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Evolution of a Theory: How Measurement Has Shaped Ayres Sensory Integration

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Evolution of a Theory: How Measurement Has Shaped Ayres Sensory Integration®

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> There are two possible outcomes: If the result confirms the hypothesis, then you've made a measurement. If the result is contrary to the hypothesis, then you've made a discovery.
> —Enrico Fermi (cited in Jevremovic, 2005, p. 397)

Scientific theory evolves through phases. Scientists observe phenomena, classify their observations, examine and explain causation, and attempt to understand their results in varied circumstances. If anomalies are found that do not mesh with the theory, revision occurs, and the theory is improved (Christensen, Carlile, & Sundahl, 2001). Each stage requires accurate and precise measurement and, therefore, appropriate measurement tools.

The body of scientific inquiry developed by A. Jean Ayres is deeply rooted in systematic and methodical measurement, and her work marked the first effort by an occupational therapist to build a theory for clinical application with an evidence-based approach. The trajectory of the growth of Ayres Sensory Integration® (ASI), beginning in the 1950s with continual advancements from the ongoing contributions of the researchers who have built on her seminal work since that time, has occurred simultaneously with the widespread use of more rigorous research methods, attention to measurement of fidelity, greater usage of exploratory and factor analysis, and more routine practice of examining multivariate research problems with computer statistical programs (Century, Rudnick, & Freeman, 2010; Elmore & Woehlke, 1988; Keselman et al., 1998; Ottenbacher & Peterson, 1985; Press, 2013; Tukey, 1980; West, Carmody, & Stallings, 1983).

This special issue of the *American Journal of Occupational Therapy* consists of an impressive compilation of the wide-reaching application of the concepts that have evolved from those early efforts in measurement and that now continue to serve as a model for the profession, in line with the American Occupational Therapy Association's (2007) *Centennial Vision* aiming toward "a powerful, widely recognized, science-driven, and evidence-based profession" (p. 613). This issue provides multiple examples of the improvements in methodological rigor that occupational scientists have brought to the study of ASI theory. The articles include measurement in sensory integration across age spans and diagnostic categories, with implications for theory and practice ranging from assessment to intervention. In "The Issue Is" article by Schaaf et al. (2014), the current state of measurement in sensory integration is thoughtfully analyzed and articulated. In this editorial, we highlight the ways in which the foundations in measurement established by Ayres have evolved and how this earlier work connects with current and future trends.

Historical Foundations for Current and Future Trends

Ayres (1954, 1955a, 1955b, 1957) began her study of brain function and its impact on learning, behavior, and occupation in her early work with patients who had frank neurological conditions, such as cerebrovascular accidents and cerebral palsy. After doctoral and postdoctoral work, Ayres became intrigued by the role of sensory systems, in particular the tactile, proprioceptive, and vestibular senses, which had not previously been commonly identified as factors in explaining function and dysfunction. In a unique combination of roles for occupational therapists at that time, Ayres worked simultaneously as a researcher, educator, and clinician, with each of these positions informing and shaping her course.

In the 1960s, interest was emerging in perceptual–motor functions and dysfunctions (Frostig, Lefever, & Whittlesey, 1961). Ayres published her first test, the Ayres Space Test (Ayres, 1962), followed by others such as the Southern California Kinesthesia and Tactile Perception Tests (Ayres, 1966b), and began studying sensory integration constructs via measurement through a series of factor analyses (Ayres 1965, 1966a). During this period, awareness and identification of learning disorders were also emerging. These problems had characteristics that were more subtle than the neurological and developmental disabilities that were more commonly known, contributing to Ayres' focus on understanding sensory integration functions that were hard to identify without specialized measurement tools.

With a robust set of measurement instruments, Ayres embarked on conducting a series of factor and cluster analyses. In the early studies (Ayres, 1964, 1965, 1966a, 1966b, 1969, 1971), Ayres regularly included nonstandardized measures and clinical observations of functions (such as the presence or absence of tactile defensiveness and the ability to assume and maintain a prone extension posture) along with the standardized measures she was developing. Through this work, she identified several common and consistently found patterns of sensory integrative function and dysfunction, including somatodyspraxia, visuodypraxia, vestibular–bilateral integration and sequencing deficits, and sensory over- and underresponsiveness (Ayres, 1964, 1965, 1966b, 1969, 1971, 1972c, 1977, 1989). These patterns have continued to be studied and refined (Mailloux et al., 2011; Mulligan, 1998), and, in fact, demonstration of several of these patterns is further explicated with a new population and with new measures in the articles by Carrasco Koester et al. (2014) and Su and Parham (2014) in this issue.

