CHAPTER 1

Neuropsychology and the Prediction of Everyday Functioning

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Modern neuropsychology rose to prominence as a discipline during the middle of the 20th century. Armed with a toolkit of cognitive, motor, and sensory tests, neuropsychologists helped localize brain lesions and contributed to the diagnosis of neurological and neuropsychiatric conditions. Over the past decades, the role of neuropsychology in lesion localization has waned considerably, given the improved accuracy of imaging techniques. Neuropsychological assessment is, however, crucial for understanding the nature and severity of any behavioral manifestations that may result from brain abnormalities. Increasingly, a primary reason for neuropsychological referrals is to answer questions about the effects that brain alterations are likely to have on everyday functioning, such as the ability to be successful at work, handle finances, drive an automobile, or live independently (Rabin, Barr, & Burton, 2005). In addition to being a common clinical question, functional status is a focus in forensic referrals, where decisions on financial compensation may depend on estimates of a client's functional levels, and also in referrals that seek to identify treatment targets for rehabilitation efforts.

The neuropsychological approach to assessment, in the psychological tradition, usually integrates results on tests that have been well standardized and carefully characterized in terms of reliability and validity. Such measures can be useful for tracking the effects of disease progression, as well as any beneficial effects of rehabilitation programs or treatment of underlying brain abnormalities. In addition, by delineating an individual's cognitive deficits, as well as strengths, neuropsychologists aim to understand how these might impact functioning in day-to-day life. Such determinations are also an important component of some diagnostic criteria (e.g., interferes with independence; major neurocognitive disorder).

Even though the questions being asked of neuropsychologists have shifted, neuropsychologists continue to use traditional tests (e.g., Wisconsin Card Sorting Test) originally designed to address issues of lesion localization and clinical diagnosis rather than predict how an individual with a particular injury or cognitive decline might function in everyday life (Chaytor & Schmitter-Edgecombe, 2003; Rabin, Paolillo, & Barr, 2016). In addition, tests that were not originally designed to be used as clinical measures, such as the Stroop Color–Word Interference Test and Tower of London, later found their way into the clinical realm (Burgess et al., 2006). These instruments have been used to help predict difficulties with everyday functioning, primarily based on the assumption that they assess functions/constructs that are important to carrying out real-world activities. For example, regarding the Stroop, one might hypothesize that the ability to inhibit an automatic, overlearned response would, at times, be beneficial to the safe driving of an automobile, such as being able to withhold a reflex to press the brakes if a traffic light turns red when the driver is halfway through the intersection.

The approach of predicting everyday functioning using neuropsychological measures designed for other purposes has been questioned because it is not always clear how performance on basic abilities translates to behavior within the varying environments found in the real world (Goldstein, 1996). Further, multiple interacting factors (e.g., emotional, environmental) can impact the relationship between functional and neurocognitive deficits and real-world outcomes. In this chapter we review key issues in the assessment of everyday functioning, including factors that complicate the relationship between performance on laboratory tests and real-world performance. In addition, we briefly summarize the literature on the use of different types of neuropsychological measures to predict real-world performance. We limit our discussion regarding specific neuropsychological predictors and outcomes, as this aspect is covered in other chapters throughout this book.

Ecological Validity

Originally coined by Brunswik (1955), the term *ecological validity* refers to whether the findings obtained within a controlled experiment or environment can be generalized to what we see in the real world, where the organism/person exhibits “free behavior in the open environment” (Franzen, 2000, p. 47). In the context of neuropsychology, Sbordone (1996) defined ecological validity as the “functional and predictive relationship between the patient’s performance on a set of neuropsychological tests and the patient’s behavior in a variety of real-world settings” (p. 15). Although the term *real world* has been criticized as being nonspecific (Rogers, 2008) and as suggesting that behavior in the lab does not count as “real-world” behavior (Goldstein, 1996), we find the term useful to indicate the environment outside the confines of the laboratory/clinic.

Veridicality and *verisimilitude* are two general approaches to ecological validity, as described by Franzen and Wilhelm (1996). Veridicality is “the extent to which test results reflect or can predict phenomena in the open environment” (p. 93). This usually involves using neuropsychological measures or combinations of measures to predict real-world performance (e.g., employment status). Verisimilitude refers to the “the topographical similarity of the data collection method to a task in the free environment” (Franzen, 2000, p. 47). In other words, the test resembles a task people perform in everyday life and is developed considering the theoretical relationship between the demands of the test procedures and the behavior that is being predicted. Because the tests more closely approximate everyday tasks, the inferential leap from test performance to real-world performance can be made more easily (Spooner & Pachana, 2006). Most traditional neuropsychological measures fall into the category of veridicality because they do not directly measure everyday behaviors but do assess some basic requirements of such behaviors; therefore, they may predict functioning outside of the laboratory.

Examples of standardized neuropsychological tests developed with greater verisimilitude include the Rivermead Behavioral Memory Test (Wilson, Cockburn, & Baddeley, 1985; now in its third edition), the Behavioral Assessment of the Dysexecutive Syndrome (Wilson, Alderman, Burgess, Emslie, & Evans, 1996), and the Test of Everyday Attention (Robertson, Ward, Ridgeway, & Nimmo-Smith, 1996; there is also a children's version). Such instruments typically include multiple subtasks that more closely resemble the activities individuals would be expected to undertake in everyday life (e.g., remembering names associated with faces, recalling a hidden object and its location, searching maps, listening to broadcasts of lottery numbers, preparing a letter for mailing, managing medications), with the hope of better predicting real-world functioning. Many of these "performance-based" measures are designed to assess functional capacity—that is, the person's ability to perform tasks under optimal circumstances. The focus is not on differentiating normal and patient groups per se, but on "identifying people who have difficulty performing real-world tasks, regardless of the etiology of the problem" (Chaytor & Schmitter-Edgecombe, 2003, p. 182). Therefore, in theory, these tests should be applicable to many different patient groups and, in some cases, people with normal cognition. Such tests are also often well accepted by patients/participants, given their strong face validity.

Many of the more recent tasks developed with a focus on verisimilitude are leveraging technologies, including computers and the internet. Virtual reality assessment involves administering tasks, in either an immersive (e.g., three-dimensional world via user-worn equipment) or nonimmersive (two-dimensional) environment, that simulate activities that people complete in the real world, such as preparing a cup of coffee (e.g., Virtual Kitchen; Allain et al., 2014) or shopping for grocery items (Virtual Reality Functional Capacity Assessment Tool; Keefe et al., 2016). Other performance-based tasks have been designed to evaluate everyday technology use skills such as filling a prescription by phone (Marshall et al., 2015), performing banking transactions (Woods et al., 2017), or purchasing airline tickets online (e.g., internet-based actual reality; Goverover, O'Brien, Moore, & De Luca, 2010). Although creating tests with verisimilitude continues to be a popular approach, a test based on verisimilitude is not necessarily ecologically valid (Chaytor & Schmitter-Edgecombe, 2003), and such tests need to be validated with respect to their true, real-world counterparts (Rabin, Burton, & Barr, 2007). As an example, in recent work, Ziemnik and Suchy (2019) found that a motor-sequencing task outperformed a laboratory Pillbox Test (high verisimilitude) in classifying participants according to the accuracy of their real-world medication management (weekly pill counts) and in accounting for variance in medication management. Another consideration is the potential trade-off between developing tools with highly specific verisimilitude, in that they closely match a specific task within a specific environment, versus tools with a range of tasks that have greater generalizability to "real-world" situations (e.g., planning routes to different kinds of environments, managing finances in different situations).

Defining "Everyday Functioning" Outcomes

One of the challenges in relating neuropsychological performance to real-world functioning is the lack of agreed-upon best methods for determining impairments in everyday abilities. Should we simply ask patients how they are doing in their daily lives? Should we require documentation of their daily performance, something that is often difficult to come by, if not entirely nonexistent? How about asking a third party who may be prone to bias (positive or negative) and only witness the patient performing tasks under specific circumstances? Or is it best to try to objectively measure the patient's ability to carry out an everyday task (i.e., performance-based task), even though this test would be conducted in a controlled environment and perhaps have limited real-world applicability? Can newer smart environment and wearable technologies be used to capture continuous and in-the-moment performance data and provide meaningful information about real-world abilities?

As noted by Goldstein (1996), "tests or predictors and outcome measures or criteria are both surrogates for actual abilities and behaviors" (p. 84). There is a tendency in the literature to accept various outcome measures as being closely related to real-world functioning, but we must pay as much attention to the outcome, how it is measured, and its relationship to actual real-world tasks/functioning as to the predictors themselves. For example, is slowing on a task in which the individual is required to press a brake pedal when a stimulus on a computer screen changes color evidence of a reduction in "driving ability"? In addition, methods used to assess everyday functioning may at times be used to predict real-world performances and at other times serve as a proxy for real-world performance. For example, some studies have investigated the incremental validity of performance-based tests to predict functional outcome (assessed by self- or informant report) over and above traditional neurocognitive tests (e.g., Robertson, Schmitte-Edgecombe, Weeks, & Pimentel, 2018). In contrast, other studies have examined how well differing cognitive domains predict functional capacity defined by scores on performance-based measures (e.g., Burton, Strauss, Bunce, Hunter, & Hultsch, 2009). Moreover, studies that have directly compared differing functional outcome measures (e.g., self-report, performance-based) have found that these measures do not always correlate highly and can provide differing estimates in their rating of functional ability (e.g., Burton et al., 2009).

The use of outcome measures is addressed in various chapters in this volume; here we touch upon them briefly since they are critical in understanding the relationship, or lack thereof, between performance on neuropsychological measures and "real-world" outcomes.

Self-Report

Directly asking patients/participants how they are functioning in the world is the most relied-upon method for assessing real-world outcomes; in many cases it is the most practical method, given its lower time and cost compared to lengthier objective measures. Self-report may also give a reasonably accurate representation of real-world performance, given that functional abilities can fluctuate across varied environmental situations (Sikkes, de Lange-de Klerk, Pijnenburg, Scheltens, & Uitdehaag, 2009). Self-report is also advantageous because it provides important information regarding an individual's perception of their status, even if it lacks external validity in some cases.

Self-report measures, however, often have a less clear relationship to formal testing than reports from informants or clinical ratings, particularly in neurological populations that may lack insight into their difficulties (Miller, Brown, Mitchell, & Williamson, 2013). In individuals who are cognitively healthy or have mild cognitive difficulties, self-report may be more useful as some types of errors (e.g., self-corrections) or methods of compensation (e.g., more double checking) may not be readily observable by informants. Self-report is also susceptible to biases based on the individual's mood and cognitive status. For example, depressed individuals tend to manifest negative self-judgments across multiple domains and may underestimate their true abilities (see Chapter 20). On the other hand, individuals with impairments in metacognition and self-awareness may be prone to over-confidence in their real-world abilities (e.g., Chiao et al., 2013). In addition, patients may not always accurately identify the likely sources of reductions in functioning, such as attributing declines to physical causes, when they may actually be due to cognitive issues (Obermeit et al., 2017). Other factors, such as litigation and the possibility of secondary gain, may also influence self-report.

Significant Others (Collateral/Proxy)

Another common approach to assessing real-world outcomes is to ask for input from an informant, such as a spouse or caregiver. Such persons may be in a position to give the most accurate reports of how the patient handles everyday activities across multiple environmental contexts, but there are limitations to this approach. The informant may be biased by factors such as caregiver burden or executive dysfunction, may not know the patient well, or may see the person only in situations in which his or her functioning is maximized (or minimized; e.g., Dassel & Schmitt, 2008; Morrell, Camic, & Genis, 2019). Caregivers may be particularly influenced by certain obvious deficits; for example, evaluation of memory difficulties may be more influenced by word-finding difficulties than actual memory deficits (Cahn-Weiner, Ready, & Malloy, 2003). Questionnaire methods can also be impacted by how the rater interprets questions, which might differ based on factors such as level of education, culture, and language (Azar et al., 2017). And, of course, the patient and caregiver may disagree regarding each other's assessments, perhaps making it difficult to determine which view is more accurate, and so clinical judgment must be applied.

Ratings by Clinicians

Clinician ratings are often used as an outcome measure. Examples include the Global Assessment of Functioning, Karnofsky Performance Status Scale, and the Clinical Dementia Rating Scale. A key disadvantage to this approach is that clinicians have only what they see before them in the clinic—a snapshot of the person's functional level. Moreover, clinicians are also subject to biases and often place significant emphasis on input from the patient and/or caregiver. Some studies have found that the clinician's judgment more closely matches performance on neuropsychological tests than the caregiver's reports (Zaidi, Kat, & de Jonghe, 2014), possibly because the neuropsychological and clinical evaluations occur in the same structured environment. Importantly, although the approaches may lead to common conclusions, they still may not reflect real-world performance as closely as reports of an observer in the everyday living environment.

Performance-Based Tests

Performance-based tests range from analog tasks like tying shoes and filling medication dispensers to digital activities such as filling prescriptions online (Czaja, Sharit, Hernandez, Nair, & Loewenstein, 2010) and evaluating online health records (Woods et al., 2016), to simulations of automobile driving (Marcotte et al., 2004). An advantage of these tests over the use of raters is their objective and standardized nature, which allows for clear comparisons of measured functional capacity across individuals and over time. Although most performance-based tests are administered within the clinic or laboratory, some are administered within a naturalistic environment (e.g., Baycrest Multiple Errands Test; Dawson et al., 2009) or in the home (e.g., Assessment of Motor and Process Skills; Fisher, 2003). Performance-based tests can be both time and resource intensive. Performance-based measures also differ on other dimensions, including the population targeted by the test (e.g., mild cognitive impairment, dementia), the domain or domains of function targeted by the measure (e.g., medications, financial etc.), information available about the psychometric properties of the test (e.g., reliability, validity), administration procedures (e.g., open-ended, specific), and scoring procedures (e.g., accuracy, time, error types; Schmitter-Edgecombe & Giovannetti, forthcoming).

