Chapter 1
Introduction

> *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.*
>
> —Paul Meehl (1987)

> *There is one industry, however, that remains a glaring exception to the general rapid rate of technological progress that is ongoing in our society–the standardized-testing industry.*
>
> —Sternberg (1997)

Decades ago Paul Meehl (1987) called for clinical psychologists to embrace the technological advances prevalent in our society. Meehl's endorsement of technology for clinical psychology reflects the developments that were occurring during the 1980s for psychological testing (Bartram and Bayliss 1984; French and Beaumont 1987; Space 1981). In the 1980s, neuropsychologists also discussed the possibilities of computer-automated neuropsychological assessments and compared them to traditional approaches that involved paper-and-pencil testing (Adams 1986; Adams and Brown 1986; Adams and Heaton 1987; Long and Wagner 1986). An unfortunate limitation of progress beyond this period is that too great of emphasis was placed upon interpretive algorithms which led to questions about whether then-current programs could generate accurate clinical predictions (Anthony et al. 1980; Heaton et al. 1981). While it is unclear whether the computerized platforms during this period were adequate, it is clear that the use of computerized interpretation of clinical results from fixed batteries stalled progress in development of technologically advanced neuropsychological assessments (Russell 2011).

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1 Sternberg's Call for Advances in Technology for Assessment of Intelligence

A decade after Meehl, Sternberg (1997) described the ways in which clinical psychologists have fallen short of meeting Meehl's challenge. This failure 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 USA (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 also points out cognitive testing needs progress in ideas, not just new measures, for delivering old technologies. While clinical neuropsychology emphasizes its role as a science, its technology is not progressing in pace with other clinical neurosciences.

2 Dodrill's Call for Advances in Technology for Neuropsychological Assessment

At the same time Sternberg was describing the discrepancy between progress in cognitive assessment measures and progress in other areas of technology, Dodrill (1997) was contending that neuropsychologists had made much less progress than would be expected in both absolute terms and in comparison with the progress made in other clinical neurosciences. Dodrill points 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). If neuroradiologists were this slow in technological development, then they would be limited to pneumo-encephalograms 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.

3 From Lesion Localization to Assessment of Everyday Functioning

In addition to serving as an example of progress in neurology and the clinical neurosciences, neuroimaging reflects a technology that changed the way clinical neuropsychologists answered referral questions. By the 1990s, neuropsychologists were experiencing a shift in referrals from lesion localization to assessment of everyday functioning (Long 1996). With the advent and development of advanced technologies in the clinical neurosciences, there was decreased need for neuropsychological assessments to localize lesions and an increased need for neuropsychologists to describe behavioral manifestations of neurologic disorders. Clinical neuropsychologists were increasingly being asked to make prescriptive statements about everyday functioning (Sbordone and Long 1996).

Recently, scholars have been discussing the potential for a paradigm shift in clinical neuropsychology (Baxendale and Thompson 2010; Bilder 2011; Dodrill 1997, 1999; Green 2003; Parsons 2011; 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 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 and Abrahamsen 1990). Within the last decade, convergence between the social sciences and the neurosciences has resulted in social cognitive and affective neurosciences (Davidson and Sutton 1995; Lieberman 2010; Panksepp 1998). 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; Barrett 2006; Mateer and Sohlberg 1988). 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; Sakoglu et al. 2011). Finally, we are seeing shifts in computer science in the areas of social computing (Wang 2007), information systems (Merali and McKelvey 2006), neuroinformatics (Jagaroo 2009; Koslow 2000; Fornito and Bullmore 2014), and even the video game industry (de Freitas and Liarokapis 2011; Zackariasson and Wilson 2010).

4 Bilder's Neuropsychology 3.0: Evidence-Based Science and Practice

Recently, Bilder (2011) has argued that 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 knowledgebases and the design of Web-based assessment methods.

5 Computerized Neuropsychological Assessment Devices

One area of technological advance in neuropsychological assessment is the advent of computer-automated neuropsychological assessment devices. These computer-automated neuropsychological assessments have been lauded for their potential to augment task administration (Parsey and Schmitter-Edgecombe 2013), scoring (Woo 2008), collect normative data (Bilder 2011), and in some cases interpret tests (Russell 1995, 2000). In addition to administration issues, advantages have been noted for complexity of stimulus presentation (Gur et al. 2001a, b; Schatz and Browndyke 2002) and logging of responses (Crook et al. 2009; Woo 2008). Bilder (2011) has argued that computerized neuropsychological assessments enable presentation of stimuli and collection of responses that clearly outperform a human examiner because these computerized assessments have enhanced timing precision and can rapidly implement of adaptive algorithms. The enhanced timing precision of the computer-automated assessment enables implementation of subtle task manipulations and trial-by-trial analysis methods found in cognitive neuroscience. Bilder argues that these offer greater sensitivity and specificity to individual differences in neural system function. Relatedly, there is increased interest in Internet-based assessment and the possibility for acquiring hundreds of thousands of participants in months. The longitudinal behavioral data garnered from Internet-based assessment offers potential for the development of repositories that can be stored with electronic medical records, genome sequences, and each patient's history.

