ELSEVIER

Archives of Clinical Neuropsychology 22 (2007) 389–404

Archives of CLINICAL NEUROPSYCHOLOGY

Neuropsychological assessment of persons with physical disability, visual impairment or blindness, and hearing impairment or deafness

Felicia Hill-Briggs [a,*], Jack G. Dial [b], Donna A. Morere [c], Arthur Joyce [d]

[a] *Johns Hopkins School of Medicine, Baltimore, MD, United States*
[b] *Clinical and Consulting Neuropsychology, Irving, TX, United States*
[c] *Gallaudet University, Washington, DC, United States*
[d] *North Texas State Hospital, Vernon, TX, United States*

Downloaded from https://academic.oup.com/acn/article/22/3/389/2947 by guest on 19 April 2024

Abstract

Conducting assessment with individuals with physical disability, visual impairment or blindness, and hearing impairment or deafness poses significant challenges for the neuropsychologist. Although standards for psychological testing have been devised to address assessment of persons with disabilities, little research has been conducted to validate neuropsychological test accommodation and modification practices that deviate from standard test administration or to develop test parameters and interpretive guidelines specifically for persons with different physical or sensory disabilities. This paper reviews issues pertaining to neuropsychological test selection and administration, common accommodation and modification practices, test development and validation, and disability-related factors that influence interpretation of test results. Systematic research is needed to develop methodological parameters for testing and to ensure reliable and valid neuropsychological assessment practices for individuals with physical or sensory disabilities.
© 2007 National Academy of Neuropsychology. Published by Elsevier Ltd. All rights reserved.

Keywords: Accommodation; Functional status; Testing

1. Introduction

Persons with physical or sensory disabilities constitute groups requiring specialized standards of practice for assessment (American Educational Research Association, American Psychological Association, National Council on Measurement in Education; AERA, APA, NCME, 1999). Increasing rates of disability and increased access to health services for persons with disabilities (O'Keefe, 1994) make this issue salient for neuropsychologists working in clinical assessment and intervention settings. Prevalence of disability differs by race/ethnicity and is highest among African Americans (24.3%), American Indians and Alaska Natives (24.3%), and Hispanics and Latinos of any race (20.9%) (U.S. Census Bureau, 2000). Disability is most prevalent (41.9%) among persons 65 years of age and older. In the general population, an estimated 21.2 million people (8.2%) specifically have a physical disability, defined as limitation in basic physical activities, such as walking, climbing stairs, reaching, lifting, or carrying, and an estimated 9.3 million people (3.6%) have a sensory disability, defined as limitations in sight or hearing (U.S. Census Bureau, 2000).

* Corresponding author at: Department of Medicine, 2024 E. Monument Street, Baltimore, MD 21205, United States. Tel.: +1 410 502 2064; fax: +1 410 955 0476.

E-mail address: fbriggsh@jhmi.edu (F. Hill-Briggs).

0887-6177/$ – see front matter © 2007 National Academy of Neuropsychology. Published by Elsevier Ltd. All rights reserved.
doi:10.1016/j.acn.2007.01.013

In many clinical settings in which neuropsychologists practice, rates of physical and sensory disability are significantly higher than in the general population (Garahan, Waller, Houghton, Tisdale, & Runge, 1992; Iezzoni, McCarthy, Davis, & Siebens, 2001; Park, Mayer, Moghimi, Park, & Deremeik, 2005; Wainapel, Kwon, & Fazzari, 1989). When an individual presents with physical or sensory disability that impacts test-taking, testing standards and nondiscrimination policies for persons with disabilities necessitate that the clinician ensure fairness and accuracy in test administration and interpretation (AERA, APA, NCME, 1999; Nester, 1998). Neuropsychologists are confronted with challenges in selecting tests, modifying test administration to accommodate disability, and interpreting results from nonstandard test administration.