Currently, no single performance-based measure has been widely adopted in the literature, likely because of the lack of clarity regarding the ecological validity of performance-based tests. Performance-based tests are typically administered in an environment that is devoid of everyday environmental cues and the ability to engage with typical compensatory strategies. Furthermore, performance-based tasks (e.g., write a check) may not reflect the way an individual completes the task in the real-world environment (e.g., online bill pay). As noted earlier, one of the biggest challenges for performance-based test validation and development is the identification of a gold standard against which to evaluate ecological validity.

Manifest Functioning

Another approach is to seek external documentation of real-world deficits, such as examining employment history, official driving records, or medical records (e.g., for medication adherence measurements). This approach better reflects how people function in their everyday lives and perhaps provides insights regarding whether, due to noncognitive factors, individuals perform better (e.g., using compensatory strategies) or worse (e.g., due to environmental limitations such as distractors) than one would expect, based on their functional capacities as assessed in the laboratory. This approach, however, also can be prone to error. For example, employability or even employment status can be influenced by factors other than capacity (mood disorders, environmental factors such as reduced opportunities, reluctance to give up disability income support, etc.). And in the case of driving ability, crashes are rare, often only reported to authorities in more severe cases and may be related to many external factors (e.g., other drivers, road conditions). Crash history can also be influenced by risk exposure (i.e., driving mileage, urban vs. rural driving, traffic conditions) and may thus not provide an accurate reflection of a person's true driving ability (Janke, 1991).

Actual everyday functioning can be assessed at the "molar" level (e.g., is the individual employed vs. unemployed?) or at a more granular level (e.g., is the individual as effective at his or her job as in the past? Sawamura, Ikoma, Ogawa, & Sakai, 2018; Baughman, Basso, Sinclair, Combs, & Roper, 2015). It appears that composite global cognitive test measures often best predict molar outcomes, perhaps because both types of variables encompass a broad range of abilities (Franzen & Wilhelm, 1996).

Multimodal Approaches

Multimodal approaches that integrate self-report questionnaires, informant-rated measures, performance-based tasks, and objective indicators (e.g., unemployment,) provide another lens to assess global everyday functioning. Such approaches have the potential to increase sensitivity as they allow the clinician to overcome the limitations associated with any one approach (Blackstone et al., 2013; Doyle et al., 2013). These multimodal approaches might provide a more robust assessment of everyday functioning, but the risk of Type I error warrants consideration. To some extent, a multimodal assessment of everyday functioning is utilized in clinical contexts; however, greater empirical attention to standardize their use and maximize their clinical utility is needed.

Technology-Enabled Real-World Assessments

Arguably, the most valid determination of "real-world" outcomes would be direct observation of the person in the real world. Ideally, this observation would occur unobtrusively, without the person's awareness, since the act of being observed can change behavior. The maturing of sensor design, pervasive computing, and machine learning has contributed to new methods for unobtrusively monitoring performances in the real-world environment, both continuously or through the use of in-the-moment assessment. Rather than capturing functional ability under optimized laboratory conditions, the use of sensors in the environment (e.g., home, car), on the person (e.g., smartwatch), and/or on equipment the person uses (e.g., car, phone) can improve understanding of functional abilities across interacting person (e.g., mobility, mood) and environmental (e.g., noise level, time of day) factors, as well as capture variability in performances.

Current sensor technologies differ on a number of dimensions, including the requirements involved in monitoring (e.g., normal routine, charge a battery, respond to questions), types of sensors (e.g., ambient, mobile), and types of data collected by the sensors (e.g., activity level, location, voice, cognition). A few examples of functional behaviors that have been monitored in the real-world environment with sensors include pill box use, vehicle driving behavior, time spent out of the home, overall activity level in the home, and sleep interruptions (e.g., Cook, Schmitter-Edgecombe, Jonsson, & Morant, 2019; Rawtaer et al., 2020). Research also supports the feasibility of using these technologies and machine learning methods with neurologically impaired individuals to capture everyday behaviors and predict function (e.g., Alberdi, Weakley, Goenaga, Schmitter-Edgecombe, & Cook, 2018; Seelye et al., 2017); however, these methods are still in their infancy (see Chapter 10). Psychometric work will be necessary to establish that developed measures are reliable and valid and add value to traditional assessment. Other challenges include usability issues, costs, privacy and security concerns, confidentiality, and challenges associated with analyzing and interpreting large amounts of data. Despite these challenges, these technological advances do represent exciting new options for observing how patients with neurological conditions truly behave in the open environment. (These advances are discussed in more detail in Chapters 9–12 of this book.)

Examples Relating Neuropsychological Performance and Everyday Functioning

A recurring question in the field is whether tests originally developed for the detection and localization of brain pathology can predict real-world functioning (Heaton & Pendleton, 1981). Because of the importance of this question, a considerable amount of research has used traditional neuropsychological tests to predict outcomes such as academic performance, financial management, medication management, and automobile driving. Meta-analyses have also explored the relationship between cognition and functional status, with functional outcome represented by questionnaire and performance-based tests assessing activities of daily living (e.g., Royall et al., 2007). Despite the fact that investigators have used a large variety of neuropsychological tests, ranging from a select number of measures to comprehensive batteries, together with varying operational definitions of functional outcomes, it is clear that basic cognitive functioning (measured via neuropsychological tests) *is* related to one's ability to carry out such real-world tasks. The strength of this relationship can best be characterized as "moderate." Meta-analyses conducted with a variety of populations (e.g., MCI, mixed sample, bipolar disorder) consistently suggest that cognition accounts on average for a modest 21–27% of the total variance in everyday function as assessed by questionnaire and performance-based measures (Depp et al., 2012; McAlister, Schmitter-Edgecombe, & Lamb, 2016; Royall et al., 2007). Similarly, a review article using quality-of-job performance as the outcome concluded that cognitive ability predicted from 4 to 30% of the variance (Sternberg, Grigorenko, & Bundy, 2001). In general, the strength of the relationship between cognition and function varies widely across studies (e.g., 0–80%; Royall et al., 2007), with numerous factors influencing findings, including variables being accounted for (e.g., demographics and global cognitive status), the neuropsychological tests used as predictors, the methods used to measure functional outcome (Schmitter-Edgecombe & Farias, 2018), and the population being studied. Specific examples of this type of research are provided throughout this volume.

As yet, there is no clear answer as to which neuropsychological tests are most predictive of the many components of real-world functioning, even when we narrow the question down to specific real-world tasks and neurological disorders. Using driving as an example, we find that as with most studies addressing everyday functioning, attempts to summarize the field of driving research are complicated by the variety of populations sampled and methods used across studies. Researchers have used divergent test batteries and different gold standards regarding "driving impairment" (Molnar, Marshall, Man-Son-Hing, & Wilson, 2006; Reger et al., 2004; Withaar, Brouwer, & van Zomeren, 2000). For example, driving impairments have been determined via on-road drives, performance on driving simulators, and reviews of real-world crash or moving violation history. Even though several studies have shown "modest" results in using specific neuropsychological tests to predict driving ability, note that in most cases these studies do not yield cutpoints that can guide the clinician in determining fitness to drive for an individual person. In addition, many factors beyond neuropsychological ability can affect driving performance, including motivation, personality, driving experience, use of medications and other substances with CNS effects, and road conditions (Marcotte & Scott, 2009).

We can have the most confidence in the very general statement that global cognitive impairment is associated with worse performance on everyday functioning measures. Neuropsychologically, overall impairment levels can often be best estimated using summary scores such as the Average Impairment Rating from the Halstead–Reitan Battery, or a Global Deficit Score calculated from a reasonably comprehensive battery (Carey et al., 2004; Heaton, Taylor, et al., 2004). At the domain-specific level, findings from several meta-analyses suggest that executive measures may be the strongest and most consistent predictors of everyday functioning (e.g., Royall et al., 2007; McAlister et al., 2016), in concurrence with the notion that complex measures are more likely to correlate with the complex aspects of real-world functioning (Chaytor & Schmitter-Edgecombe, 2003). Thus, it has been argued that future research should specifically focus on executive functioning as a predictor of real-world performance (e.g., Cahn-Weiner et al., 2003). In addition, learning/memory abilities have also been implicated in predicting real-world behavioral functioning (Heaton, Marcotte, et al., 2004; Van Gorp et al., 2007). But these conclusions are by no means universally true. The utility of specific measures, and even specific cognitive domains, will depend on the pattern of deficits and everyday requirements prevalent in the population being considered.

Factors Further Complicating the Relationship between Neuropsychological Performance and Everyday Functioning

As one considers everyday functioning, a distinction needs to be made between an individual's capacity to perform a task and the actual execution of that capacity. Goldstein (1996) refers to this distinction as the difference between *ability*—a skill or talent within the individual, which is assessable via neuropsychological testing—and *function*—the exercise of that ability in an environmental context (a distinction between what a person *can do* and what (s)he *does do*). A person develops an *impairment* in ability (e.g., attention), which may then lead to *functional deficits* or *disability* (e.g., in driving an automobile). Clinic-based tests typically focus on capacity/ability, whereas in predicting real-world behavior, in addition to understanding what the person is capable of doing, we are also concerned with what the person actually *does*. In order to understand the limitations in using laboratory measures to predict real-world functioning, it is also important to remain cognizant that the person being evaluated must function within a changing environment and under varying contexts (Tupper & Cicerone, 1990), which can make success in the activity more or less likely. The same ability deficit can change from having no effect in nondemanding everyday situations to disabling if the requirements of a person's everyday life increase. Unlike the laboratory testing situation, everyday functioning is not standardized across people and time.

Importantly, even though cognitive abilities are an important determinant of functional capacities, real-world functioning is determined by multiple factors. We have already discussed some of the challenges associated with defining everyday outcomes, including the fact that we currently have no gold standard measure against which we can evaluate clinic-based functional outcome measures to demonstrate that these measures are related to what a person actually does in the real-world environment. As Bilder and

Reise (2019) recently reported, we may need new validation methods in order to best demonstrate associations between real-world outcomes and clinic-based measures. In the following section, we briefly review other factors that can complicate the relationship between test performance and real-world functioning.

Testing Environment

Neuropsychological assessment typically emphasizes the elicitation of "optimal performance" from an individual in order to determine the person's underlying capacity (Lezak, Howieson, & Loring, 2004). By design, external factors (e.g., noise, distracting stimuli), task complexity (e.g., multitasking), and task length (many tests are relatively brief) are kept to a minimum. Even the newer ecologically oriented instruments (Schmitter-Edgecombe et al., 2020; Woods et al., 2017), which may require completion of a variety of ill-structured tasks, are often designed to be carried out within a clinic setting where distractions are minimized. In contrast, in the real world, tasks are typically undertaken in environments where there are variable distractions, no direction, multiple decision pathways, and limited encouragement.

Limited Sampling of Behavior

Neuropsychological testing provides only a brief snapshot of behavior (Chaytor & Schmitter-Edgecombe, 2003), whereas real-world tasks can take place over a long time period. A client may be able to rally resources for a brief testing period but have difficulty when that time is extended, perhaps due to problems with stamina and fatigue (Chaytor & Schmitter-Edgecombe, 2003), limited attentional capacity, or limited ability to exert cognitive control when faced with fluctuating state-dependent factors (e.g., stress, lack of sleep) that can impact compensatory cognitive resources in real-world situations (Small, Jim, Eisel, Jacobsen, & Scott, 2019). Further, some performance-based functional outcome measures exclusively sample one specific functional domain (e.g., medication management, financial capacity) or cognitive process (e.g., multitasking), which limits generalizability given the wide range of activities people carry out within the everyday environment. Similarly, questionnaires may have limited sensitivity to capture more subtle aspects of functional deficits by sampling for broad responses (e.g., independent, needs some help, dependent) or including only one overarching question about a functional domain (e.g., shopping).

Specificity of the Neuropsychological Test

Neuropsychological tests are often cited as measures of specific cognitive constructs. Yet identification of these constructs can vary from author to author, adding to the difficulty in consistently identifying cognitive domains that are critical to real-world functioning. For example, the Trail Making Test Part B (TMT B; Army Individual Test Battery, 1944; Reitan & Davidson, 1974) is often considered one of the measures most sensitive to brain dysfunction. In a recent meta-analysis conducted regarding individuals with mild cognitive impairment (MCI), TMT B emerged as the test most predictive of everyday functioning as measured by questionnaire and performance-based measures (McAlister et al., 2016). In the literature, TMT B has been referred to as a measure of "complex visual scanning," "speed of executive functioning," "cognitive flexibility," "visual–perceptual processing speed," and "set switching ability" (Gunstad et al., 2008; Kennedy, Clement, & Curtiss, 2003; Lezak et al., 2004; Schwab et al., 2008; Wobrock et al., 2007). The truth, of course, is that it has aspects of all of these constructs and receives a label of "X" due to the specific factor analysis that was conducted, the other measures included in the analyses, the subject group (e.g., patients with different clusters of impairments), or the author's own interpretation of the measure.

Domains of Cognition Being Assessed

Also adding to the difficulty of identifying cognitive domains that are critical to real-world functioning, most prior work has focused on traditionally assessed cognitive domains, including episodic content memory, executive functions, attention, speeded processing, language, visuospatial abilities, and general cognitive status. An accumulating body of work (e.g., Bettcher, Giovannetti, Macmullen, & Libon, 2008; Schmitter-Edgecombe, Woo, & Greeley, 2009; Schmitter-Edgecombe et al., 2011; Woods, Weinborn, Velnoweth, Rooney, & Bucks, 2012) indicates that cognitive constructs such as prospective memory, temporal order memory, and error monitoring play important roles in supporting accurate performance of many everyday activities, including remembering to take medication or sequencing events when cooking. Research also indicates that these cognitive constructs account for incremental variance in predicting everyday functioning over and above traditional neuropsychological tasks (e.g., Schmitter-Edgecombe et al., 2009). Therefore, determining the relationship between cognition and real-world task performance will likely involve considering cognitive abilities outside of those typically assessed in neuropsychological evaluations, although assessing such abilities often presents with their own challenges (e.g., evaluating prospective memory over extended time periods).

