Ecological Validity in Virtual Reality–Based Neuropsychological Assessment

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INTRODUCTION

Over 25 years ago, Paul Meehl (1987) called for clinical psychologists to embrace the technological advances prevalent in our society: "It would be strange, and embarrassing, if clinical psychologists, supposedly sophisticated methodologically and quantitatively trained, were to lag behind internal medicine, investment analysis, and factory operations control in accepting the computer revolution" (p. xv). Ten years later (15 years ago), Sternberg (1997) described the ways in which clinical psychologists failed in meeting Meehl's challenge as is apparent in the discrepancy between progress in cognitive assessment measures like the Wechsler scales and progress in other areas of technology. Sternberg used the example of the now obsolete black and white televisions, vinyl records, rotary-dial telephones, and the first commercial computer made in the United States (i.e. UNIVAC I) to illustrate the lack of technological progress in the standardized testing industry. According to Sternberg, currently used standardized tests differ little from tests that have been used throughout this century. For example, while the first edition of the Wechsler Adult Intelligence Scale appeared some years before UNIVAC, the Wechsler scales (and similar tests) have hardly changed at all (aside from primarily cosmetic changes) compared to computers. Although one may argue that innovation in the computer industry is different from innovation in the standardized testing industry, there are still appropriate comparisons. For example, whereas millions of dollars spent on technology in the computer industry typically reflects increased processing speed and power; millions of dollars spent on innovation in the testing industry tends to reflect the move from multiple-choice items to fill-in-the-blank items. Sternberg's statements are as true now as they were 15 years prior to the publication of this manuscript. While clinical psychology emphasizes its role as a science, its technology is not progressing in pace with other clinical neurosciences. Sternberg also points out cognitive testing needs progress in ideas, not just new measures, for delivering old technologies.

Over the course of the last several decades, clinical neuropsychology has gained increasing recognition as a discipline with relevance to a number of diverse practice areas (e.g., neurology, neurosurgery, psychiatry, and family medicine) as well as neuroscience specific research areas (e.g., behavior, learning, and individual differences). Although today's neuropsychological assessment procedures are widely used, clinical neuropsychologists have been slow to embrace technological advancements. Two essential limitations have resulted from this refusal of technological adaptation: First, current neuropsychological assessment procedures represent a technology that has barely changed since the first scales were developed in the early 1900s. Second, while the historical purpose of clinical neuropsychology was differential diagnosis of brain pathology, technological advances in other clinical neurosciences have changed the neuropsychologist's role to that of making ecologically valid predictions about the impact of a given patient's neurocognitive abilities and disabilities on everyday functioning.

Recently, scholars have been discussing the potential for a paradigm shift in clinical neuropsychology (Bilder, 2011; Dodrill, 1997; Green, 2003; Parsons and Courtney, 2011; Parsons, 2011; 2012; Puente, 1992; Perry, 2009). The historical development of neuropsychology has resulted in a "normal science" that is informed by developments in psychology, neuroscience, neurology, psychiatry, and computer science. Each of these "informing disciplines" has gone through changes that challenge theory and praxes of neuropsychological assessment. These changes are what Kuhn (1962/1996) describes as paradigm shifts, in which new assumptions (paradigms/theories) require the reconstruction of prior assumptions and the reevaluation of prior facts. For psychology, the paradigmatic shifts are found in

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the move from mentalism (i.e., study of consciousness with introspection) to behaviorism (Watson, 1912), and then cognition (Miller, 2003) as now understood through connectionist frameworks (Bechtel & Abrahamsen, 1990). Further, in clinical psychology, shifting paradigms are seen in the incorporation of innovative technologies in treatment delivery (Dimeff et al., 2010). Neurorehabilitation has undergone a paradigm shift as a result of influences from basic and clinical research (Nadeau, 2002). For psychiatry (e.g., neuropsychopharmacology) the "paradigm shift" has been found in an understanding of psychiatric disorders and molecular biology models that account for gene/environment/development interaction (Meyer, 1996). Likewise, neuroscience has seen a shift related to the understanding of communication between nerve cells in the brain—shift from predominant emphasis upon electrical impulses to an enhanced model of chemical transmission (Carlsson, 2001). For neurology (and a number of related branches of neuroscience) a shift is found in new ways to visualize the details of brain function (Raichle, 2009). Finally, we are seeing shifts in computer science in the areas of social computing (Wang, 2007), information systems (Merali and McKelvey, 2006), and even the video game industry (Zackariasson & Wilson, 2010).

Dodrill (1997) has discussed the lack of progress in clinical neuropsychology. According to Dodrill, neuropsychologists are making much less progress than would be expected in both in absolute terms and in comparison with the progress made in other clinical neurosciences. Dodrill offers evidence for this assertion through pointing out that clinical neuropsychologists are using many of the same tests that they were using 30 years ago (in fact close to 50 years ago given the date of this publication). Dodrill points out that if neuroradiologists were this slow in technological development, then they would be limited to pneumoencephalograms and radioisotope brain scans—procedures that are considered primeval by current neuroradiological standards. According to Dodrill, the advances in neuropsychological assessment (e.g., Weschler scales) have resulted in new tests that are by no means conceptually or substantively better than the old ones. The full scope of issues raised by Dodrill becomes more pronounced when he compares progress in clinical neuropsychology to that of other neurosciences. For example, clinical neuropsychologists have historically been called upon to identify focal brain lesions. When one compares clinical neuropsychology's progress with clinical neurology, it is apparent that while the difference may not have been that great prior the appearance of computerized tomographic (CT) scanning (in the 1970s), the advances since then (e.g., magnetic resonance imaging) has given clinical neurologists a dramatic edge. What options are available for clinical neuropsychogists to move beyond an outmoded approach to their field?

According to Bilder (2011), Clinical neuropsychology is ready to embrace technological advances and experience a transformation of its concepts and methods. For Bilder the theoretical formulations of neuropsychology are represented in three waves. In Neuropsychology 1.0 (1950–1979), clinical neuropsychologists focused on lesion localization and relied on interpretation without extensive normative data. In Neuropsychology 2.0 (1980-present), clinical neuropsychologists were impacted by technological advances in neuroimaging and as a result focused on characterizing cognitive strengths and weaknesses rather than differential diagnosis. For Neuropsychology 3.0 (a future possible Neuropsychology), Bilder emphasizes the need to leverage advances in neuroimaging that Dodrill discussed. Further, he calls on clinical neuropsychologists to incorporate findings from the human genome project, advances in psychometric theory, and information technologies. Bilder argues that a paradigm shift toward evidence-based science and praxes is possible if neuropsychologists understand the need for innovations in neuropsychological knowledge bases and the design of Web-based assessment methods.

For the current article, the focus will be upon three "modalities" found in the practice of "Neuropsychological Assessment" that reflect the three waves found in theoretical formulations of neuropsychology (see Bilder, 2011). The organization of this article is as follows. In Section One: "Neuropsychological Assessment 1.0" a brief overview will be given of the historical development of clinical neuropsychology's normal science and the crisis state that is leading to a paradigm shift. In Section Two: "Neuropsychological Assessment 2.0," current applications of computer-based neuropsychological assessment are described. In Section Three: "Neuropsychological Assessment 3.0" a discussion is proffered of the utility of simulation technology for ecologically valid neuropsychological