This paper reviews key issues pertaining to administration and interpretation of neuropsychological evaluations conducted on persons with physical or sensory disability. Specific issues addressed are: (a) testing accommodation and modification practices for persons with physical disabilities; (b) test development, norming, and interpretation issues for persons with visual impairment or blindness; and (c) communication modes, use of interpreters, and test selection and interpretation considerations for persons with hearing impairment or deafness.

2. Neuropsychological assessment of persons with physical disability

Physical disabilities that result from a congenital condition (e.g. cerebral palsy), an illness or disease affecting the brain, nerves, or muscles (e.g. multiple sclerosis, amyotrophic lateral sclerosis); an injury to the brain, spine, or limb (e.g. spinal cord injury, stroke); or limb loss (e.g. amputation) can impact the extent to which an individual can perform standardized neuropsychological tests and batteries. In particular, impairment or complete loss of motor function in the upper extremities, impacting fine motor control and dexterity, will reduce response format options due to impairment in such functions as picking up objects, gripping or otherwise manually manipulating stimuli; pointing; holding a writing utensil; writing, copying, or drawing. If the purpose of testing is to determine extent to which the physical disability impacts performance of tasks, or when the physical disability is itself being evaluated, then test modification is not appropriate. However, when the physical disability is not the focus of the evaluation, but the standard test administration requires motor skills that are impacted by the physical disability, then alternate means of assessing cognitive functions are necessary (Nester, 1994). Issues related to such a accommodation and modification are addressed.

2.1. Accommodation and modification

Accommodations include modifying test presentation format, response format, timing, and test selection (AERA, APA, & NCME, 1999). Unfortunately, methodological research on test accommodations and modifications for mobility disabilities is sparse, in part because historically, modifications for physical disability have been considered less problematic than those for visual or auditory disability (Lezak, Howieson, & Loring, 2004). Clinical judgement and experience have led to several common practices for test accommodation and modification (Pratt & Moreland, 1998), which are presented in Table 1. Included in test accommodations are test setting and environment, which may require modification for accessibility and physical comfort for problems associated with the physical disability (AERA, APA, NCME, 1999; Pratt & Moreland, 1998).

Research with spinal cord injury (SCI) patients with complete or incomplete paraplegia and quadriplegia provides examples of test selection and modification for motor-free neuropsychological assessment (Davidoff, Roth, & Richards, 1992; Dowler et al., 1997; Richards, Bown, Hagglund, Bua, & Reeder, 1988; Roth et al., 1989). Tests frequently selected for inclusion in comprehensive batteries in these studies included: Wechsler Memory Scale (WMS) omitting visual reproduction, Wechsler Adult Intelligence Scale (WAIS) verbal subtests, Symbol Digit Modalities Test, Stroop Test, Rey Auditory Verbal Learning Test; California Verbal Learning Test, Benton Visual Retention Test, Benton Facial Recognition Test, Halsted Category Test, Judgement of Line Orientation, Hooper Visual Organization Test, and Controlled Oral Word Association Test. Dowler and colleagues (1997) included the Wisconsin Card Sorting Test, modified for quadriplegic patients by having the examiner perform the incidental motor skill needed based on the verbal response given by the patient. These SCI studies have accommodated through test selection, administration, and response format modifications.

Downloaded from https://academic.oup.com/acn/article/22/3/389/2947 by guest on 19 April 2024

Table 1
Common testing accomodations and modifications for motor impairment or disability

