Thomas D. Parsons

Clinical Neuropsychology and Technology

What's New and How We Can Use It

Springer

Clinical Neuropsychology and Technology

Thomas D. Parsons

Clinical Neuropsychology and Technology

What's New and How We Can Use It

Springer

Thomas D. Parsons
University of North Texas
Denton, TX
USA

ISBN 978-3-319-31073-2 ISBN 978-3-319-31075-6 (eBook)
DOI 10.1007/978-3-319-31075-6

Library of Congress Control Number: 2016934011

Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer International Publishing AG Switzerland

I dedicate this book to Valerie Parsons…
her pure blue eyes reminded me that true
discovery consists not in simply seeking
novel landscapes, but in having new eyes.

Preface

> Perhaps it is because the profession of clinical neuropsychology is so young that any progress made in it may seem to be significant. However, it appears to the President of this Division that we are not actually making as much progress as we are inclined to believe and that this is true both in absolute terms and in comparison with the progress made in other clinical neurosciences.
>
> Dodrill (1997, p. 1)

As is apparent in Dodrill's presidential address to the American Psychological Associations's division on neuropsychology, I am not the first to stress the importance of technological progress for advancing neuropsychological assessments. What is striking about Dodrill's comments is that they are as true today as they were two decades ago. Advances in neuropsychological assessment are far behind progress made in other clinical neurosciences. The developments in neuroscience, computer science, and information technology have all the hallmarks of a broad technological revolution.

I began thinking about the importance of technology for neuropsychological assessment around the same time that Dodrill's presidential address was published. In 1998 I started graduate training in clinical psychology with an emphasis on neuropsychology. I had a background in computer science and electrical engineering from my time in the military and experience in computer networks and database programming. Throughout my neuropsychology training (graduate school, internship, and postdoctoral work), I was struck by the inefficiency of paper-and-pencil assessments and the fact that so many of the tests seemed to fall short of answering the referral questions I received while working in academic medical centers. Most of these tests were slightly modified tests that had been developed decades earlier. In addition to their lack of technological progress, the tests were theoretically questionable as they reflected early approaches to assessment found in non-clinical disciplines. A good deal of my training was in neurology departments, but most of the neuropsychological assessment tools revealed little correspondence to well-defined neuroanatomic systems. This seemed strange to me given that my work with researchers in neuroscience and computer science revealed many neural systems and modules that interconnected, with relative precision, neurocognitive processes to brain areas. When I compared these experiences with my work using neuropsychological assessment tools, I was frustrated by the imprecision and lack of sophistication of neuropsychological models of cognition. I felt then, and continue to believe, that technological upgrades to neuropsychological assessment tools would allow for clinical neuropsychological assessment data to better comport with functional neuroanatomic/neurocognitive systems.

My interest in computer science and advanced technologies led me to accept a position as a research scientist and assistant research professor position at the University of Southern California's Institute for Creative Technologies. During this time I was able to explore computerized methods for enhancing stimulus presentation, event logging, database development, and neuroinformatic approaches that could link behavioral responses to neurological models.

A few years ago I decided to make the transition into a more traditional tenure position where I would have increased opportunities to train the next generation of neuropsychologists in the application of advanced technologies for neuropsychological assessment. When preparing lectures I was once again struck by the absence of advances in computer science, information technology, and neuroinformatics in clinical neuropsychology. In other neuroscience subdisciplines evidence is readily apparent of advanced technologies, innovative research methods, novel data analytics, and collaborative knowledge bases. Unfortunately, clinical neuropsychology remains rather unchanged and there is little evidence of progress.