Multiple Cognitive Determinants of Real-World Functioning

As noted earlier in this chapter, most everyday tasks involve multiple cognitive processes, including tasks that may appear simple, such as making toast (Hart, Giovannetti, Montgomery, & Schwartz, 1998; Giovannetti, Schwartz, & Buxbaum, 2007). Even a simple task (e.g., making coffee) may involve different abilities based on an individual's prior experience or inexperience with the general task or the specific coffeemaker. Thus, determining the relationship between a cognitive ability and performance of a real-world task depends not only on how important the specific ability is to the task, but also the person's degree of impairment in that ability. Some activities may have a threshold whereby significant impairment in a single domain, even if it is not considered critical to the task, can impact the ability to carry out the task. For example, attention and basic arithmetic skills may be key to managing a checkbook, but severe visuospatial or memory impairments may outweigh the relevance of the intact domains.

Environmental Factors and Resources

The ability to carry out everyday functions can be significantly impacted by the environment. For example, being able to safely drive an automobile may differ depending on whether a person is alone in the car, using a cell phone, or transporting a group of middle schoolers. Environmental factors differ between individuals and for a single individual from moment to moment: During the course of a commute, an individual may drive on both a rural roadway and a congested city street, and weather-related driving conditions may change. A person's work environment may also determine if cognitive declines impact vocational functioning: Mild declines may be very evident in a highly demanding or changing work environment, and less so when the responsibilities are more routine and not as challenging (Chaytor & Schmitter-Edgecombe, 2003). Environmental factors can be beneficial as well as detrimental. The availability of resources and support systems, such as electronic reminders or individuals who can guide the person through specific tasks and provide moral/emotional support, may help a person to be more successful in the real world than suggested by a laboratory assessment of functional capacity. Unfortunately, as important as it is to assess environmental demands for each person, few studies incorporate such evaluations in a standardized manner.

Compensatory Strategies

Because clinic/laboratory assessments are typically highly structured and assess only a limited number of abilities, these evaluations may at times underestimate an individual's capacity to perform in the open environment by not providing opportunities to implement compensatory strategies (Franzen & Wilhelm, 1996). Individuals may have learned strategies such as monitoring tasks using a to-do list or setting an alarm as a medication reminder. Thus, they may function adequately in their daily life but do poorly on a clinic-based prospective memory task if they cannot implement their typical strategies. In a recent study that coded for the use of observed real-world compensatory strategies, after accounting for general cognition and proxy measures of functional ability (i.e., questionnaires, performance-based tests), use of compensation accounted for incremental variance in predicting completion of an everyday prospective memory task (Weakley, Weakley, & Schmitter-Edgecombe, 2019). On the other hand, individuals may make a concerted effort to strategize during a testing session but not do so in everyday life. For example, a person might use semantic clustering to remember items on a memory test, but not use such a strategy when trying to remember a shopping list (Chaytor & Schmitter-Edgecombe, 2003). In addition to providing information regarding an individual's deficits, neuropsychological testing can provide valuable information regarding a person's cognitive strengths, which may also suggest ways that he or she could potentially compensate for deficits. This is one reason why neuropsychologists should always consider assessing multiple domains, and not just those in which they hypothesize likely impairment (Heaton & Marcotte, 2000). Questionnaires to assess compensatory behaviors are in development (e.g., Farias et al., 2020).

Individualized Approaches to Problem Solving

Even neurologically normal individuals approach the same task differently (Chaytor & Schmitter-Edgecombe, 2003). For example, some people may spend a great deal of time ineffectively "organizing" their to-do lists, whereas others may focus on completing the tasks that are in front of them. Others may routinely and effectively use shopping lists or map out a driving route ahead of time. These idiosyncratic approaches to everyday life complicate the prediction of real-world performance; in some cases, a well-developed "list-making" approach may help individuals should they suffer a decline in functional capacity in the future.

Physical Impairments and Health Comorbidities

Physical impairments can affect both activities of daily living (ADLs) and instrumental activities of daily living (IADLs) and should be considered in many neuropsychological or functional evaluations. The impact of physical impairments is evident in many neurological conditions (e.g., stroke, traumatic brain injury, multiple sclerosis) and across many real-world tasks (e.g., driving and vocational functioning). A recent study found that although general capability to complete IADLs as measured by multiple methods (i.e., self-reported, informant-reported, performance-based, and direct observation) was similar across groups with MCI and Parkinson's disease, the nature of the error profiles, completion time, and cognitive correlates differed as a result of cognitive and motor difficulties (Schmitter-Edgecombe, McAlister, & Greeley, 2021). Furthermore, greater IADL limitations have been found in individuals with higher levels of physical inactivity, two or more chronic diseases, obesity, and those with frail status (Portela et al., 2020), highlighting the importance of considering health comorbidities.

Neuropsychiatric Symptoms, Psychiatric Disorders, and Substance Use Disorders

Neuropsychiatric symptoms and conditions, such as depression and apathy (Rog et al., 2014), schizophrenia (Green, Kern, & Heaton, 2004), and bipolar disorder (Martinez-Aran et al., 2007), can significantly affect a person's ability to initiate and complete ADLs and impact the reliability of self-reported functioning (Heaton, Marcotte, et al., 2004). Depression in particular is a prevalent condition that can affect everyday functioning (see Chapter 20). Although medications for these conditions often improve functioning, they can potentially have negative effects as well (e.g., on automobile driving). Acute and chronic substance use can also affect key everyday activities such as employment, financial management, and driving ability (e.g., Hser, Huang, Chou, & Anglin, 2007; Johansson, Alho, Kiiskinen, & Poikolainen, 2007), although the literature using objective measures of functional capacity in these groups is limited (Morgan et al., 2014).

Culture, Race, and Ethnicity

People differ in their daily activities and their methods of engagement (e.g., driving versus taking public transportation, using cash versus all-electronic methods for handling finances). Such differences can be found at both the individual level and within larger groups based on factors such as culture, race, and ethnicity. These differences are apparent within the United States as well as internationally (e.g., Labra Pérez & Menor, 2018). Such differences make it difficult to simply adapt functional assessment methods validated primarily within English-speaking subgroups in the Western world to other populations. As noted in several chapters of the present volume, especially Chapter 5, this complicates attempts to characterize changes in everyday functioning in a single, universal matter; it also requires in-depth understanding of such differences and creativity in determining the best way to assess functioning within various groups and societies. This is particularly true when developing instruments emphasizing verisimilitude. In addition, though, the relationships between cognitive and functional measures have frequently not been appropriately validated for individuals of diverse ethnic backgrounds, limiting the inferences that can be drawn from a veridicality approach. Lastly, differences in the prevalence of various health conditions across racial and ethnic groups further impacts our understanding of the relationship between cognition and function. This remains an area in need of much further research.

Education and Literacy

Although educational levels and neuropsychological test performance clearly travel together on many tests, and IQ is closely linked to educational and ultimately job attainment, little attention has been paid to the direct relationship between education and the ability to carry out everyday tasks. At lower levels of education, in particular, literacy (numeracy, reading and writing) may be an issue. Many resource-limited countries have high illiteracy rates. Inadequate numeracy ("the ability to understand and use numbers in daily life") may adversely impact health outcomes and everyday functioning in tasks such as reading food labels, interpreting bus schedules, and refilling prescriptions (Rothman, Montori, Cherrington, & Pignone, 2008, p. 585). However, education and literacy are not completely synonymous, as individuals learn many life skills (e.g., how to count money) without formal education.

Experience/Functional Reserve

It is generally accepted that certain individuals, typically those with higher IQs, educational level, and/or occupational attainment, may be able to withstand greater brain insults before such damage manifests itself clinically (Satz, 1993; Stern, 2003), suggesting cognitive resilience (Stern, Barnes, Grady, Jones, & Raz, 2019). It has been hypothesized that individuals may have a "cognitive reserve" based on innate levels or, alternatively, that such a reserve is expanded by exposure to schooling and other stimulating activities. For most individuals, repeated exposure increases the "automaticity" with which tasks can be completed, enhances their expertise, and perhaps increases reserve. One example of an everyday activity modifying brain structure can be found in a study of London taxi drivers. In this project, the more time the participant spent as a driver, the larger the hippocampal volumes (Maguire et al., 2000), suggesting the possibility of increased reserve. One might hypothesize that more experienced individuals can suffer more brain abnormality prior to reaching a point where they no longer work at a minimally competent level.

Motivation

Clients may be motivated to do their best during testing but perhaps have less motivation in the real world, or vice versa. For example, they may be able to avoid undesirable tasks at home if they feign an inability to do the tasks. In the example of forensic cases, clients may see benefits in not performing their best during an evaluation in order to get increased compensation. Even in nonlitigation cases, clients may simply lack the motivation to try their best across a battery of neuropsychological or everyday functioning tests. These motivational issues suggest a need for skilled examiners, conversant with such problems, even when computerized measures are being administered. A number of instruments assess "effort," symptom validity, and malingering in the clinic/lab (e.g., Morgan & Sweet, 2008).

Given the many factors that might affect everyday functioning, it is not surprising that, as with most behavioral research, measures of cognitive status alone remain only "moderately" related to real-world performance. Improving assessment in the areas mentioned earlier might enhance laboratory predictions of behavior in the open environment. As an example, the Royal Prince Alfred Prospective Memory Test (RPA-ProMem; Radford, Lah, Say, & Miller, 2011) allows participants to use any strategies they think might help them remember to complete future tasks (e.g., phone and leave a message after they arrive home). Casaletto, Weber, Iudicello, and Woods (2017) proposed a comprehensive assessment model that includes as interacting factors the overlap between the individual's pattern of deficits and the particular demands of the real-world task, motivation, awareness of cognitive and functional deficits, as well as the availability, effectiveness, and use of compensatory strategies, and the presence and influence of biopsychosocial cofactors. The model accounts for dynamic changes in one area that can impact other areas of functioning as well as reciprocal relationships (e.g., real-world declines negatively impact cognitive functioning, which in turn may exacerbate disability). This conceptualization can guide ongoing efforts by investigators to develop new measures that have a strong neuropsychological bent but focus on cognitive constructs specifically hypothesized to relate to real-world performance—measures designed to assess more directly the abilities needed to carry out everyday tasks.

Selection of Neuropsychological Test Variables

Is a common, underlying set of cognitive abilities necessary in order to adequately perform all everyday activities? Alternatively, is it the case that some key abilities (e.g., attention) are necessary, but perhaps not sufficient, to carry out many tasks, and that specific activities require specific skill sets? Can we predict human behavior by examining performance on cognitive constructs individually and in isolation, or do we need to know how they work in concert? Although these questions remain unanswered, or incompletely answered, practicing neuropsychologists appear to be in general agreement regarding the key abilities that should be assessed when predicting everyday functioning. These include attention, executive functions, intelligence, language, motor skills, verbal and nonverbal (visual) memory, construction, and visuospatial skills. Nevertheless, there remains significant variability with respect to which tests are used to assess these domains (Rabin et al., 2007, 2016), and which normative standards might be most appropriate.

When predicting everyday functioning, most neuropsychologists use traditional neuropsychological tests along with structured interviews/questionnaires and may augment their battery with one or more ecologically oriented measures. A survey of 512 doctorate-level psychologists (Rabin, 2016) revealed that none of the 15 most frequently endorsed assessment instruments were developed primarily with ecological validity in mind. Similarly, across specific cognitive testing domains (e.g., memory, executive functioning), tests developed with high ecological validity in mind (e.g., Brief Test of Attention) were endorsed as being administered by only a small percentage of respondents

(< 8%). Moreover, the most frequently used method for assessing activities of daily living was a structured interview (Rabin, 2016).

Neuropsychological tests can yield a number of performance variables: raw scores, scaled scores, and demographically adjusted scores. To determine whether there has been a decline in functioning, the examiner needs to know the patient's premorbid functional level. However, neuropsychological testing is rarely available for the period prior to an insult (e.g., head injury) or illness. A variety of methods have been developed to estimate prior functioning, including measures based on educational and occupational attainment, as well as performance on tests that are relatively insensitive to acquired brain abnormalities (e.g., Holdnack, Schoenberg, Lange, & Iverson, 2013; Pearson Clinical, 2017). Neuropsychological performance tends to correlate with characteristics such as age, education, gender, and ethnicity (Heaton, Taylor, et al., 2004; Heaton, Miller, et al., 2004), and the use of norms that adjust for these factors are particularly helpful in estimating differences between observed and expected levels of performance.

Although the method of using demographically adjusted normative standards works well for determining whether individuals are impaired relative to expected levels, the use of adjusted scores may not be the best method for predicting performance of activities that most of the population should be able to accomplish routinely. For example, although we might expect a person with a PhD in engineering to perform better on cognitive tests than an individual with a high school education, we would not necessarily expect that person to be a better driver or more adept at managing his or her medications.

When addressing the relationship between cognition and everyday functioning, we are not so much concerned with whether someone has declined from a previous level of neurocognitive performance, but rather whether his or her functioning is adequate for their individual everyday functioning requirements *now*. One approach to predicting competence in everyday skills would be to simply consider raw scores, such as time to complete TMT B, or the learning rate on the California Verbal Learning Test. However, raw scores are difficult to compare across tests and to interpret in relation to expected functioning of the general population. For example, one measure may be timed, in which a fewer number of seconds indicates good performance, whereas higher scores on another measure (e.g., a list-learning test) are indicative of good performance. These differences also make it difficult to combine such variables into summary scores. For these reasons we have recommended the use of scaled scores in predicting everyday functioning (Heaton & Marcotte, 2000). Scaled scores are uncorrected (e.g., for age and other demographics) scores that are generated from a population of normal controls (ideally representing a broad range of demographic characteristics, similar to the society of interest; e.g., based on a national census), and transformed so that they are normally distributed (often with a mean of 10 and a *SD* of 3). Since each test variable is put onto this common metric, one can then compare performance across measures and generate summary scores, such as estimates of overall or domain-specific functioning (Heaton, Taylor, et al., 2004).