At the same time as Ayres was studying patterns of sensory integration in children with learning and other developmental concerns, she also began to measure efficacy of intervention. In 1972, she published an article titled "Improving Academic Scores Through Sensory Integration" (Ayres, 1972a) in which she reported that a group of children with learning disorders who received occupational therapy using a sensory integration approach 5 days a week (25–40 min a day) for 5–6 mo showed significantly improved scores on achievement tests, in comparison with a matched group of children who received equal time in classroom instruction—a very early version of a randomized controlled trial (RCT). Recent RCTs by Pfeiffer, Koenig, Kinnealey, Sheppard, and Henderson (2011) and Schaaf et al. (2013) have demonstrated the advancements made since Ayres' early study but have also reflected a common foundation of theoretical constructs and outcomes focused on improved participation. The emergence of the Ayres Sensory Integration Fidelity Measure™ (Parham et al., 2007, 2011) has been instrumental in allowing researchers to meet current standards of rigor for intervention research, with further validation of this measure presented by May-Benson et al. (2014) in this issue.

In addition to identifying relevant outcome measures to evaluate overall effectiveness of the intervention, Ayres was also concerned with studying the variables that would predict which children would benefit most from her interventions. For example, Ayres (1978) showed that the duration of postrotary nystagmus (PRN) was the best predictor of change in reading and spelling, with children who had shortened-duration PRN making greater gains than those without shortened-duration PRN. Those important results resonate with the finding by Mailloux et al. (2014) reported in this issue, showing that the measure of PRN can now be used with infants and toddlers, perhaps with promise for making predictions about response to intervention in the youngest of those in need.

As scientific methods became more sophisticated, Ayres began to focus on standardized measures with strong psychometric properties, thus reducing representation of measures in some areas (e.g., tactile defensiveness or observations related to vestibular functions) for which norm-referenced assessments were not yet available. However, in her clinical practice she continued to observe these and other issues, and she constantly aimed for better ways to assess and ameliorate all aspects of sensory integration concerns. Standardized questionnaires such as the Sensory Profile (Dunn, 1999) and the Sensory Processing Measure (Parham, Ecker, Miller-Kuhaneck, Henry, & Glennon, 2006) have become strong tools for assessing areas that were previously dependent on nonstandardized measures. Other work continues to build on both the nonstandardized and the standardized measures used by Ayres to evaluate proprioceptive functions (Blanche, Bodison, Chang, & Reinoso, 2012) and tactile processing (Yochman, Alon-Beery, Sribman, & Parush, 2013). In this issue, Blanche, Parham, Chang, and Mallinson (2014) offer a further expansion of assessing these areas with the Adult Sensory Processing Scale; Schoen, Miller, and Sullivan (2014) report on a promising new observational measure of sensory modulation with the Sensory Processing Scale; and Lane, Ivey, and May-Benson provide two new ways to assess praxis in preschoolers with the Test of Ideational Praxis (Lane, Ivey, & May-Benson, 2014) and the Motor Planning Maze Assessment (Ivey, Lane, & May-Benson, 2014). These measures offer new and expanding ways to assess sensory integration functions and to further document and support the benefits of ASI intervention across varied populations.

A Promising Future

Interest in sensory integration is increasing dramatically. According to the Interactive Autism Network, parents of children with autism spectrum disorder report that sensory interventions are the fifth most common type of treatment their children receive (Autism Speaks, 2014). The latest edition of the *Diagnostic and Statistical Manual of Mental Disorders* has included "hyper- or hypo-reactivity to sensory input or unusual interests in sensory aspects of the environment" as part of the diagnostic criteria for autism spectrum disorder (American Psychiatric Association, 2013, p. 50). Although this increased attention to sensory function and dysfunction has the potential to offer wide-reaching benefits to children, families, and the profession of occupational therapy, greater attention also brings increased scrutiny and the need for enhanced precision from the field of occupational therapy.

