks measuring sensorimotor skills have ceiling effects and low reliability. Data from the Florida Longitudinal Project, for example, showed that finger identification deficits seen in younger poor readers and predictive from kindergarten involved the child's capacity to learn a verbal code for numbering the fingers as opposed to a finger agnosia (Fletcher et al. 1982). In longitudinal studies, directional sense and right-left confusion had ceiling effects and poor reliability even as pathognomic signs, as did deficits on more complex finger and tactile recognition paradigms. Perceptual tests that were very predictive of grade 2 reading outcomes in kindergarten (Satz et al. 1978) did not maintain their unique predictive capacity when competed with contemporary assessments of phonological awareness and rapid letter naming speed (Schatschneider et al. 2004). Note, however, that some of these studies emerged in part because of the theory advanced by Satz and Sparrow (1970).

Why didn't these findings have a more sustained influence? There were two primary issues that reflect the shift in thinking about reading and reading disabilities that has occurred over the past 30 years. The first is the importance of classification and definition. As Benton (1975) noted in his review, definitions of dyslexia and reading disability were poorly formulated and largely on the basis of excluding children with known causes of reading difficulty (e.g., intellectual and sensory disabilities). Children could be identified with dyslexia based on a neuropsychological deficit, soft neurological signs, clumsiness, electrophysiological deficits, and behavior problems, or even a reading problem, all of which were treated roughly equivalently and reflect the impact of the concept of minimal brain dysfunction (Rutter 1982). In fact, the resultant population of children with "developmental dyslexia" was very heterogeneous, which Benton felt was partly responsible for the differences in findings across laboratories. In the 1970s, researchers became acutely aware of the heterogeneity of reading disabilities (Rourke 1975). In the Florida Longitudinal Project, what began as a study of "specific developmental dyslexia" became a study of "specific reading disabilities" after 3 years and the first grant renewal, and a study of "reading disabilities" after 6 years and the second renewal. With considerable encouragement from Sparrow, who was keenly interested in the findings, Satz and colleagues used the data from the Florida Longitudinal Project to initiate a series of studies involving the specificity of developmental dyslexia (Taylor et al. 1979) and subtypes of reading disabilities (Satz and Morris 1981). From these studies methods and conceptual frameworks were developed (Morris and Fletcher 1988) that lead to specific studies of definition and classification through a collaboration of the authors with the Yale Center for the Study of Learning and Attention Disorders and Haskins Laboratories (Fletcher et al. 1994). Among other findings, these studies strongly questioned the validity of identifying children with reading disabilities using discrepancies of IQ and achievement that Sparrow applauded based on her own experience with assessment and efforts to obtain services for children (Fletcher et al. 2007).

The other problem involved the absence of a strong theory of reading. Satz and Sparrow began their work prior to the important discoveries of the relation of speech and print and the alphabetic principle in which Alvin and Isabelle Liberman, Don Shankweiler, and others at the Haskins Laboratories were so seminal (Brady and Shankweiler 1991; Shavelson and Towne 2002). The prevailing view of reading at the time was either behavioral or perceptual (Gibson and Levin 1980) and perceptual training programs were routinely used as remedial

interventions for children with learning disabilities. These programs were ineffective (Mann 1979; Vellutino 1979), even though variants continue to be used for children with all kinds of cognitive and behavioral difficulties. Although Satz and Sparrow (1970) attended to the perceptual view, especial in terms of early stages of reading acquisition, they believed that the reading problem was one of multiple difficulties attributed to the maturational lag. As Satz and van Nostrund (1973, p. 9) stated,

> "A critical postulate in the Satz and Sparrow (1970) theory is that the dyslexic child is handicapped on a number of developmental skills which are directly or seemingly not related to the reading process…this phenomena has been ignored or dismissed as irrelevant by investigators who focused on direct operant intervention of the reading process…one might still ask why these children have long been report to have difficulties in one or more of the following skills: right-left discrimination, finger sequencing and identification, writing and calculation ability, verbal intelligence, perceptual discrimination, perceptual-motor integration, auditory-visual integration, and the like…"

They went on to relate this pattern to the maturational lag and the idea that these patterns provide clues to the etiology of reading disabilities, which they acknowledged was an unobservable hypothetical construct involving brain maturation.

From a contemporary perspective, a theory of dyslexia has to explain the core reading problem, and will be no better in its usefulness than the theory of reading. Dyslexia is clearly the lower end of a normally distributed dimension of reading ability (Shaywitz et al. 1992) and the cognitive factors associated with reading proficiency, when present, explain reading deficiencies when absent. Thus, the discovery of the alphabetic principle, representing what Stanovich (2000) termed a "big idea in science," has had enormous impact on scientific understanding and instruction of children with dyslexia and on children who are simply learning to read. We now know that dyslexia must be defined as core impairment at the level of single word reading and spelling and that the capacity for relating the sound structure of language to print is the core cognitive correlate (Fletcher et al. 2007). We can identify the neural correlates of good and poor word recognition, which don't appear to represent a lag, but can be a persistent deficit without the correct forms of intervention. Thus, a theory of dyslexia must explain the reading problem, and a focus on associated features is likely to be a weak explanation, especially when it is used as a basis for academic remediation. Understanding the reading problem, however, is also not a complete explanation for the difficulties in adaptation experienced by children with dyslexia, who may be clumsy, inattentive, and have deficits in other cognitive skills not related to reading (Rourke 1975; Denckla et al. 1985). Thus, the associated signs identified by Satz and Sparrow (1970) remain very important for understanding brain development and possible dysfunction, and overall adaptation in children with dyslexia, especially because they vary in association with the reading problems. As Satz and Sparrow (1970) and others (Rourke 1975; Denckla et al. 1985) have noted, without an explanation of these associated deficiencies, we don't have a strong explanation for brain dysfunction in learning disabilities.

Final Comments

Sara Sparrow began her career at Yale University as the cognitive revolution began and major changes in theories of reading and reading disability began to emerge from the work of investigators at the Haskins Laboratories and others around the world. She was quick to embrace this work and its implications for children with dyslexia, reveling in the enhanced capacity for explaining reading difficulties that were the starting point of her scientific career. She personally encouraged those of us who followed her on the Florida Longitudinal

Project to pay careful attention to this research during our training and was especially supportive of our efforts to collaborate with the Yale Center for the Study of Learning and Attention Disorders and Haskins Laboratories. Based on her experiences evaluating interventions for children with intellectual disabilities (Sparrow and Ziegler 1978), and observing interventions that emerged in other areas for children with learning disabilities, she would support the kinds of historical reviews that we have provided in this paper.

Despite the emergence of a strong scientific basis for understanding reading instruction and reading disabilities, this evidence has not had the impact on schooling, assessment, or on classification models that it should. Assessment approaches are outmoded and the same approaches to assessment and intervention shown repeatedly to be ineffective continue to emerge as hopeful candidates for the future. This impedes scientific progress, which is too infrequently the basis for decision making in education and clinical arenas. Above all, and in view of her outstanding contributions as a clinician and trainer, Sara was a scientist who actively sought development of an evidence base that would support decision making for improving the lives of all children, but especially those with disabilities. She was clearly one of the foundational thought leaders during her career, whose influence on the science and its translation will continue to have impact on those she touched, both children and colleagues, for many years to come.

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