There remains a fair amount of variability in whether investigators use raw, scaled, or *T*-scores. One study directly compared the use of adjusted and unadjusted scores (Silverberg & Millis, 2009) in a group of patients with traumatic brain injury (TBI). Real-world outcomes were based on patient and caregiver reports. The authors used the normative data provided by Heaton, Miller, Taylor, and Grant (2004) to generate "absolute scores"—unadjusted scores that were placed upon the *T*-scale metric, where the overall mean of the normative group is 50, with a standard deviation of 10, in order to facilitate comparisons of the two methods. They then created two overall test battery mean scores (for absolute and adjusted scores) in order to predict outcomes on their questionnaires. The authors found that (1) absolute and adjusted scores were often divergent, usually based, as would be expected, on the degree to which the patient differed from the normative group average on demographic factors (age, education, gender, ethnicity); and (2) whereas both measures predicted everyday functioning, the results tended to favor the use of absolute scores. It should be noted, however, that the superiority of absolute scores for predicting everyday functioning may depend on whether the tasks are those that all or most adults would be expected to perform successfully. If the everyday tasks are exceptionally demanding and normally performed only by people with high levels of education (e.g., physicians, attorneys, scientists, university professors), use of education-corrected scores may be better predictive of success or failure.

Additional studies comparing these methods may yield useful insights as to the best way to use neuropsychological test results to predict real-world behavior. For example, such studies might identify absolute levels of functioning in various domains that are needed to accomplish specific tasks, such as medication management. The findings might vary by neurological group. The role of compensatory strategies and other factors that might influence the relationship between neuropsychological test performance and everyday behaviors would also need to be considered. Over time, investigators could build a common base of knowledge that would inform clinicians and future studies.

Challenges in Developing Instruments Focusing on Ecological Validity

A survey of 747 North American doctorate-level psychologists that examined their use of assessment instruments designed with ecological validity in mind revealed that in many cases neuropsychologists emphasized clinical acumen and nonstandardized evaluations rather than published tests (Rabin et al., 2007). According to the authors, the survey "highlights the disparity between the proportion of neuropsychologists who conduct assessments that focus on ecological issues and the proportion who use the instruments designed for ecological purposes" (p. 736). If ecologically oriented instruments hold promise, why have neuropsychologists hesitated to incorporate such measures into their standard test batteries? Spooner and Pachana (2006) propose the following possibilities: (1) the assumption that traditional tests are ecologically valid, despite limited evidence that this is the case; (2) the tendency to stay with those instruments on which one received graduate training or to remain committed to a particular theory of assessment approach; (3) the view that verisimilitude is synonymous with face validity, suggesting a less rigorous or "unscientific" evaluation of the ecological validity of the measure, even though many of these instruments have undergone such evaluations; (4) the belief that tests based on verisimilitude overlap with the occupational therapy approach and thus encroach on another discipline; and (5) the belief that traditional tests measure specific constructs, even though "the application of labels to cognitive domains is not necessarily reflective of unambiguous empirical findings" (p. 334).

Although ecologically oriented instruments hold promise, many of these instruments continue to be most widely used within the context of research. Mimicking everyday tasks in the clinic/lab does not necessarily mean that the findings will directly relate to how patients/participants function in the real world, where they must deal with competing tasks, prioritizing, paying attention in the context of distractions, and so on. Burgess and colleagues (2006) advocated for a function-led approach to creating clinical tasks—models that proceed from a directly observable everyday behavior backward to examine how a sequence of actions leads to behavior, and how that behavior might become disrupted. Ecological validity may be improved because of more specific delineation of cognitive processes, even in seemingly simple behaviors (e.g., making toast and coffee; Schwartz, 2006).

Throughout this book, the reader will be exposed to numerous approaches to studying everyday functioning and a variety of ecologically oriented tests developed with the goal of improving the real-world predictive ability of clinic-based tests. Some of these ecologically oriented tests have taken a more function-led approach to development. For example, in addition to coding accuracy and time to completion, to understand how behaviors become disrupted, these tests also code for specific errors being committed (e.g., omissions, commissions) in the actual execution of an action sequence such as making coffee (e.g., Naturalistic Action Test; Schwartz, Buxbaum, Ferraro, Veramonti, & Segal, 2003) or in more complex skills that are ill-structured and involve multitasking (Baycrest Multiple Errands Test-Revised; Clark, Anderson, Nalder, Arshad, & Dawson, 2017). Despite their open-ended and naturalistic nature, such tasks have generally displayed adequate psychometric properties (Knight, Alderman, & Burgess, 2002; Schwartz, Segal, Veramonti, Ferraro, & Buxbaum, 2002) and have shown moderately high correlations with independent outcomes assessing everyday functioning (Dawson et al., 2005, 2009; Schmitter-Edgecombe, McAlister, & Weakley, 2012).

Other aspects of performance being captured by newer ecologically oriented clinic-based tasks include skills such as planning, mid-task planning, self-monitoring, and compensatory strategy use (e.g., Night Out Task: Schmitter-Edgecombe, Cunningham, McAlister, Arrotta, & Weakley, 2021; RPA-ProMem: Radford et al., 2011). "Actual Reality" is an assessment approach that uses the internet to perform real everyday activities such as purchasing an airline ticket (Goverover, O'Brien, Moore, & DeLuca, 2010) or health-related internet searches (Woods et al., 2016). Detecting impairments in navigating technology and the internet might help clinicians and researchers capture potential barriers to optimal quality of life and identify targets for rehabilitation. Newer approaches are also making use of virtual reality to simulate the real world (see Chapter 13, this volume). These computer-administered approaches allow for analysis of more fine-grained details of movement and performance as data is captured automatically and on a continuous time scale. In some cases, individuals may display a number of errors on these ecologically oriented assessment instruments while performing adequately on more traditional measures of similar constructs (Marcotte et al., 2004). To date, many of the instruments that have been developed using a function-led approach are still being used predominantly in clinical research. They await further validation and normative standards before being widely used in clinical care.

These newer instruments may offer ecologically relevant additions to a battery of assessment instruments when such everyday problems are suspected. To this end, we need to demonstrate that ecologically oriented instruments can provide incremental improvement on the prediction of everyday functioning achieved using traditional neuropsychological measures. For example, in a study of the driving abilities of HIV-positive individuals (Marcotte et al., 2004), participants completed a detailed neuropsychological test battery and interactive PC-based driving simulations assessing routine driving and accident avoidance skills, as well as navigational abilities (i.e., using a map, participants were asked to drive to a location within a virtual city and then return to their starting location). Global neuropsychological performance was found to be a significant predictor of passing or failing an on-road drive. However, performance on the simulations explained additional variance beyond traditional testing in predicting on-road performance. This suggested that the simulations may provide information on real-world behaviors that are not captured by neuropsychological measures, such as the ability to anticipate high-risk situations or respond to complex demands when under time pressure. The difficulty in identifying gold standards for evaluating the ecological validity of clinic-based tests, however, makes this work challenging.

Advances in technologies that allow for continuous and in-the-moment assessment within the real-world environment may offer new opportunities for development of gold standard functional outcome measures; these advances may also serve to further augment clinic-based assessment (see Chapters 10–12, this volume). Technology-enabled assessment of real-world function may also improve understanding of the impact of contextual (e.g., environment, mood) and time-varying influences on real-world everyday activities. For example, real-time associations have been found between fluctuations in cognition and behavioral symptom expression, including the side effects of medication (Frings et al., 2008) and fatigue (Small et al., 2019). The ability to capture both variability and trajectories of change in real-world everyday activities could also augment and improve the sensitivity of traditional assessment methods, which typically compare a limited number of assessment points spread out across lengthy time periods to reduce the impact of practice effects.

Ideally, it would be useful to employ ecologically oriented measures that encompass a broad range of skill levels (from easy to challenging), are able to detect subtle declines (in the case of early-stage neurological disorders) or improvements (in the case of pharmaceutical treatments) and are valid across persons of diverse cultural backgrounds. However, it is very difficult to develop measures that reflect everyday functioning—tasks that most people successfully perform in their daily lives—and are still challenging enough to provide a distribution of functioning across “normal” individuals (i.e., so that not everyone either receives a perfect score or fails the test). As the difficulty of a task increases, correlations with education and intelligence increase, and it becomes a challenge to keep the measure from being “test-like” (Goldstein, 1996) or game-like. For example, how much complexity can be added to a money management task before the testee will need to be a certified public accountant to succeed on the test? Or at what point does adding difficulty to a driving simulation (e.g., accident avoidance scenarios) produce the look and feel of an arcade videogame, thus losing the real-world aspects of the measures? The Rivermead Behavioral Memory Test is an example of a measure that was “extended” when the earlier version was found to be insufficiently challenging to delineate functioning within normal individuals (de Wall, Wilson, & Baddeley, 1994). From our own experience, our battery of functional measures (cooking, shopping, financial management, medication management, vocational abilities) underwent a number of modifications before achieving a reasonable balance between task difficulty and real-world applicability (Heaton, Marcotte, et al., 2004). In addition, given that most healthy individuals perform near ceiling on many everyday measures, it is also often challenging to establish test–retest reliability via traditional correlational methods.

What Is the Best Lab- and Clinic-Based Approach to Predicting Real-World Behavior?

As noted earlier, the existing literature suggests a “moderate” relationship between traditional neuropsychological measures and real-world functioning, and no single test, or battery of tests, is predictive of all aspects of everyday functioning across all groups. However, the neuropsychological approach brings many advantages in that many tests have good psychometric properties, established reliability and validity, and norms. In addition, there is abundant evidence that performance on traditional neuropsychological tests relates to aspects of everyday functioning. Few studies have conducted direct comparisons between approaches emphasizing veridicality versus verisimilitude, and comparisons between studies are complicated by the use of different test instruments, different outcome measures, and different samples. However, in a review of studies using one, or both, approaches, Chaytor and Schmitter-Edgecombe (2003) found some evidence favoring the verisimilitude approach in predicting everyday performance, at least with respect to memory and executive functioning. A few studies have also demonstrated that tests with verisimilitude can provide incremental improvement when predicting real-world outcomes after accounting for traditional neuropsychological measures (Marcotte et al., 2004; Robertson et al., 2018). But the matter is still unresolved.

At this juncture, it appears that the best approach remains one in which, in most circumstances, the neuropsychologist uses demographically adjusted scores to determine whether there has likely been a decline from previous cognitive levels. If the decline appears to be of sufficient magnitude to affect everyday functioning, the examination of nonadjusted scaled or absolute scores can be used to predict most real-world activities (Silverberg & Millis, 2009). Greater precision of this prediction is likely to be possible if future studies help clarify basic levels needed to perform specific tasks. In some cases of highly demanding positions (e.g., physician, pilot), it is advisable to continue to focus on expected levels of cognitive functioning, using demographic corrections, since an average level of scaled scores may not adequately encompass the cognitive expertise needed for the most challenging real-world tasks. Based on meta-analytic data, in addition to global cognitive status, a focus on executive functioning and perhaps learning and memory may provide the greatest yield regarding the prediction of real-world functioning (Royall et al., 2007; McAlister et al., 2016). Additional cognitive domains specific to the real-world tasks in question could also be assessed (e.g., prospective memory). As noted earlier, since one is also interested in cognitive strengths (e.g., for potential compensatory mechanisms), we recommend the administration of a comprehensive battery whenever the prediction of real-world functioning is the goal.

It should also be clear that there are benefits to the multimodal assessment of an individual’s ability to carry out everyday tasks successfully. Such assessments would include information gleaned from some of the well-developed, ecologically oriented measures discussed here and throughout this book, as well as self- and informant-reported perceptions about how well the individual is functioning in his or her daily life gathered through structured interviews and surveys. Traditional neuropsychological tests and performance-based everyday functioning measures inform us of the individual’s capacity, but the clinician also needs to be familiar with other factors (e.g., environmental, emotional, psychosocial) that might cause differences between capacity and implementation.

On the one hand, overestimating functional capacity may result in irreversible negative consequences to a patient, such as financial debt or injury to self. On the other hand, underestimation could lead to unnecessary restriction of daily responsibilities that can diminish independence and sense of self-worth.

The Path Forward

Traditional neuropsychological measures continue to prove useful, as has been described here. However, although measures that assess specific cognitive constructs (e.g., for diagnosis) will always be needed, the field of neuropsychology continues to be faced with the question of how to more effectively use the traditional tests or how to best develop new tests and make use of evolving technology to better predict and assess functioning in the real world. Chapters 2 through 4, this volume, provide information about general theoretical approaches that have been applied to examining the relationship between cognition and function. Chapter 5 draws attention to the importance of considering cultural challenges in the assessment of functional abilities.

As discussed earlier, one needs to pay as much attention to the measurement of outcomes as to predictors. Chapters 6–13 discuss in detail numerous assessment methods, ranging from questionnaires to virtual reality to technology-enabled real-world assessment, that have been employed to improve predictions of everyday functioning. A significant challenge for development of any new clinic-based test is to demonstrate the ecological validity of the test as currently "real-world" outcome is itself poorly defined. In the field of automobile driving, for example, the relationship between cognitive performance and "driving" may differ if driving performance is assessed via reaction time to a video, a fully interactive desktop simulator, a full-motion car cab, a closed-course challenge drive, an open-road assessment, or a tally of real-world crashes. As described in Chapters 9 and 10, newer driving sensor technologies have the potential for unobtrusively collecting continuous data about driving performances and observing important driving behaviors (e.g., off-road glances, driving speed adaptations) and changes in driving behaviors over time (e.g., driving less on highway) in the open, real-world environment. Other technologies described in Chapters 10–13 (e.g., smart environments, wearable) also hold promise for recognizing, describing, and assessing routine behaviors in the real-world environment such as cooking, grooming, pill box use, activity level, and computer use (e.g., Cook et al., 2019; Rawtaer et al., 2020). Although such approaches can raise privacy and security issues and present data informatics challenges, they offer an exciting window for observing how normal and impaired individuals behave in their day-to-day life. They will likely offer new measures of "real-world" outcomes.