6 Ecological Validity and Assessment of Everyday Functioning

While Bilder's arguments are very similar to the ones made in this book, they do not include a discussion of the need for ecological validity in neuropsychological assessments. An unfortunate limitation of most computer-automated neuropsychological measures is that they simply automate construct-driven paper-and-pencil assessments. The changing role for neuropsychologists has also resulted in increased emphasis upon the ecological validity of neuropsychological instruments (Franzen and Wilhelm 1996). An unfortunate limitation for neuropsychologists interested in assessing everyday functioning has been the lack of definitional specificity of the term "ecological validity" (Franzen and Wilhelm 1996). Early attempts to define ecological validity for neuropsychological assessment emphasized the functional and predictive relation between a patient's performance on a set of neuropsychological tests and the patient's behavior in everyday life. Hence, an ecologically valid neuropsychological measure has characteristics similar to a naturally occurring behavior and can predict everyday function (Sbordone 1996). Franzen and Wilhelm (1996) refined the definition of ecological validity for neuropsychological assessment via an emphasis upon verisimilitude and veridicality. By verisimilitude, they meant that the demands of a test and the testing conditions must resemble demands found in the everyday world of the patient. A test with verisimilitude resembles a task the patient performs in everyday life and links task demands to the prediction of real-world behavior (Spooner and Pachana 2006). By veridicality, they meant that performance on a test should predict some aspect of the patient's functioning on a day-to-day basis.

7 Construct-Driven Versus Function-Led Approaches

A refinement of the ecological validity discussion can be found in Burgess and colleagues' (2006) suggestion that neuropsychological assessments be developed to represent real-world "functions" and proffer results that are "generalizable" for prediction of the functional performance across a range of situations. According to Burgess and Colleagues (2006), a "function-led approach" to creating neuropsychological assessments will include neuropsychological models that proceed from directly observable everyday behaviors backward to examine the ways in which a sequence of actions leads to a given behavior in normal functioning; and the ways in which that behavior might become disrupted. As such, he calls for a new generation of neuropsychological tests that are "function led" rather than purely "construct driven." These neuropsychological assessments should meet the usual standards of reliability, but discussions of validity should include both sensitivity to brain dysfunction and generalizability to real-world function.

A number of function-led tests have been developed that assess cognitive functioning in real-world settings. For example, Shallice and Burgess (1991) developed the multiple errands test (MET) as a function-led assessment of multitasking in a hospital or community setting. However, there are a number of unfortunate limitations for such tests that are apparent in the obvious drawbacks to experiments conducted in real-life settings. Function-led neuropsychological assessments can be time-consuming, require transportation, involve consent from local businesses, costly, and difficult to replicate or standardize across settings. Further, data collection in these naturalistic observations tends to be limited.

8 Affective Neuroscience and Clinical Neuropsychology

A further issue for ecological validity is the need for assessments that take seriously the impact of affective arousal upon neurocognitive performance. While current approaches to neuropsychological assessment aid our understanding of cognitive conflict, everyday activities commonly come in the form of emotional distractors. Social and affective neuroscience studies have found that affective stimuli are particularly potent distracters that can reallocate processing resources and impair cognitive (e.g., attention) performance (Dolcos and McCarthy 2006; Pessoa 2008). Affective responses to emotional distractors may be understood as multimodal events in response to a stimulus that has particular significance for the participant, often signifying a potential threat or reward. Affective stimuli are particularly potent distracters that can reallocate processing resources and impact attentional performance (Dolcos and McCarthy 2006). Enhanced understanding of the effect of threatening stimuli upon executive functions has important implications for affective disorders (e.g., specific phobias, depression, and post-traumatic stress disorder) that are characterized by increased susceptibility to affective distraction (Ellis and Ashbrook 1988; Wang et al. 2008). Although cognitive-based understandings of brain–behavior relationships have grown in recent decades, the neuropsychological understandings of emotion remain poorly defined (Suchy 2011). Likewise, neuropsychological assessments often fail to assess the extent to which affective arousal may impair cognitive performance.