Affected Motor Function	Examples of Accomodation and Test Modification
Motor Impairment or Disability Affecting Hand Use	Test Administration[a]
	■ Adjustment of time limits and avoidance of speed tests
	■ Administration of portion of test that does not require skills affected by disability (e.g. administer WAIS-III verbal subtests and Matrix Reasoning, omitting other performance subtests; WMS-III primary subtests, omitting Spatial Span and optional Visual Reproduction)
	■ Oral administration and responding rather than self-administration (e.g. BDI, BAI)
	■ Substitution of tests that do not require motor response (e.g. TICS; SDMT; Ammons Quick Test, Ravens Progressive Matrices; Motor-Free Visual Perception Test; TONI)
	Response Format
	■ Use of adaptive equipment to facilitate motor responding when there is residual motor function (e.g. pen and pencil grips, handles, or clips; weighted writing utensil holders; hand weights for wrists; paper/document holders)
	■ Use of adaptive equipment to compensate for absent motor response (e.g. head stick, light beam, switching mechanism)
	■ Use of an unaffected nondominant hand
Associated Problems	Test Setting Accomodations
Pain, Fatigue	■ Rest breaks and positioning changes
	■ Schedule during optimal time of day with regard to physical discomfort
	■ Schedule brief sessions
	■ Provision of seating options (e.g. hard or soft seat, arm chair, availability of foot rest for elevation) for non-wheelchair or persons preferring to transfer from wheelchair during testing
Accessibility	■ Width and length of table sufficient for ease of reach, resting of affected hand/arm, arm braces/splints
	■ Table with tilt and fasteners to hold materials to be viewed in place
	■ Accessible test location with accessible ancillary facilities (building, restroom, cafeteria/eating area)
	■ Room size to accommodate wheelchairs
	■ Adjustable table height to accommodate wheelchair size

[a] Tests selected as examples describe the identified accommodation/modification as allowable for persons with motor or related impairment in the administration manuals; normative data on the modifications are not available. BDI = Beck Depression Inventory, BAI = Beck Anxiety Inventory, TICS = Telephone Interview for Cognitive Status, TONI = Test of Nonverbal Intelligence, SDMT = Symbol Digit Modalities Test, WAIS-III = Wechsler Adult Intelligence Test, 3rd ed., WMS-III = Wechsler Memory Scale, 3rd ed.

2.2. *Accomodation/modification and test validity and reliability*

Standards for testing persons with disabilities recommend that: (a) test modifications be piloted prior to clinical use; (b) test developers describe permissible test modifications in their manuals; (c) data regarding their validity be presented when it is available; and (d) test publishers conduct empirical investigations of test use with persons with disabilities (AERA, APA, & NCME, 1999). However, to date, standardized neuropsychological tests have not provided data related to test use with persons with disabilities (Smith & Stovall, 2002). Difficulties in conducting research to develop validity and normative data for test modifications include heterogeneity among persons with disability and difficulty obtaining sufficiently large sample sizes (AERA, APA, & NCME, 1999). As a result, normative data or "standard" modification recommendations (for example, specific time limit extension recommendations) to provide parameters for accommodation and modification use, are not available. Tests including the WAIS-III and the WMS-III, for example, note permissibility of accommodation and modification for differing disabilities (e.g. omitting subtests) but caution the user that no normative data exist for the modifications described (Wechsler, 1997a; Weshsler, 1997b).

One accomodation that has been the focus of research in early studies is use of an unimpaired nondominant hand during testing. Studies using volunteers with normal hand function demonstrated that the Digit Symbol test of the WAIS was invalidated if completed with the nondominant hand (Briggs, 1960). However, performance of mazes with the nondominant hand was accurate and valid, but of poor quality (Briggs, 1963). Studies of patients with unilateral lesions revealed that nondominant hand use did not significantly increase number of errors on the Benton Visual Retention Test (Dee & Fourtnoy, 1969; Dee, 1970).

Downloaded from https://academic.oup.com/acn/article/22/3/389/2947 by guest on 19 April 2024