As is evident in Chapters 14–21, this volume, where the state of the literature regarding the relationship between cognition and function is discussed relative to specific disorders, additional factors complicate the prediction of real-world behavior. Among these considerations is the fact that an individual's ability to function in the real world at any particular time depends on a complex interaction of a person's neurocognitive deficits with other person-specific and environment factors (e.g., cognitive resilience, compensatory strategy use; Casaletto et al., 2017; Burton, O'Connell, & Morgan, 2018; Delgado et al., 2019). Furthermore, of the ecologically oriented instruments that have been developed, most have yet to gain widespread use, either by different research groups or across different neurological populations. Many tools are "home grown" and are applied within a single laboratory or across only a few patient groups, thus limiting their utility to the field at large. Until these approaches are more widely implemented. which will require greater investment by neuropsychological organizations or government entities, the field will likely continue to progress slowly. Such investments are also important for clinical trials where calls have been issued for better measurement of outcomes relating to everyday functioning and requirements to include co-primary measures that assess clinically meaningful/relevant functional outcomes (e.g., Buchanan et al., 2005; Laughren, 2001). Thus, there may be greater movement toward measures that include a verisimilitude approach to predicting real-world behavior or toward technology-enabled assessment of real-world functioning, if indeed such measures are better predictors.

The ability of neuropsychological testing to predict everyday functioning has been clearly established. However, performance on these clinic-based measures does not capture all of the variance associated with behavior in the open environment. Advances in theoretical conceptualizations, test development, technology, and multimodal methods of assessing predictors and outcomes portend a promising future for our ability to understand the relationship between brain function and behavior in the real world.

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References

Alberdi, A. A., Weakley, A., Goenaga, A. A., Schmitter-Edgecombe, M., & Cook, D. J. (2018). Automatic assessment of functional health decline in older adults: A smart-home approach. *J Biomed Inform*, *81,* 119–130.

Allain, P., Foloppe, D. A., Besnard, J., Yamaguchi, T., Etcharry-Bouyx, F., Le Gall, D., et al. (2014). Detecting everyday action deficits in Alzheimer's disease using a nonimmersive virtual reality kitchen. *J Int Neuropsychol Soc, 20*(5), 468–477.

Amick, M. M., D'Abreu, A., Moro-de-Casillas, M. L., Chou, K. L., & Ott, B. R. (2007). Excessive daytime sleepiness and on-road driving performance in patients with Parkinson's disease. *J Neurol Sci, 252*(1), 13–15.

Army Individual Test Battery. (1944). *Manual of directions and scoring.* Washington, DC: War Department, Adjutant General's Office.

Azar, M., Zhu, C., DeFeis, B., Gu, Y., Ornstein, K., Lawless, S., & Cosentino, S. (2017). Increased reporting accuracy of Alzheimer disease symptoms in Caribbean Hispanic informants. *Alzheimer Dis Assoc Disord, 31*(4), 328–334.

Ball, K. K., Beard, B. L., Roenker, D. L., Miller, R. L., & Griggs, D. S. (1988). Age and visual search: expanding the useful field of view. *J Opt Soc Am A, 5*(12), 2210–2219.

Ball, K., Owsley, C., Sloane, M. E., Roenker, D. L., & Bruni, J. R. (1993). Visual attention problems as a predictor of vehicle crashes in older drivers. *Invest Ophthalmol Vis Sci, 34*(11), 3110–3123.

Ball, K., & Roenker, D. (1998). *Useful field of view.* San Antonio, TX: Psychological Corporation.

Barcroft, J., Binger, C. A., Bock, A. V., Doggart, J. H., Forbes, H. S., Harrop, G., et al. (1923). Observations upon the effect of high altitude on the physiological processes of the human body, carried out in the Peruvian Andes, chiefly at Cerro de Pasco. *Philos T Roy Soc B*, *211*, 351–480.

Barona, A., & Chastain, R. L. (1986). An improved estimate of premorbid IQ for blacks and whites on the WAIS-R. *Int J Clin Neuropsy, 8,* 169–173.
Baughman, B. C., Basso, M. R., Sinclair, R. R., Combs, D. R., & Roper, B. L. (2015). Staying on the job: The relationship between work performance and cognition in individuals diagnosed with multiple sclerosis. *J Clin Exp Neuropsychol, 37*(6), 630–640.
Bell-McGinty, S., Podell, K., Franzen, M., Baird, A. D., & Williams, M. J. (2002). Standard measures of executive function in predicting instrumental activities of daily living in older adults. *Int J Geriatr Psych, 17*(9), 828–834.
Bettcher, B. M., Giovannetti, T., Macmullen, L., & Libon, D. J. (2008). Error detection and correction patterns in dementia: A breakdown of error monitoring processes and their neuropsychological correlates. *J Int Neuropsychol Soc, 14*(2), 199–208.
Bieliauskas, L. A., Roper, B. R., Trobe, J., Green, P., & Lacy, M. (1998). Cognitive measures, driving safety, and Alzheimer's disease. *Clin Neuropsychol, 12*(2), 206–212.
Bilder, R. M., & Reise, S. P. (2019). Neuropsychological tests of the future: How do we get there from here? *Clin Neuropsychol*, *33*(2), 220–245.
Blackstone, K., Iudicello, J. E., Morgan, E. E., Weber, E., Moore, D. J., Franklin, D. R., et al. (2013). Human immunodeficiency virus infection heightens concurrent risk of functional dependence in persons with long-term methamphetamine use. *J Addict Med, 7*(4), 255–263.
Boyle, P. A., Paul, R. H., Moser, D. J., & Cohen, R. A. (2004). Executive impairments predict functional declines in vascular dementia. *Clin Neuropsychol, 18*(1), 75–82.
Braun, C. M., Godbout, L., Desbiens, C., Daigneault, S., Lussier, F., & Hamel-Hebert, I. (2004). Mental genesis of scripts in adolescents with attention deficit/hyperactivity disorder. *Child Neuropsychol, 10*(4), 280–296.
Brooks, N., McKinlay, W., Symington, C., Beattie, A., & Campsie, L. (1987). Return to work within the first seven years of severe head injury. *Brain Inj, 1*(1), 5–19.
Brouwer, W. H. (2002). Attention and driving: A cognitive neuropsychological approach. In P. Zimmermann & M. Leclercq (Eds.), *Applied neuropsychology of attention: Theory diagnosis and rehabilitation*. Hove, UK: Psychology Press.
Brunswik, E. (1955). Symposium of the probability approach in psychology: Representative design and probabilistic theory in a functional psychology. *Psychol Rev, 62,* 193–217.
Buchanan, R. W., Davis, M., Goff, D., Green, M. F., Keefe, R. S. E., Leon, A. C., et al. (2005). A summary of the FDA-NIMH-MATRICS Workshop on clinical trial design for neurocognitive drugs for schizophrenia. *Schizophr Bull, 31*(1), 5–19.
Burgess, P. W. (2000). Strategy application disorder: the role of the frontal lobes in human multitasking. *Psychol Res-Psycholog Forsch, 63*(3–4), 279–288.
Burgess, P. W., Alderman, N., Evans, J., Emslie, H., & Wilson, B. A. (1998). The ecological validity of tests of executive function. *J Int Neuropsychol Soc, 4*(6), 547–558.
Burgess, P. W., Alderman, N., Forbes, C., Costello, A., Coates, L. M. A., Dawson, D. R., et al. (2006). The case for the development and use of "cologically valid" measures of executive function in experimental and clinical neuropsychology. *J Int Neuropsychol Soc, 12*(2), 194–209.
Burton, R. L., O'Connell, M. E., & Morgan, D. G. (2018). Cognitive and neuropsychiatric correlates of functional impairment across the continuum of no cognitive impairment to dementia. *Arch Clin Neuropsychol, 33*(7), 795–807.
Burton, C. L., Strauss, E., Bunce, D., Hunter, M. A., & Hultsch, D. F. (2009). Functional abilities in older adults with mild cognitive impairment. *Gerontology, 55*(5), 570–581.
Cahn-Weiner, D. A., Ready, R. E., & Malloy, P. F. (2003). Neuropsychological predictors of everyday memory and everyday functioning in patients with mild Alzheimer's disease. *J Geriatr Psychiatry Neurol, 16*(2), 84–89.
Carey, C. L., Woods, S. P., Gonzalez, R., Conover, E., Marcotte, T. D., Grant, I., et al. (2004). Predictive validity of global deficit scores in detecting neuropsychological impairment in HIV infection. *J Clin Exp Neuropsychol, 26*(3), 307–319.

Carey, C. L., Woods, S. L., Rippeth, J. D., Heaton, R. K., & Grant, I. (2006). Prospective memory in HIV-1 infection. *J Clin Experimental Neuropsychol, 28*(4), 536–548.

Casaletto, K. B., Weber, E., Iudicello, J. E., & Woods, S. P. (2017). Real-world impact of HIV-associated neurocognitive impairment. In N. Chiaravalloti & Y. Goverover (Eds.), *Changes in the brain* (pp. 211–245). New York: Springer.

Chan, A. S., Chiu, H., Lam, L., Pang, A., & Chow, L. Y. (1999). A breakdown of event schemas in patients with schizophrenia: An examination of their script for dining at restaurants. *Psychiatry Res, 87*(2–3), 169–181.

Channon, S., & Green, P. S. S. (1999). Executive function in depression: The role of performance strategies in aiding depressed and non-depressed participants. *J Neurol Neurosurg Psychiatry, 66*(2), 162–171.

Chaytor, N., & Schmitter-Edgecombe, M. (2003). The ecological validity of neuropsychological tests: A review of the literature on everyday cognitive skills. *Neuropsychol Rev, 13*(4), 181–197.

Chelune, G. J., Heaton, R. K., & Lehman, R. A. W. (1986). Neuropsychological and personality correlates of patients' complaints of disability. In G. Goldstein & R. E. Tarter (Eds.), *Advances in clinical neuropsychology* (Vol. 3, pp. 95–126). New York: Plenum Press.

Chelune, G. J., & Moehle, K. (1986). Neuropsychological assessment and everyday functioning. In D. Wedding, J. Horton, A. Webster, & J. Webster (Eds.), *The neuropsychology handbook: Behavioral and clinical perspectives* (pp. 489–525). New York: Springer.

Chevignard, M., Pillon, B., Pradat-Diehl, P., Taillefer, C., Rousseau, S., Le Bras, C., & Dubois, B. (2000). An ecological approach to planning dysfunction: Script execution. *Cortex, 36*(5), 649–669.

Chiao, S., Rosen, H. J., Nicolas, K., Wendelken, L. A., Alcantar, O., Rankin, K. P., et al. (2013). Deficits in self-awareness impact the diagnosis of asymptomatic neurocognitive impairment in HIV. *AIDS Res Hum Retroviruses, 29*(6), 949–956.

Clark, A. J., Anderson, N. D., Nalder, E., Arshad, S., & Dawson, D. R. (2017). Reliability and construct validity of a revised Baycrest Multiple Errands Test. *Neuropsychol Rehabil, 27*(5), 667–684.

Cook, D. J., Schmitter-Edgecombe, M., Jonsson, L., & Morant, A. V. (2019). Technology-Enabled Assessment of Functional Health. *IEEE Rev Biomed Eng, 12*, 319–332.

Covinsky, K. E., Fortinsky, R. H., Palmer, R. M., Kresevic, D. M., & Landefeld, C. S. (1997). Relation between symptoms of depression and health status outcomes in acutely ill hospitalized older persons. *Ann Intern Med, 126*(6), 417–425.

Czaja, S. J., Sharit, J., Hernandez, M. A., Nair, S. N., & Loewenstein, D. (2010). Variability among older adults in internet health information-seeking performance. *Gerontechnology, 9*(1), 46–55.

Daigneault, G., Joly, P., & Frigon, J. Y. (2002). Executive functions in the evaluation of accident risk of older drivers. *J Clin Exp Neuropsychol, 24*(2), 221–238.

Dassel, K. B., & Schmitt, F. A. (2008). the impact of caregiver executive skills on reports of patient functioning. *Gerontologist, 48*(6), 781–792.

Dawson, D. R., Anderson, N. D., Burgess, P., Cooper, E., Krpan, K. M., & Stuss, D. T. (2009). Further development of the Multiple Errands Test: Standardized scoring, reliability, and ecological validity for the Baycrest version. *Arch Phys Med Rehabil, 90*(11 Suppl), S41–S51.

Dawson, D., Anderson, N., Burgess, P., Levine, B., Rewilak, D., Cooper, E., et al. (2005). Naturalistic assessment of executive function: The Multiple Errands Test. Poster 47. *Arch Phys Med Rehabil, 86*(10).

Deary, I. J., Strand, S., Smith, P., & Fernandes, C. (2006). Intelligence and educational achievement. *Intelligence, 35*(1), 13–21.

Delgado, C., Vergara, R. C., Martinez, M., Musa, G., Henriquez, F., & Slachevsky, A. (2019). Neuropsychiatric symptoms in Alzheimer's disease are the main determinants of functional impairment in advanced everyday activities. *J Alzheimer's Dis, 67*(1), 381–392.