Clarity and accuracy are essential in relation to the ways in which occupational therapists choose and evaluate interventions, as well as to the way they communicate about them. Careful consideration of interventions such as ASI will assist in avoiding misunderstanding or misrepresentation of this approach (Case-Smith & Schaaf, n.d.; Clark, 2012a, 2012b; Schaaf & Blanche, 2011). The call for evidence-based practice across all realms of health care, coupled with the rise of interest in and research on sensory interventions, has allowed for crucial reviews of evidence that may challenge common clinical choices but may also support the underlying theory (Case-Smith, Weaver, & Fristad, 2014; Clark, 2013). These reviews highlight the need for thoughtfulness in the selection of research methods and decisions related to outcome measures.

The future offers considerable opportunities for growth and development of the measures available for documenting clinical progress and quantifying research results. Technological leaps, with the resultant decrease in costs, have great potential for increased specificity and ease of clinical measures. Examples of the astounding advancements being made and their potential applications include devices such as portable force plates and posturography (Biodex, 2014; Chaudhry, Bukiet, Zhiming, & Findley, 2011; Huang, Sue, Abbod, Jiang, & Shieh, 2013), Wii® for balance assessment (Clark et al., 2010), proprioceptive devices with or without sensors (Leibowitz et al., 2008; Wycherley, Helliwell, & Bird, 2005), or accelerometry to quantify movement (Rowland, 2007). These devices would allow clinicians to carefully measure sensory integration functions such as perception, balance, accuracy of imitation of movement, and so forth for initial assessment, as well as for pre- and postintervention measurement. Occupational therapy researchers may also gain access to more complete measures of balance with visual and proprioceptive influences, such as the SMART Balance Master® system (NeuroCom, Clackamas, OR). Further advances in new haptic interfaces or "feel screens" such as Senseg™ (Senseg, Espoo, Finland) may someday be used by occupational therapists to precisely quantify tactile localization. Developments in the research on sensory functions after cerebrovascular accident using sensors and robots to measure proprioception may someday be applied to occupational therapy research with children (Dukelow et al., 2010; Leibowitz et al., 2008; Semrau, Herter, Scott, & Dukelow, 2013). In addition, occupational therapy researchers may more frequently find themselves collaborating with neuroscientists to use functional MRI (Brodoehl, Klingner, Stieglitz, & Witte, 2013; Wacker, Spitzer, Lutzkendorf, Bernarding, & Blankenburg, 2011), diffuse tensor imaging (Owen et al., 2013), and high-density electrophysiological recordings (Butler, Foxe, Fiebelkorn, Mercier, & Molholm, 2012) to measure changes in the brains of the participants treated with ASI and to more clearly define the neurological basis of ASI theory.

As this issue demonstrates, recent decades have seen substantial growth in the body of knowledge around ASI. Ayres herself expressed optimism (personal communication, July, 1987) about the ways in which future scientific advancements would support and expand the core concepts of her sensory integration theory and practice. Perhaps new technologies will someday become commonplace in occupational therapy in ways that will continue the evolution of systematic measurement as a means for developing and revising interventions that Ayres left as her legacy to the profession. Through advancements such as these, and with the gentle reminder reflected in her well-known quote, "Truth like infinity is to be forever approached but never reached" (Ayres, 1972b, p. 4), scientists will be able to expand the boundaries of their knowledge through persistent and continual inquiry through measurement. ▲

Dedication

This special issue is dedicated to the life and accomplishments of Jane Koomar, PhD, OTR/L, FAOTA. Dr. Koomar had a distinguished career as an occupational therapist, making her mark in education, research, and clinical practice. Following in the footsteps of her mentors, Ginny Scardinia and A. Jean Ayres, Dr. Koomar was a model for us all in her untiring efforts, determined focus, and deep empathy aimed at understanding and helping people who live with sensory integration challenges. A critical thinker and thoughtful listener, Dr. Koomar continually sought to further the science behind practice and to ensure access to effective intervention. She leaned heavily on the lessons of the past but also sought to make the most of the present with a constant eye on trailblazing for the future. We believe that this special issue on the role of measurement in sensory integration, with contributions from her esteemed colleagues and friends as well as one of her own final articles, is a fitting honor to the important legacy she leaves.

Jane Koomar, PhD, OTR/L, FAOTA

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