2.3. Influence of etiology and comorbidities on neuropsychological test performance

Etiology of physical disability, and comorbid conditions related or unrelated to the etiology, jointly impact neuropsychological performance. For example, cerebral palsy often has comorbid learning disability (e.g. Shapiro, 2004). In SCI, premorbid alcohol abuse (Tate, Forchheimer, Krause, Meade, Bombardier, 2004; Turner, Bombardier, & Rimmele, 2003) and comorbid traumatic brain injury (Macciocchi, Bowman, Coker, Apple, & Leslie, 2004) can impact neuropsychological performance. In the case of stroke, a common etiology is diabetes, an independent risk factor for CNS dysfunction and neuropsychological impairment (e.g. Kuo et al., 2005; Yaffe et al., 2004), and impaired motor performance due to peripheral neuropathy (Mooradian, 1997). It is important not to attribute performance decrements in speed or control solely to test modifications (such as use of nondominant hand or adaptive equipment), when a true performance decrement may exist due to a comorbid condition. Such factors related to etiology and comborbidity necessitate caution especially if the clinician accommodates disability by omitting tests/domains when performing evaluations on patients with specific physical disabilities.

2.4. Interpretation and documentation

Clinical interpretation of test results should reflect the neuropsychologist's comprehensive analysis of etiology, age at onset, extent of disability/level of functioning, comorbid conditions, and how these factors, independently and in combination, impact neuropsychological performance. It is important to interpret findings in the context of the test administration procedures or response formats used. Interpretation should also incorporate any physical discomfort or distress at the time of testing. When significant modification for physical disability is used, it is helpful to supplement neuropsychological testing with functional tests to observe hypotheses in daily-living contexts (Holm & Rogers, 1998).

Legal policy regarding fairness in testing for individuals with disabilities necessitated standards regarding reporting of modifications and flagging of scores obtained from modified procedures (AERA, APA, & NCME, 1999). If permissible by law, the specific test accommodations and modifications are reported (e.g. time extension, use of nondominant hand) only if results obtained from using the nonstandardized procedures are deemed different from the results that would have been obtained without accommodation (AERA, APA, & NCME, 1999). Finally, the clinician is well served by stating clearly in the report the multiplicity of contributors to neuropsychological results and the perhaps several hypotheses that may exist. Further research to validate or standardize accommodation and modification strategies is needed for clearer interpretation of results when nonstandard procedures have been used for physical disability.

3. Neuropsychological assessment of persons with visual impairment or blindness

Numerous issues confront the neuropsychologist when evaluating a person with significant visual impairment or blindness (VI/B) (MacCluskie, Tunick, Dial, & Paul, 1998; Miller & Skilllman, 2003; Joyce, Isom, Dial, & Sandel, 2004). Research conducted in developing the Comprehensive Vocational Education System (CVES), a neuropsychological-based battery of tests and rating scales used in clinical, vocational and educational assessment of persons with VI/B, highlights problems and solutions in neuropsychological testing with persons with VI/B (Dial et al., 1991). Problems include: (a) limitations in test adaptation and development; (b) impact of heterogeneity of the population on test norming; and (c) impact of level of visual functioning, age at onset, and etiology on interpretation of neuropsychological performance.

3.1. Limitations in test adaptation and development for persons with VI/B

Although a variety of perceptual-motor tests, such as the Tactual Performance Test (TPT), Grip Strength (GS) and Finger Oscillation (FO) subtests from the Halstead-Reitan Battery (HRB) can and have been used to assess individuals with visual-impairments or blindness, very little success has been achieved in non-verbal cognitive or memory assessment with this population (Reitan & Davison, 1974; Reitan & Wolfson, 1993; Bigler & Tucker, 1981). Tests that can be administered without the need for vision (i.e., TPT, GS, FO, etc.) unfortunately lack sufficient or appropriate norms for this population. Although there have been significant contributions from individual clinicians and researchers (Mangiameli, Roderick, Moses, & Dohen, 1999; Mangiameli & Peters, 1998), issues regarding the availability of sufficient numbers of blind subjects for norming tests and methods for controlling for residual vision have

Downloaded from https://academic.oup.com/acn/article/22/3/389/2947 by guest on 19 April 2024

impacted commercial test development. Systematic dissemination and use of historical adaptations of performance items from the Standford-Binet or Wechsler Scales (e.g., Hayes-Binet & Perkins-Binet) have been hindered because these instruments were mainly limited to small normative samples of blind children, many of which had secondary disabilities (Gutterman, Ward & Genshaft, 1985). In all cases, these instruments experienced commercial failure, with minimal distribution to the field. Even the perceptual-motor tests and limited cognitive tests (Haptic version of the Ravens Progressive Matrices; Rich & Anderson, 1965) that do not require vision for administration have had limited contribution to neuropsychological assessment of persons with visual-impairment or blindness for a variety of reasons that extend beyond the concept of "vision," per se (Price, Mount & Coles, 1987; Kaskel, 1994).