Depp, C. A., Mausbach, B. T., Harmell, A. L., Savla, G. N., Bowie, C. R., Harvey, P. D., et al. (2012). Meta-analysis of the association between cognitive abilities and everyday functioning in bipolar disorder. *Bipolar Disord, 14*(3), 217–226.
de Leeuw, F. E., de Groot, J. C., Achten, E., Oudkerk, M., Ramos, L. M., Heijboer, R., et al. (2001). Prevalence of cerebral white matter lesions in elderly people: A population based magnetic resonance imaging study. The Rotterdam Scan Study. *J Neurol Neurosurg Psychiatry, 70*(1), 9–14.
de Wall, C., Wilson, B. A., & Baddeley, A. D. (1994). The Extended Rivermead Behavioural Memory Test: A measure of everyday memory performance in normal adults. *Memory, 2*(2), 149–166.
Doyle, K. L., Morgan, E. E., Morris, S., Smith, D. M., Little, S., Iudicello, J. E., .et al. (2013). Real-world impact of neurocognitive deficits in acute and early HIV infection. *J Neurovirol, 19*(6), 565–573.
Duchek, J. M., Hunt, L., Ball, K., Buckles, V., & Morris, J. C. (1998). Attention and driving performance in Alzheimer's disease. *J Gerontol Ser B-Psychol Sci Social Sci, 53*(2), P130–P141.
Earnst, K. S., Wadley, V. G., Aldridge, T. M., Steenwyk, A. B., Hammond, A. E., Harrell, L. E., et al. (2001). Loss of financial capacity in Alzheimer's disease: The role of working memory. *Aging Neuropsychol Cogn, 8*(2), 109–119.
Einstein, G. O., Holland, L. J., McDaniel, M. A., & Guynn, M. J. (1992). Age-related deficits in prospective memory: The influence of task complexity. *Psychol Aging, 7*(3), 471–478.
Evans, J. J., Chua, S. E., McKenna, P. J., & Wilson, B. A. (1997). Assessment of the dysexecutive syndrome in schizophrenia. *Psychol Med, 27*(3), 635–646.
Farias, S., Gravano, J., Weakley, A., Schmitter-Edgecombe, M., Harvey, D., Mungas, D., et al. (2020). The Everyday Compensation (EComp) questionnaire: Construct validity and associations with diagnosis and longitudinal change in cognition and everyday function. *J Int Neuropsychol Soc, 26*, 303–313.
Farmer, J. E., & Eakman, A. M. (1995). The relationship between neuropsychological functioning and instrumental activities of daily living following acquired brain injury. *Appl Neuropsychol, 2*(3–4), 107–115.
Fisher, A. G. (2003). *Assessment of motor and process skills, volume 1: Development, standardization, and administration manual* (5th ed.). Fort Collins, Colorado: Three Star Press.
Fisk, G. D., Novack, T., Mennemeier, M., & Roenker, D. (2002). Useful field of view after traumatic brain injury. *J Head Trauma Rehabil, 17*(1), 16–25.
Fisk, G. D., Owsley, C., & Mennemeier, M. (2002). Vision, attention, and self-reported driving behaviors in community-dwelling stroke survivors. *Arch Phys Med Rehabil, 83*(4), 469–477.
Fitten, L. J., Perryman, K. M., Wilkinson, C. J., Little, R. J., Burns, M. M., Pachana, N., et al. (1995). Alzheimer and vascular dementias and driving. A prospective road and laboratory study. *JAMA, 273*(17), 1360–1365.
Fox, G. K., Bowden, S. C., Bashford, G. M., & Smith, D. S. (1997). Alzheimer's disease and driving: prediction and assessment of driving performance. *J Am Geriatr Soc, 45*(8), 949–953.
Franzen, M. D. (2000). *Reliability and validity in neuropsychological assessment.* New York: Springer.
Franzen, M. D., & Wilhelm, K. L. (1996). Conceptual foundations of ecological validity in neuropsychological assessment. In R. J. Sbordone & C. J. Long (Eds.), *Ecological validity of neuropsychological testing* (pp. 91–112). Delray Beach, FL: GR Press/St. Lucie Press.
Frings, L., Wagner, K., Maiwald, T., Carius, A., Schinkel, A., Lehmann, C., et al. (2008). Early detection of behavioral side effects of antiepileptic treatment using handheld computers. *Epilepsy Behav, 13*(2), 402–406.
Galski, T., Bruno, R. L., & Ehle, H. T. (1992). Driving after cerebral hemorrhage: A model with implications for evaluation. *A J Occup Ther, 46*, 324–332.
Gerard, A. B., McElroy, M. K., Taylor, M. J., Grant, I., Powell, F. L., Holverda, S., et al. (2000).

Six percent oxygen enrichment of room air at simulated 5,000 m altitude improves neuropsychological function. *High Alt Med Biol, 1*(1), 51–61.
Gioia, G. A., Isquith, P. K., Guy, S. C., & Kenworthy, L. (2000). *Behavior Rating Inventory of Executive Function*. Odessa, FL: Psychological Assessment Resources.
Giovannetti, T., Libon, D. J., Buxbaum, L. J., & Schwartz, M. F. (2002). Naturalistic action impairments in dementia. *Neuropsychologia, 40*(8), 1220–1232.
Giovannetti, T., Schmidt, K. S., Gallo, J. L., Sestito, N., & Libon, D. J. (2006). Everyday action in dementia: Evidence for differential deficits in Alzheimer's disease versus subcortical vascular dementia. *J Int Neuropsychol Soc, 12*(1), 45–53.
Giovannetti, T., Schwartz, M. F., & Buxbaum, L. J. (2007). The Coffee Challenge: A new method for the study of everyday action errors. *J Clin Exp Neuropsychol, 29*(7), 690–705.
Gladsjo, J. A., Heaton, R. K., Palmer, B. W., Taylor, M. J., & Jeste, D. V. (1999). Use of oral reading to estimate premorbid intellectual and neuropsychological functioning. *J Int Neuropsychol Soc, 5*(3), 247–254.
Godbout, L., & Doyon, J. (2000). Defective representation of knowledge in Parkinson's disease: Evidence from a script-production task. *Brain Cogn, 44*(3), 490–510.
Goldstein, G. (1996). Functional considerations in neuropsychology. In R. J. Sbordone & C. J. Long (Eds.), *Ecological validity of neuropsychological testing* (pp. 75–89). Delray Beach, FL: GR Press/St. Lucie Press.
Goverover, Y., O'Brien, A. R., Moore, N. B., & DeLuca, J. (2010). Actual reality: A new approach to functional assessment in persons with multiple sclerosis. *Arch Phys Med Rehabil, 91*(2), 252–260.
Grace, J., Amick, M. M., D'Abreu, A., Festa, E. K., Heindel, W. C., & Ott, B. R. (2005). Neuropsychological deficits associated with driving performance in Parkinson's and Alzheimer's disease. *J Int Neuropsychol Soc, 11*(6), 766–775.
Green, M. F., Kern, R. S., & Heaton, R. K. (2004). Longitudinal studies of cognition and functional outcome in schizophrenia: Implications for MATRICS. *Schizophr Res, 72*(1), 41–51.
Green, P., Allen, L. M., & Astner, K. (1996). *The Word Memory Test: A user's guide to the oral and computer-administered forms*. Durham, NC: CogniSyst.
Guilmette, T. J., & Kastner, M. P. (1996). The prediction of vocational functioning from neuropsychological data. In R. J. Sbordone & C. J. Long (Eds.), *Ecological validity of neuropsychological testing* (pp. 387–409). Delray Beach, FL: GR Press/St. Lucie Press.
Gunstad, J., Spitznagel, M. B., Keary, T. A., Glickman, E., Alexander, T., Karrer, J., et al. (2008). Serum leptin levels are associated with cognitive function in older adults. *Brain Res, 1230,* 233–236.
Hart, T., Giovannetti, T., Montgomery, M. W., & Schwartz, M. F. (1998). Awareness of errors in naturalistic action after traumatic brain injury. *J Head Trauma Rehabil, 13*(5), 16–28.
Hayes, T. L., Abendroth, F., Adami, A., Pavel, M., Zitzelberger, T. A., & Kaye, J. A. (2008). Unobtrusive assessment of activity patterns associated with mild cognitive impairment. *Alzheimers Dement, 4*(6), 395–405.
Heaton, R. K., Chelune, G., & Lehman, R. (1978). Using neuropsychological and personality tests to assess likelihood of patient employment. *J Nerv Ment Dis, 166,* 408–416.
Heaton, R. K., Grant, I., Butters, N., White, D. A., Kirson, D., Atkinson, J. H., et al. (1995). The HNRC 500: Neuropsychology of HIV infection at different disease stages. *J Int Neuropsych Soc, 1,* 231–251.
Heaton, R. K., & Marcotte, T. D. (2000). Clinical neuropsychological tests and assessment techniques. In F. Boller, J. Grafman, & G. Rizzolatti (Eds.), *Handbook of neuropsychology* (pp. 27–52). Amsterdam: Elsevier.
Heaton, R. K., Marcotte, T. D., Mindt, M. R., Sadek, J., Moore, D. J., Bentley, H., et al. (2004). The impact of HIV-associated neuropsychological impairment on everyday functioning. *J Int Neuropsychol Soc, 10*(3), 317–331.

Heaton, R. K., Miller, S. W., Taylor, M. J., & Grant, I. (2004). *Revised comprehensive norms for an expanded Halstead–Reitan Battery: Demographically adjusted neuropsychological norms for African American and Caucasian adults*. Lutz, FL: Psychological Assessment Resources.

Heaton, R. K., & Pendleton, M. G. (1981). Use of neuropsychological tests to predict adult patients' everyday functioning. *J Consul Clin Psych, 49*(6), 807–821.

Heaton, R. K., Taylor, M., & Manly, J. (2004). Demographic effects and use of demographically corrected norms with the WAIS-III and WMS-III. In D. Tulsky, D. Saklofske & R. K. Heaton (Eds.), *Clinical interpretation of the WAIS-III and WMS-III* (pp. 181–209). San Diego, CA: Academic Press.

Hiscock, M., & Hiscock, C. K. (1989). Refining the forced-choice method for the detection of malingering. *J Clin Exp Neuropsychol, 11,* 967–974.

Holdnack, J. A., Schoenberg, M. R., Lange, R. T., & Iverson, G. L. (2013). Predicting premorbid ability for WAIS–IV, WMS–IV and WASI–II. In J. A. Holdnack, L. W. Drozdick, L. G. Weiss, & G. L. Iverson (Eds.), *Practical resources for the mental health professional. WAIS-IV, WMS-IV, and ACS: Advanced clinical interpretation* (pp. 217–278). Waltham, MA: Elsevier.

Hser, Y., Huang, D., Chou, C., & Anglin, M. D. (2007). Trajectories of heroin addiction: Growth mixture modeling results based on a 33-year follow-up study. *Eval Rev, 31*(6), 548–563.

Hunt, L., Morris, J. C., Edwards, D., & Wilson, B. S. (1993). Driving performance in persons with mild senile dementia of the Alzheimer type. *J Am Geriatr Soc, 41,* 747–753.

Janke, M. K. (1991). Accidents, mileage, and the exaggeration of risk. *Accid Anal Prev, 23*(2–3), 183–188.

Jeste, S. D., Patterson, T. L., Palmer, B. W., Dolder, C. R., Goldman, S., & Jeste, D. V. (2003). Cognitive predictors of medication adherence among middle-aged and older outpatients with schizophrenia. *Schizophr Res, 63*(1–2), 49–58.

Johansson, E., Alho, H., Kiiskinen, U., & Poikolainen, K. (2007). The association of alcohol dependency with employment probability: Evidence from the population survey "Health 2000 in Finland." *Hlth Econ, 16*(7), 739–754.

Kalechstein, A. D., Newton, T. F., & van Gorp, W. G. (2003). Neurocognitive functioning is associated with employment status: A quantitative review. *J Clin Exp Neuropsychol, 25*(8), 1186–1191.

Kamei, S., Hara, M., Serizawa, K., Murakami, M., Mizutani, T., Ishiburo, M., et al. (2008). Executive dysfunction using behavioral assessment of the dysexecutive syndrome in Parkinson's disease. *Mov Disord, 23*(4), 566–573.

Katai, S., Maruyama, T., Hashimoto, T., & Ikeda, S. (2003). Event based and time based prospective memory in Parkinson's disease. *J Neurol Neurosurg Psychiatry, 74*(6), 704–709.

Keefe, R. S., Davis, V. G., Atkins, A. S., Vaughan, A., Patterson, T., Narasimhan, M., & Harvey, P. D. (2016). Validation of a computerized test of functional capacity. *Schizophr Res, 175*(1–3), 90–96.

Kelly, T. P. (2000). The clinical neuropsychology of attention in school-aged children. *Child Neuropsychol, 6*(1), 24–36.

Kennedy, J. E., Clement, P. F., & Curtiss, G. (2003). WAIS-III processing speed index scores after TBI: The influence of working memory, psychomotor speed and perceptual processing. *Clin Neuropsychol, 17*(3), 303–307.

Kessler, R. K., Giovannetti, T., & MacMullen, L. R. (2007). Everyday action in schizophrenia: Performance patterns and underlying cognitive mechanisms. *Neuropsychology, 21*(4), 439–447.

Kingstone, A., Smilek, D., & Eastwood, J. D. (2008). Cognitive ethology: A new approach for studying human cognition. *Br J Psychol, 99*(Pt. 3), 317–340.

Klauer, S. G., Dingus, T. A., Neale, V. L., Sudweeks, J. D., & Ramsey, D. J. (2006). *The impact* *of driver inattention on near-crash/crash risk: An analysis using the 100-Car Naturalistic Driving Study data*. Washington, DC: National Highway Traffic Safety Administration.

Knight, C., Alderman, N., & Burgess, P. W. (2002). Development of a simplified version of the multiple errands test for use in hospital settings. *Neuropsychol Rehabil, 12,* 231–255.

Kondel, T. K. (2002). Prospective memory and executive function in schizophrenia. *Brain Cogn, 48,* 405–410.

Kopelman, M., Wilson, B. A., & Baddeley, A. D. (1990). *The autobiographical memory interview.* Bury St. Edmunds, UK: Thames Valley Test.

Labra Pérez, J. A., & Menor, J. (2018). Development and validation of a performance-based test to assess instrumental activities of daily living in Spanish older adults. *Eur J Psychol Assess, 34*(6), 386–398.

Laughren, T. (2001). A regulatory perspective on psychiatric syndromes in Alzheimer disease. *Am J Geriatr Psychiatry, 9*(4), 340–345.

Lengenfelder, J., Schultheis, M. T., Al-Shihabi, T., Mourant, R., & DeLuca, J. (2002). Divided attention and driving: A pilot study using virtual reality technology. *J Head Trauma Rehabil*, *17*(1), 26–37.

Lezak, M. D. (1982). The problem of assessing executive functions. *Int J Psychol, 17,* 281–297.