9 Virtual Environments for Enhanced Neuropsychological Assessments

Virtual environments (VE) are increasingly considered as potential aids in enhancing the ecological validity of neuropsychological assessments (Campbell et al. 2009; Renison et al. 2012). Given that VEs represent a special case of computerized neuropsychological assessment devices (Bauer et al. 2012; Schatz and Browndyke 2002), they have enhanced computational capacities for administration efficiency, stimulus presentation, automated logging of responses, and data analytic processing. Since VEs allow for precise presentation and control of dynamic perceptual stimuli, they can provide ecologically valid assessments that combine the veridical control and rigor of laboratory measures with a verisimilitude that reflects real-life situations (Parsons 2011). Additionally, the enhanced computation power allows for increased accuracy in the recording of neurobehavioral responses in a perceptual environment that systematically presents complex stimuli. Such simulation technology appears to be distinctively suited for the development of ecologically valid environments, in which three-dimensional objects are presented in a consistent and precise manner (Parsons 2011). VE-based neuropsychological assessments can provide a balance between naturalistic observation and the need for exacting control over key variables (Campbell et al. 2009; Parsons 2011). In summary, VE-based neuropsychological assessments allow for real-time measurement of multiple neurocognitive abilities in order to assess complex sets of skills and behaviors that may more closely resemble real-world functional abilities (Matheis et al. 2007).

10 Plan for This Book

In this book, I aim to discuss the evolution of technological adaptation in neuropsychological assessment. A common theme among neuropsychologists reflecting on the state of the discipline is that neuropsychologists have been slow to adjust to the impact of technology on their profession (Bigler 2013; Bilder 2011; Dodrill 1999). First, current neuropsychological assessment procedures represent a technology that has barely changed since the first scales were developed in the early 1900s (i.e., Binet and Simon's first scale in 1905 and Wechsler's first test in 1939). Although neuropsychologists are ardent to emphasize neuropsychology's role as a science, its technology is not progressing in pace with other science-based technologies. Instead, neuropsychological test developers tend to make cosmetic changes to paper-and-pencil assessments and emphasize improved psychometric properties (e.g., updated norms, improve subtest and composite reliability). An unfortunate limitation is that without the technological advances found in neuroinformatics and computer adaptive testing, updated neuropsychological test developers fail to account for back-compatibility issues that may invalidate clinical interpretations (Loring and Bauer 2010). A further issue is that while the historical purpose of clinical neuropsychology was differential diagnosis of brain pathology, technological advances in other clinical neurosciences (e.g., the development of neuroimaging) 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. These reasons alone should prompt neuropsychologists to take seriously the need for technological progress for a progressive neuropsychology.

Throughout this book, there is an emphasis upon the importance of (1) enhancing ecological validity via a move from construct-driven assessments to tests that are representative of real-world functions—it is argued that this will proffer results that are generalizable for prediction of the functional performance across a range of situations; (2) the potential of computerized neuropsychological assessment devices (CNADs) to enhance: standardization of administration; accuracy of timing presentation and response latencies; ease of administration and data collection; and reliable and randomized presentation of stimuli for repeat administrations; and (3) novel technologies to allow for precise presentation and control of dynamic perceptual stimuli—provides ecologically valid assessments that combine the veridical control and rigor of laboratory measures with a verisimilitude that reflects real-life situations.

Following a discussion of ecological validity, Part II reviews "The Evolution of Neuropsychological Assessment" and focuses upon the three waves found in theoretical formulations of neuropsychological assessment. The organization of this section is as follows. In Chap. 3, "Neuropsychological Assessment 1.0," a brief overview will be given of the historical development of clinical neuropsychology's normal science and the current state that is leading to a shift in approaches. In Chap. 4, "Neuropsychological Assessment 2.0," current applications of computer-based neuropsychological assessments are described. In Chap. 5, "Neuropsychological Assessment 3.0," a discussion is proffered of the utility of simulation technology for ecologically valid neuropsychological assessments that make use of current technological advances.

In Part III, "Next Generation Neuropsychological Applications," there will be a discussion of novel technologies and approaches that allow the clinician to reach patients in novel approaches. In Chap. 6, "Teleneuropsychology: Coming out of the office," there will be a discussion of the ways in which electronic communications may be used to deliver health-related services from a distance, and its particular usefulness in bringing specialty services to underserved populations and/or remote areas. Chapter 7, explains about "Gamification of Neurocognitive Approaches to Rehabilitation."

In Part IV, "Conclusions," the book will conclude (Chap. 8) with a presentation of "Future Prospects for a Computational Neuropsychology." Herein, there will be a discussion of the importance of using technology to develop repositories for linking neuropsychological assessment results with data from neuroimaging, psychophysiology, and genetics.