3.2. The Comprehensive vocational evaluation system battery

To address these historical limitations in use and adaptations of standard instruments, the development of the CVES battery was undertaken for use with VI/B populations. Development of the system commenced in 1981 and research

Table 2
Tests comprising the Comprehensive Vocational Evaluation System (CVES) Battery and necessary accommodations for persons with visual impairment or blindness

Factor	Tests	Accomodations
Verbal–Spatial Cognitive Factor	Wechsler Verbal Scales (WAIS III, WISC III, WISC IV)	Regular and VI/B norms. No procedural or structural adaptations necessary
	Cognitive Test for the Blind (CTB)	VI/B norms. No procedural or structural adaptations necessary
	■ Verbal Scales (Auditory Analysis, Immediate Digit Recall, Language Comprehension and Memory, Letter-Number Learning and Vocabulary)	
	■ Performance Scales (Category Learning, Category Memory, Memory Recognition, Spatial Pattern Recall and Spatial Analysis)	VI/B norms. Textured and raised rubber stimulus materials; response board, and screen to control residual functional vision
	Wide Range Achievement Test (WRAT 3)	VI/B norms. Regular, Large print or Braille reading (according to functional vision); regular or oral spelling; large print or oral arithmetic
Perceptual (Sensory) Motor Factor	Haptic Sensory Discrimination Test (HSDT)	VI/B norms. Textured and raised rubber stimulus materials; response board; screen to control residual functional vision; alternate (hands-on) methods of demonstration and instruction
	■ Discrimination and Immediate recall of shapes, sizes, textures and spatial configurations	
	McCarron Assessment of Neuromuscular Development (VI/B Version) (MAND VI):	
	■ Fine Motor Scales (Beads-in-Box, Beads on Rod, Finger-Tapping, Nut & Bolt and Rod Slide)	VI/B norms. Some subtests performed with eyes closed to control for residual functional vision; and alternate (hands-on) methods of demonstration and instruction.
	■ Gross Motor Scales (Hand Strength, Finger-Nose-Finger, Jumping, Heel-Toe-Walk and Standing on One Foot.	VI/B norms. Some subtests performed with eyes closed to control for residual functional vision; raised rubber or cloth line for gross coordination subtest; and alternate (hands-on) methods of demonstration and instruction
Emotional–Coping Factor	Observational Emotional Inventory – Revised (OEI-A)	VI/B Norms
	Emotional–Behavioral Checklist (EBC)	VI/B Norms
	Minnesota Multiphasic Personality Inventory (MMPI-2 or A)	Tape, Oral, Large print or CCTV issues regarding presentation; interpretation in persons with chronic disabilities
	Rotter Incomplete Sentence Blank (RISB)	Oral, Large print or CCTV presentation
	Beck Depression and Beck Anxiety Inventories (BDI and BAI)	Oral, Large print or CCTV presentation
	Survey of Functional Adaptive Behavior (SFAB)	VI/B norms. Interview and behavioral observations

Downloaded from https://academic.oup.com/acn/article/22/3/389/2947 by guest on 19 April 2024

on the battery continues, with a total of 1794 cases to date in the development sample. The CVES measures three primary neuropsychological factors: verbal-spatial cognitive abilities (VSC); perceptual-motor functions (PM); and emotional-coping concerns (EC). Tests comprising the CVES battery, and accommodations utilized, are shown in Table 2. Findings from initial investigation of the CVES (Chan, Lynch, Dial, Wong, & Kates, 1993; Dial et al., 1991; Kasker, Dial, Chan, & Roldan, 1991) demonstrate its utility with VI/B populations.