Lezak, M. D., Howieson, D. B., & Loring, D. W. (2004). *Neuropsychological assessment* (4th ed.). New York: Oxford University Press.

Loewenstein, D. A., Amigo, E., Duara, R., Guterman, A., Hurwitz, D., Berkowitz, N., et al. (1989). A new scale for the assessment of functional status in Alzheimer's disease and related disorders. *J Gerontol, 44*(4), 114–121.

Loewenstein, D. A., Arguelles, S., Bravo, M., Freeman, R. Q., Arguelles, T., Acevedo, A., et al. (2001). Caregivers' judgments of the functional abilities of the Alzheimer's disease patient: A comparison of proxy reports and objective measures. *J Gerontol B Psychol Sci Soc Sci, 56*(2), P78–P84.

Logan, B. K. (1996). Methamphetamine and driving impairment. *J Forensic Sci, 41*(3), 457–464.

Lundberg, C., Hakamies-Blomqvist, L., Almkvist, O., & Johansson, K. (1998). Impairments of some cognitive functions are common in crash-involved older drivers. *Accident Anal Prev, 30*(3), 371–377.

Machamer, J., Temkin, N., Fraser, R., Doctor, J. N., & Dikmen, S. (2005). Stability of employment after traumatic brain injury. *J Int Neuropsychol Soc, 11*(7), 807–816.

Maguire, E. A., Gadian, D. G., Johnsrude, I. S., Good, C. D., Ashburner, J., Frackowiak, R. S., et al. (2000). Navigation-related structural change in the hippocampi of taxi drivers. *Proc Natl Acad Sci USA, 97*(8), 4398–4403.

Marcotte, T. D., Heaton, R. K., Wolfson, T., Taylor, M. J., Alhassoon, O., Arfaa, K., et al. (1999). The impact of HIV-related neuropsychological dysfunction on driving behavior. *J Int Neuropsych Soc, 5*(7), 579–592.

Marcotte, T. D., Lazzaretto, D., Scott, J. C., Roberts, E., Woods, S. P., Letendre, S., et al. (2006). Visual attention deficits are associated with driving accidents in cognitively-impaired HIV-infected individuals. *J Clin Exp Neuropsyc, 28*(1), 13–28.

Marcotte, T. D., & Scott, J. C. (2009). Neuropsychological performance and the assessment of driving behavior. In I. Grant & K. M. Adams (Eds.), *Neuropsychological assessment of neuropsychiatric disorders* (3rd ed., pp. 652–687). New York: Oxford University Press.

Marcotte, T. D., Wolfson, T., Rosenthal, T. J., Heaton, R. K., Gonzalez, R., Ellis, R. J., et al. (2004). A multimodal assessment of driving performance in HIV infection. *Neurology, 63*(8), 1417–1422.

Marshall, G. A., Dekhtyar, M., Bruno, J. M., Jethwani, K., Amariglio, R. E., Johnson, K. A., et al. (2015). The Harvard Automated Phone Task: New performance-based activities of daily living tests for early Alzheimer's disease. *J Prev Alzheimer's Dis, 2*(4), 242–253.

Martin, E. M., Nixon, H., Pitrak, D. L., Weddington, W., Rains, N. A., Nunnally, G., et al. (2007).

Characteristics of prospective memory deficits in HIV-seropositive substance-dependent individuals: Preliminary observations. *J Clin Exp Neuropsychol, 29*(5), 496–504.
Martinez-Aran, A., Vieta, E., Torrent, C., Sanchez-Moreno, J., Goikolea, J. M., Salamero, M., et al. (2007). Functional outcome in bipolar disorder: The role of clinical and cognitive factors. *Bipolar Disord, 9*(1–2), 103–113.
Matarazzo, J. D. (1972). *Wechsler's measurement and appraisal of adult intelligence* (5th ed.). Oxford, UK: Williams & Wilkins.
Maylor, E. A., Smith, G., Della Sala, S., & Logie, R. H. (2002). Prospective and retrospective memory in normal aging and dementia: An experimental study. *Mem Cognit, 30*(6), 871–884.
Mazer, B. L., Sofer, S., Korner-Bitensky, N., Gelinas, I., Hanley, J., & Wood-Dauphinee, S. (2003). Effectiveness of a visual attention retraining program on the driving performance of clients with stroke. *Arch Phys Med Rehab, 84*(4), 541–550.
McAlister, C., Schmitter-Edgecombe, M., & Lamb, R. (2016). Examination of variables that may affect the relationship between cognition and functional status in individuals with mild cognitive impairment: A meta-analysis. *Arch Clin Neuropsychol, 31*(2), 123–147.
McCall, R. B. (1977). Childhood IQ's as predictors of adult educational and occupational status. *Science, 197*(4302), 482–483.
McCue, M., Rogers, J. C., & Goldstein, G. (1990). Relationships between neuropsychological and functional assessment in elderly neuropsychiatric patients. *Rehabil Psychol, 35,* 91–99.
McGurk, S. R., & Mueser, K. T. (2006). Cognitive and clinical predictors of work outcomes in clients with schizophrenia receiving supported employment services: 4-year follow-up. *Adm Policy Ment Hlth, 33*(5), 598–606.
Miller, L. S., Brown, C. L., Mitchell, M. B., & Williamson, G. M. (2013). Activities of daily living are associated with older adult cognitive status: Caregiver versus self-reports. *J Appl Gerontol, 32*(1), 3–30.
Mirsky, A. F., Anthony, B. J., Duncan, C. C., Ahearn, M. B., & Kellam, S. G. (1991). Analysis of the elements of attention: A neuropsychological approach. *Neuropsychol Rev, 2*(2), 109–145.
Molnar, F. J., Patel, A., Marshall, S. C., Man-Son-Hing, M., & Wilson, K. G. (2006). Clinical utility of office-based cognitive predictors of fitness to drive in persons with dementia: A systematic review. *J Am Geriatr Soc, 54*(12), 1809–1824.
Morgan, E. E., Doyle, K. L., Minassian, A., Henry, B. L., Perry, W., Marcotte, T. D., et al. (2014). Elevated intraindividual variability in methamphetamine dependence is associated with poorer everyday functioning. *Psychiatry Res, 220*(1–2), 527–534.
Morgan, J. E., & Sweet, J. J. (Eds.). (2008). *Neuropsychology of malingering casebook*. New York: Psychology Press.
Morrell, L., Camic, P. M., & Genis, M. (2019). Factors associated with informant-reported cognitive decline in older adults: A systemised literature review. *Dementia, 18*(7–8), 2760–2784.
Myers, R. S., Ball, K. K., Kalina, T. D., Roth, D. L., & Goode, K. T. (2000). Relation of Useful Field of View and other screening tests to on-road driving performance. *Percept Motor Skill, 91*(1), 279–290.
Najavits, L. M., & Lester, K. M. (2008). Gender differences in cocaine dependence. *Drug Alcohol Depen, 97*(1–2), 190–194.
Obermeit, C. L., Beltran, J., Casaletto, K. B., Franklin, D. R., Letendre, S., Ellis, R., et al. (2017). Evaluating the accuracy of self-report for the diagnosis of HIV associated neurocognitive disorder (HAND): Defining "symptomatic" versus "asymptomatic" HAND. *J NeuroVirol, 23*(1), 67–78.
Odenheimer, G. L., Beaudet, M., Jette, A. M., Albert, M. S., Grande, L., & Minaker, K. L. (1994). Performance-based driving evaluation of the elderly driver: Safety, reliability, and validity. *J Gerontol, 49*(4), M153–M159.
Owsley, C., Ball, K., McGwin, G., Jr., Sloane, M. E., Roenker, D. L., White, M., et al. (1998).

Visual processing impairment and risk of motor vehicle crash among older adults. *JAMA, 279*(14), 1083–1088.
Park, D. C., & Kidder, D. P. (1996). Prospective memory and medication adherence. In M. Brandimonte, G. O. Einstein, & M. A. McDaniel (Eds.), *Prospective memory: Theory and applications* (pp. 369–390). Mahwah, NJ: Erlbaum.
Patterson, T. L., Goldman, S., McKibbin, C. L., Hughs, T., & Jeste, D. V. (2001). UCSD Performance-Based Skills Assessment: Development of a new measure of everyday functioning for severely mentally ill adults. *Schizophr Bull, 27*(2), 235–245.
Pearson Clinical. (2017). *TOPF (test of pre-morbid function): Case studies*. San Antonio, TX: Pearson Clinical.
Portela, D., Almada, M., Midão, L., & Costa, E. (2020). Instrumental activities of daily living (iADL) limitations in Europe: An assessment of SHARE Data. *Int J Environ Res Public Hlth, 17,* 7387.
Rabin, L. A., Barr, W. B., & Burton, L. A. (2005). Assessment practices of clinical neuropsychologists in the United States and Canada: A survey of INS, NAN, and APA Division 40 members. *Arch Clin Neuropsychol, 20*(1), 33–65.
Rabin, L. A., Burton, L. A., & Barr, W. B. (2007). Utilization rates of ecologically oriented instruments among clinical neuropsychologists. *Clin Neuropsychol, 21*(5), 727–743.
Rabin, L. A., Paolillo, E., & Barr, W. B. (2016). Stability in test-usage practices of clinical neuropsychologists in the United States and Canada over a 10-year period: A follow-up survey of INS and NAN members. *Arch Clin Neuropsychol, 31*(3), 206–230.
Radford, K. A., Lah, S., Say, M. J., & Miller, L. A. (2011). Validation of a new measure of prospective memory: The Royal Prince Alfred Prospective Memory Test. *Clin Neuropsychol, 25*(1), 127–140.
Rawtaer, I., Mahendran, R., Kua, E. H., Tan, H. P., Tan, H. X., Lee, T. S., et al. (2020). Early detection of mild cognitive impairment with in-home sensors to monitor behavior patterns in community-dwelling senior citizens in Singapore: Cross-sectional feasibility study. *J Med Internet Res, 22*(5).
Rebok, G. W., Bylsma, F. W., Keyl, P. M., Brandt, J., & Folstein, S. E. (1995). Automobile driving in Huntington's disease. *Mov Disord, 10*(6), 778–787.
Reger, M. A., Welsh, R. K., Watson, G. S., Cholerton, B., Baker, L. D., & Craft, S. (2004). The relationship between neuropsychological functioning and driving ability in dementia: A meta-analysis. *Neuropsychology, 18*(1), 85–93.
Reitan, R. M., & Davidson, L. A. (Eds.). (1974). *Clinical neuropsychology: Current status and applications*. Washington, DC: Winston.
Rey, A. (1964). *L'examen clinique en psychologie* (2nd ed.). Paris: Presses Universitaires de France.
Rizzo, M., Reinach, S., McGehee, D., & Dawson, J. (1997). Simulated car crashes and crash predictors in drivers with Alzheimer disease. *Arch Neurol, 54*(5), 545–551.
Robertson, I. H., Ward, T., Ridgeway, V., & Nimmo-Smith, I. (1996). The structure of normal human attention: The Test of Everyday Attention. *J Int Neuropsychol Soc, 2*(6), 525–534.
Robertson, K., Schmitter-Edgecombe, M., Weeks, D., & Pimentel, J. (2018). Naturalistic assessment using a simulated environment: Cognitive correlates and relationship to functional status in individuals with neurologic conditions. *Arch Clin Neuropsychol, 33*(8), 1024–1039.
Roca, M., Torralva, T., Meli, F., Fiol, M., Calcagno, M., Carpintiero, S., et al. (2008). Cognitive deficits in multiple sclerosis correlate with changes in fronto-subcortical tracts. *Mult Scler, 14*(3), 364–369.
Rog, L., Park, L. Q., Harvey, D., Huang, C-J, Mackin, S., & Farias, S. T. (2014). The independent contributions of cognitive impairment and neuropsychiatric symptoms to everyday function in older adults. *Clin Neuropsychol, 28,* 215–236.
Rogers, W. A. (2008). Editorial. *J Exp Psychol-Appl, 14*(1), 1–4.