In November 2013 I received the early career award from the National Academy of Neuropsychology. At the same meeting, Dean Delis received the Distinguished Lifetime Contribution to Neuropsychology Award. Dr. Delis discussed the evolution of neuropsychological test development and the new frontiers in tablet-based testing. I remember my excitement when I realized that the distinguished lifetime achievement awardee and the early career awardee were both involved in advancing neuropsychological assessment with novel technologies. The following year, in February 2014, I presented two papers at the annual meeting of the International Neuropsychological Society, in Seattle, Washington. One paper was for a keynote symposium on ecologically valid methods of assessment in neuropsychology and the other paper was for a symposium on neuropsychology and technology in the twenty-first century. In addition to comparing paper-and-pencil, computer-automated, and simulation-based approaches to neuropsychological assessment these papers described the potential of virtual reality and information technology for enhancing clinical neuropsychology. Soon after, I began to structure these presentations into this text.

This book reviews currently available technologies that may be useful for neuropsychologists. In addition to enhanced technologies for administration and data capture, there is emphasis on the need for information technologies that can link outcome data to neuroinformatics and collaborative knowledgebases. I understand that this book is a rather ambitious first account of advances in technology for neuropsychological assessment. It is important to note that neuropsychologists need not view these advanced technologies as necessary replacements for current batteries. Instead, it is hoped that the tools described herein will offer neuropsychologists with additional tools that can be used judiciously with current batteries.

Denton, TX, USA Thomas D. Parsons

Acknowledgements

I wish to acknowledge the amazing people who helped me in making this book possible.

First, I wish to acknowledge my colleagues at the University of Southern California, and the University of North Texas. While at the University of Southern California's Institute for Creative Technologies, I had the great opportunity of working with Galen Buckwalter, Skip Rizzo, and Patrick Kenny. Their passion for virtual reality and neuropsychology shaped my development and proffered an impetus for my desire to update the tools used currently for neuropsychological assessment. At the University of North Texas, I have had a number of interesting interactions with my colleagues in Psychology. Additionally, I have benefitted from collaborative work with Ian Parberry in Computer Science and Lin Lin in Learning Technologies.

I also wish to acknowledge the first intellects who shaped my thinking. First, is Umberto Eco, in addition to Eco's semiotics (e.g., semiological guerrilla), his creation of the Abulafia computer in *Foucault's Pendulum* will always be my favorite technology for generating Aristotelian metaphors. I am also indebted to Jorge Luis Borges for his discussions of libraries, labyrinths, time, and infinity. Next, there is Ludwig Wittgenstein's brilliant early work in the *Tractatus Logico-Philosophicus*, and his later work in the *Philosophical Investigations*, wherein he discarded much of what he argued in the *Tractatus*!

There are also a number of students and postdoctoral fellows who both inspired me and diligently assisted with the research for the manuscript. Two graduate students stand out as exemplars of "why I do what I do" each day: Christopher Courtney from the University of Southern California and Timothy McMahan from the University of North Texas.

Finally, I must thank my best friend Valerie Parsons. Her encouragement and support have been invaluable. Also, our children, Tommy and Sophie: I am proud to have a bearcat and a bugaboo that are already fascinated by the brain and what it means to be a person. My family inspires and heals me. Dostoyevsky was correct that "The soul is healed by being with children."

Contents

About the Author

Thomas D. Parsons Ph.D., is a Clinical Neuropsychologist and Associate Professor of Psychology at the University of North Texas. Prior to joining the faculty at UNT, he was an Assistant Professor and Research Scientist at the University of Southern California's Institute for Creative Technologies. His work integrates neuropsychology and simulation technologies for novel assessment, modeling, and training of neurocognitive and affective processes. He is a leading scientist in this area and he has directed 17 funded projects during his career and he has been an investigator on an additional 13 funded projects. In addition to his patents for the eHarmony.com matching system, he has invented and validated virtual reality-based assessments of attention, spatial abilities, memory, and executive functions. He uses neural networks and machine learning to model mechanisms underlying reinforcement learning, decision making, working memory, and inhibitory control. He has over 100 publications in peer reviewed journals and book chapters. His contributions to neuropsychology were recognized when he received the 2013 National Academy of Neuropsychology Early Career Achievement award. In 2014, he was awarded the Fellow status in the National Academy of Neuropsychology.

Part I
Introduction

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).

T.D. Parsons, *Clinical Neuropsychology and Technology*,
DOI 10.1007/978-3-319-31075-6_1

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