3.3. Impact of VI/B population heterogeneity on norming neuropsychological tests

Special consideration must be given to defining an appropriate normative sample when adapting existing non-visual tests or developing special instrumentation for the VI/B population. A significant error is to conceptualize the "blind population" from a single homogenous disability perspective. Although it is true that this "population" has rallied as "one" around many legislative, advocacy and program issues, it is quite diverse in all other respects. The only common denominator in this population is some level of vision loss that is functionally restrictive. There are numerous specific etiologies of visual-impairment/blindness, including congenital and acquired causes resulting from disease or trauma, and a large percentage of individuals present with multiple etiologies of their visual loss. In the CVES sample, 25 different etiologies were present, with nystagmus/strabismus ($n=290$, 16.2%), optic atrophy, hydroplasia ($n=260$, 14.5%), diabetes ($n=251$, 14.0%), glaucoma ($n=214$, 11.9%), cataracts ($n=210$, 11.7%), and retinitis pigmentosa ($n=184$, 10.3%), the most prevalent. Multiple etiologies were present in 35% of the sample.

Persons with VI/B differ in age at onset, level of visual impairment, and nature of the vision loss. In the CVES sample 56% of the cases were congenital-birth to 1 year, 11 months; 8% were early blind (2 years to 5 years, 11 months); 9% were school age (6 years to 17 years, 11 months); and 27% were adults (18 years and older). With regard to level of vision loss, 18% of the cases were classified "visually-impaired;" 71% "Legally Blind;" and 11% "Totally Blind." However, any two individuals with the same optical refraction (i.e., 20/200 OU) may see differently (e.g. one may read regular print and the other cannot read even enlarged print). These factors significantly interact to determine not only residual functional vision, if any, but also performance on neuropsychological tests assessing major higher cortical functions.

Heterogeneity is further increased by presence of comorbidities or secondary disabilities that may be associated with or completely independent from the etiology of vision loss. During the normative data collection for the CVES battery, 75% of VI/B persons presenting for a general vocational or psychological evaluation had one or more additional disabilities (e.g. physical disability, hearing disability, learning disability) or diagnosed medical conditions (e.g. peripheral neuropathy, hypertension). Moreover, of the first 1000 cases tested, 44% had profiles consistent with neuropsychological disorder (Rabeck, 1994; Dial, Chan, Tunick, Gray, & Marme, 1991). Presenting neurological diagnoses included seizure disorder, closed head injury, cerebral palsy, penetrating head injury, tumor, degenerative disease, and anoxia.

During the development of the CVES, it was decided that the most appropriate VI/B reference group for norm development would be that portion of the entire VI/B sample that had no other disability or medical condition aside from visual-impairment or blindness (about 25%). This approach was selected in order to increase the sensitivity of the battery to detect other conditions that would likely exist in those persons referred for evaluation in the clinical setting; in fact, this was later verified in research and practice (Nelson, Dial, & Joyce, 2002; Dial et al., 1990). Neuropsychological tests that do not take into account the significant number of persons with higher cortical dysfunction in the general VI/B population and are, consequently, normed on that general population will, de facto, suffer from poor sensitivity in detecting brain related disorders.