Rohde, T. E., & Thompson, L. A. (2007). Predicting academic achievement with cognitive ability. *Intelligence, 35*(1), 83–92.
Rothman, R. L., Montori, V. M., Cherrington, A., & Pignone, M. P. (2008). Perspective: The role of numeracy in health care. *J Hlth Commun, 13*(6), 583–595.
Royall, D. R., Lauterbach, E. C., Kaufer, D., Malloy, P., Coburn, K. L., & Black, K. J. (2007). The cognitive correlates of functional status: A review from the Committee on Research of the American Neuropsychiatric Association. *Journal of Neuropsychiatry and Clinical Neuroscience, 19*(3), 249–265.
Royall, D. R., Palmer, R., Chiodo, L. K., & Polk, M. J. (2005). Normal rates of cognitive change in successful aging: The freedom house study. *J Int Neuropsychol Soc, 11*(7), 899–909.
Rytsala, H. J., Melartin, T. K., Leskela, U. S., Sokero, T. P., Lestela-Mielonen, P. S., & Isometsa, E. T. (2005). Functional and work disability in major depressive disorder. *J Nerv Ment Dis, 193*(3), 189–195.
Satz, P. (1993). Brain reserve capacity on symptom onset after brain injury: A formulation and review of evidence for threshold theory. *Neuropsychology, 7,* 273–295.
Sawamura, D., Ikoma, K., Ogawa, K., & Sakai, S. (2018). Clinical utility of neuropsychological tests for employment outcomes in persons with cognitive impairment after moderate to severe traumatic brain injury. *Brain Inj, 32*(13–14), 1670–1677.
Sbordone, R. J. (1996). Ecological validity: Some critical issues for the neuropsychologist. In R. J. Sbordone & C. J. Long (Eds.), *Ecological validity of neuropsychological testing* (pp. 55–41). Delray Beach, FL: GR Press/St. Lucie Press.
Schanke, A. K., & Sundet, K. (2000). Comprehensive driving assessment: Neuropsychological testing and on-road evaluation of brain injured patients. *Scand J Psychol, 41*(2), 113–121.
Schmitter-Edgecombe, M., Cunningham, R., McAlister, C., Arrotta, K., & Weakley, A. (2021). The night out task and scoring application: An ill-structured, open-ended clinic-based test representing cognitive capacities used in everyday situations. *Arch Clin Neuropsychol, 36*(4), 537–553.
Schmitter-Edgecombe, M., & Farias, S. T. (2018). Aging and everyday functioning: Measurement, correlates and future directions. In G. E. Smith & S. T. Farias (Eds.), *APA handbook of dementia* (pp. 187–218). Washington, DC: American Psychological Association.
Schmitter-Edgecombe, M., & Giovannetti, T. (forthcoming). Measures of activities of daily living. In G. J. Boyle, Y. Stern, D. J. Stein, & B. Sahakian (Eds.), *The SAGE handbook of clinical neuropsychology* (Vol. 2). London: Sage.
Schmitter-Edgecombe, M., McAlister, C., & Greeley, D. (2021). A comparison of functional abilities in individuals with mild cognitive impairment and Parkinson's disease with mild cognitive impairment using multiple assessment methods. *J Int Neuropsychol Soc, 6*, 1–12.
Schmitter-Edgecombe, M., McAlister, C., & Weakley, A. (2012). Naturalistic assessment of everyday functioning in individuals with mild cognitive impairment: The day out task. *Neuropsychology, 26*(5), 631–641.
Schmitter-Edgecombe, M., Parsey, C., & Cook, D. (2011). Cognitive correlates of functional performance in older adults: comparison of self-report, direct observation and performance-based measures. *J Int Neuropsychol Soc, 17*(5), 853–864.
Schmitter-Edgecombe, M., Woo, E., & Greeley, D. (2009). Characterizing multiple memory deficits and their relation to everyday functioning in individuals with mild cognitive impairment. *Neuropsychology, 23,* 168–177.
Schretlen, D. (2005). *Brief Test of Attention.* Lutz, FL: Psychological Assessment Resources.
Schultheis, M. T., Garay, E., & DeLuca, J. (2001). The influence of cognitive impairment on driving performance in multiple sclerosis. *Neurology, 56*(8), 1089–1094.
Schwab, S. G., Plummer, C., Albus, M., Borrmann-Hassenbach, M., Lerer, B., Trixler, M., et al.

(2008). DNA sequence variants in the metabotropic glutamate receptor 3 and risk to schizophrenia: An association study. *Psychiatr Genet, 18*(1), 25–30.
Schwartz, M. F. (2006). The cognitive neuropsychology of everyday action and planning. *Cogn Neuropsychol, 23,* 202–221.
Schwartz, M. F., & Buxbaum, L. J. (1997). Naturalistic action. In L. G. Rothi & K. M. Heilman (Eds.), *Apraxia: The neuropsychology of action* (pp. 267–289). Hove, UK: Psychology Press.
Schwartz, M. F., Buxbaum, L. J., Ferraro, M., Veramonti, T., & Segal, M. (2003). *The Naturalistic Action Test.* Bury St. Edmunds, UK: Thames Valley Test Corporation.
Schwartz, M. F., Buxbaum, L. J., Montgomery, M. W., Fitzpatrick-DeSalme, E., Hart, T., Ferraro, M., et al. (1999). Naturalistic action production following right hemisphere stroke. *Neuropsychologia, 37*(1), 51–66.
Schwartz, M. F., Montgomery, M. W., Buxbaum, L. J., Lee, S. S., Carew, T. G., Coslett, H. B., et al. (1998). Naturalistic action impairment in closed head injury. *Neuropsychology, 12*(1), 13–28.
Schwartz, M. F., Segal, M. E., Veramonti, T., Ferraro, M., & Buxbaum, L. J. (2002). The Naturalistic Action Test: A standardized assessment for everyday-action impairment. *Neuropsychol, Rehabil, 12,* 311–339.
Seelye, A., Mattek, N., Sharma, N., Witter, P., Brenner, A., Wild, K., et al. (2017). Passive assessment of routine driving with unobtrusive sensors: A new approach for identifying and monitoring functional level in normal aging and mild cognitive impairment. *J Alzheimer's Dis, 59*(4), 1427–1437.
Semple, S. J., Patterson, T. L., & Grant, I. (2003). Binge use of methamphetamine among HIV-positive men who have sex with men: Pilot data and HIV prevention implications. *AIDS Educ Prev, 15*(2), 133–147.
Shallice, T. (1991). Higher-order cognitive impairments and frontal lobe lesions in man. In H. S. Levin, H. M. Eisenberg, & A. L. Benson (Eds.), *Frontal lobe function and injury* (pp. 125–138). Oxford, UK: Oxford University Press.
Shallice, T., & Burgess, P. W. (1991). Deficits in strategy application following frontal lobe damage in man. *Brain, 114*(Pt. 2), 727–741.
Sikkes, S. A., de Lange-de Klerk, E. S., Pijnenburg, Y. A., Scheltens, P., & Uitdehaag, B. M. (2009). A systematic review of Instrumental Activities of Daily Living scales in dementia: Room for improvement. *J Neurol Neurosurg Psychiatry, 80*(1), 7–12.
Silverberg, N. D., & Millis, S. R. (2009). Impairment versus deficiency in neuropsychological assessment: Implications for ecological validity. *J Int Neuropsychol Soc, 15*(1), 94–102.
Simons, J. S., Scholvinck, M. L., Gilbert, S. J., Frith, C. D., & Burgess, P. W. (2006). Differential components of prospective memory?: Evidence from fMRI. *Neuropsychologia, 44*(8), 1388–1397.
Sims, R. V., Owsley, C., Allman, R. M., Ball, K., & Smoot, T. M. (1998). A preliminary assessment of the medical and functional factors associated with vehicle crashes by older adults. *J Am Geriatr Soc, 46*(5), 556–561.
Sirigu, A., Zalla, T., Pillon, B., Grafman, J., Agid, Y., & Dubois, B. (1995). Selective impairments in managerial knowledge following pre-frontal cortex damage. *Cortex, 31*(2), 301–316.
Small, B. J., Jim, H. S. L., Eisel, S. L., Jacobsen, P. B., & Scott, S. B. (2019). Cognitive performance of breast cancer survivors in daily life: Role of fatigue and depressed mood. *Psycho-Oncology, 28*(11), 2174–2180.
Spooner, D. M., & Pachana, N. A. (2006). Ecological validity in neuropsychological assessment: A case for greater consideration in research with neurologically intact populations. *Arch Clin Neuropsychol, 21*(4), 327–337.
Stern, Y. (2003). The concept of cognitive reserve: A catalyst for research. *J Clin Exp Neuropsychol, 25*(5), 589–593.

Stern, Y., Barnes, C. A., Grady, C., Jones, R. N., & Raz, N. (2019). Brain reserve, cognitive reserve, compensation, and maintenance: Operationalization, validity, and mechanisms of cognitive resilience. *Neurobiol Aging, 83,* 124–129.

Sternberg, R. J., Grigorenko, E. L., & Bundy, D. A. (2001). The predictive value of IQ. *Merrill–Palmer Quart, 47*(1), 1–41.

Stolwyk, R. J., Charlton, J. L., Triggs, T. J., Iansek, R., & Bradshaw, J. L. (2006). Neuropsychological function and driving ability in people with Parkinson's disease. *J Clin Exp Neuropsychol, 28*(6), 898–913.

Stutts, J. C., Reinfurt, D. W., & Rodgman, E. A. (2001). The role of driver distraction in crashes: An analysis of 1995–1999 Crashworthiness Data System data. *Annu Proc Assoc Adv Automot Med, 45,* 287–301.

Szlyk, J. P., Myers, L., Zhang, Y., Wetzel, L., & Shapiro, R. (2002). Development and assessment of a neuropsychological battery to aid in predicting driving performance. *J Rehabil Res Dev, 39*(4), 483–496.

Tchanturia, K., Anderluh, M. B., Morris, R. G., Rabe-Hesketh, S., Collier, D. A., Sanchez, P., et al. (2004). Cognitive flexibility in anorexia nervosa and bulimia nervosa. *J Int Neuropsychol Soc, 10*(4), 513–520.

Toglia, J. P. (1993). *Contextual Memory Test.* San Antonio, TX: Pearson.

Tombaugh, T. (1997). *TOMM: Test of Memory Malingering manual.* Toronto: Multi-Health Systems.

Tupper, D. E., & Cicerone, K. D. (1990). Introduction to the neuropsychology of everyday life. In D. E. Tupper & K. D. Cierone (Eds.), *The neuropsychology of everyday life* (pp. 3–17). Boston: Kluwer.

Twamley, E. W., Woods, S. P., Zurhellen, C. H., Vertinski, M., Narvaez, J. M., Mausbach, B. T., et al. (2008). Neuropsychological substrates and everyday functioning implications of prospective memory impairment in schizophrenia. *Schizophr Res, 106*(1), 42–49.

Uc, E. Y., Rizzo, M., Anderson, S. W., Sparks, J. D., Rodnitzky, R. L., & Dawson, J. D. (2006a). Driving with distraction in Parkinson disease. *Neurology, 67*(10), 1774–1780.

Uc, E. Y., Rizzo, M., Anderson, S. W., Sparks, J., Rodnitzky, R. L., & Dawson, J. D. (2006b). Impaired visual search in drivers with Parkinson's disease. *Ann Neurol, 60*(4), 407–413.

Van Gorp, W. G., Rabkin, J. G., Ferrando, S. J., Mintz, J., Ryan, E., Borkowski, T., et al. (2007). Neuropsychiatric predictors of return to work in HIV/AIDS. *J Int Neuropsychol Soc, 13*(1), 80–89.

Van Zomeren, A. H., Brouwer, W. H., & Minderhoud, J. M. (1987). Acquired brain damage and driving: A review. *Arch Phys Med Rehabil, 68*(10), 697–705.

Weakley, A., Weakley, A. T., & Schmitter-Edgecombe, M. (2019). Compensatory strategy use improved real-world functional performance in community dwelling older adults. *Neuropsychology, 33,* 1121–1135.

Whelihan, W. M., DiCarlo, M. A., & Paul, R. H. (2005). The relationship of neuropsychological functioning to driving competence in older persons with early cognitive decline. *Arch Clin Neuropsychol, 20*(2), 217–228.

Wilson, B. A., Alderman, N., Burgess, P. W., Emslie, H., & Evans, J. J. (1996). *Behavioral Assessment of the Dysexecutive Syndrome (BADS).* Bury St. Edmunds, UK: Thames Valley Test Company.

Wilson, B. A., Cockburn, J., & Baddeley, A. D. (1985). *The Rivermead Behavioural Memory Test.* Reading, UK: Thames Valley Test.

Wilson, B. A., Cockburn, J. M., & Halligan, P. (1987). *The Behavioral Inattention Test.* Bury St. Edmunds, UK: Thames Valley Test.

Withaar, F. K., Brouwer, W. H., & van Zomeren, A. H. (2000). Fitness to drive in older drivers with cognitive impairment. *J Int Neuropsych Soc, 6*(4), 480–490.

Wobrock, T., Sittinger, H., Behrendt, B., D'Amelio, R., Falkai, P., & Caspari, D. (2007). Comorbid substance abuse and neurocognitive function in recent-onset schizophrenia. *Eur Arch Psychiatry Clin Neurosci, 257*(4), 203–210.

Woods, S. P., Carey, C. L., Moran, L. M., Dawson, M. S., Letendre, S. L., & Grant, I. (2007). Frequency and predictors of self-reported prospective memory complaints in individuals infected with HIV. *Arch Clin Neuropsychol, 22*(2), 187–195.

Woods, S. P., Iudicello, J. E., Morgan, E. E., Cameron, M. V., Doyle, K. L., Smith, T. V., et al. (2016). Health-related everyday functioning in the Internet age: HIV-associated neurocognitive disorders disrupt online pharmacy and health chart navigation skills. *Arch Clin Neuropsychol, 31*(2), 176–185.

Woods, S. P., Iudicello, J. E., Morgan, E. E., Verduzco, M., Smith, T. V., Cushman, C., et al. (2017). Household everyday functioning in the internet age: Online shopping and banking skills are affected in HIV-associated neurocognitive disorders. *J Int Neuropsychol Soc, 23*(7), 605–615.

Woods, S. P., Iudicello, J. E., Morgan, L. M., Carey, C. L., Dawson, M. S., & Grant, I. (2008). HIV-associated prospective memory impairment increases risk of dependence in everyday functioning. *Neuropsychology, 22*(1), 110–117.

Woods, S. P., Morgan, E. E., Dawson, M., Scott, J. C., Grant, I., & the HNRC Group. (2006). Action (verb) fluency predicts dependence in instrumental activities of daily living in persons infected with HIV-1. *J Clin Exp Neuropsychol, 28*(6), 1030–1042.

Woods, S. P., Twamley, E. W., Dawson, M. S., Narvaez, J. M., & Jeste, D. V. (2007). Deficits in cue detection and intention retrieval underlie prospective memory impairment in schizophrenia. *Schizophr Res, 90*(1–3), 344–350.

Woods, S. P., Weinborn, M., Velnoweth, A., Rooney, A., & Bucks, R. S. (2012). BRIEF COMMUNICATION Memory for intentions is uniquely associated with instrumental activities of daily living in healthy older adults. *J Int Neuropsychol Soc, 18,* 134–138.

Worringham, C. J., Wood, J. M., Kerr, G. K., & Silburn, P. A. (2006). Predictors of driving assessment outcome in Parkinson's disease. *Mov Disord, 21*(2), 230–235.

Zaidi, S., Kat, M. G., & de Jonghe, J. F. (2014). Clinician and caregiver agreement on neuropsychiatric symptom severity: A study using the Neuropsychiatric Inventory - Clinician rating scale (NPI-C). *Int Psychogeriatr, 26*(7), 1139–1145.

Ziemnik, R. E., & Suchy, Y. (2019). Ecological validity of performance-based measures of executive functions: Is face validity necessary for prediction of daily functioning?. *Psychol Assess, 31*(11), 1307–1318.