3.4. Level of visual functioning, age at onset, etiology and test interpretation

The interacting effects on test performance of level of visual functioning, age at onset, and etiology need to be understood for test interpretation and for eventual consideration in the norming process. In a study by Hupp (2003), sighted and totally blind adults performed significantly better on the WAIS VIQ than did the group of legally blind persons. Furthermore, the congenital onset group (onset within the first two years of age) performed significantly better than all other groups (congenital: 0–1 year, 11 months; early: 2–5 years, 11 months; school age: 6–17 years, 11 months; and adults: 18 years and above) on tests of immediate and working verbal memory. Congenitally blind persons also significantly outperformed other groups on tests of haptic non-verbal abstract learning and rote verbal learning (the CTB from the CVES battery). In contrast, an earlier study by MacCluskie et al. (1998) utilizing a smaller sample attributed

Downloaded from https://academic.oup.com/acn/article/22/3/389/2947 by guest on 19 April 2024

differences in verbal conceptualization (WAIS-R VIQ subtest) between early and late onset blindness (congenital vs. adult) to the interaction effects of education. Therefore, research and development of neuropsychological tests for use with this population should consider this issue in the norming and interpretive processes. Joyce et al. (2004) studied the effect of age at onset and level of visual functioning on perceptual motor functions (the HSDT and MAND-VI from the CVES battery). Results of this study (with adults) indicate that persons who became blind earlier in life had better shape and texture discrimination abilities than person who became blind as adults. Furthermore, individuals who were totally blind outperformed those who retained functional vision. Several small magnitude, but nevertheless significant differences were also observed in motor function. For example, the adult onset group performed better than the early onset group on measures of persistent motor control, while the school age onset group outperformed the early onset group on a measure of bimanual dexterity.

Etiological differences in VI/B have been observed to impact neuropsychological test performance in two studies. Nelson, O'brien, Dial, & Joyce (2001) compared three groups representing major etiologies of blindness; e.g., Retinopathy of Prematurity (ROP), Retinitis Pigmentosa (RP) and Congenital Cataracts (CC). The authors conjectured that the ROP group by virtue of early birth would likely demonstrate the greatest level of impairment on cognitive and perceptual motor measures compared to the CC or RP groups. Significant differences in the predicted direction were observed on neuropsychological measures of spatial analysis and auditory analysis (CVES Cognitive Factor), as well as, hand strength (PM Factor). McGee (1994) compared a group of individuals with diabetes to a non-diabetic "normal" group. The results revealed significant lateralized deficits in perceptual-motor functions on the left side of the body in the diabetic group with corresponding non-verbal in contrast to verbal-cognitive deficits. A post hoc examination of the data revealed that 50% of the diabetic group demonstrated the aforementioned neuropsychological profile suggesting right parietal dysfunction. This subgroup was characterized by an average diabetic chronicity of 15 years and as having one or more of the following: peripheral neuropathy; hypertension; and/or early stage renal failure. Considering these preliminary findings in concert with the Nelson et al. (2001) results, the neuropsychologist should consider the potential confound of etiology, in addition to age at onset and level of visual functioning, when interpreting test results for persons who have visual disabilities.

In summary, experience gained through ongoing development of the CVES battery has identified numerous issues related to the neuropsychological assessment of persons with visual impairment or blindness, including lack of appropriate instrumentation; misconceptualization of the population as homogeneous; absence of well defined norms for most instruments; and the failure to recognize the potential effects of such variables as age at onset, level of visual functioning, etiology, and comorbidity on the interpretation of neuropsychological tests. Even those traditional neuropsychological tests that can be administered without vision should be interpreted in the context of these issues and, likely, others yet to be identified.

4. Neuropsychological assessment of persons with hearing impairment or deafness

In general, standardized test administration is broken when testing deaf and hard of hearing individuals due to the very nature of the accommodations needed for communication (Braden, 1994; Maller, 2003). The impact of linguistic mediation, instructions, and other factors cause this to alter the task demands and the outcomes on a variety of tasks. The most significant impact on assessment occurs with severe and profound hearing loss; however, any degree of hearing loss can affect functioning and test performance (Braden, 1994). Described herein are (a) demographic factors that impact development and communication in individuals with hearing loss or deafness; (b) issues of test selection and test administration; (c) use of interpreters; and (d) factors influencing test interpretation.

4.1. Communication mode and test administration

Oral assessment of a deaf individual who typically uses ASL or another form of visual communication is never acceptable, even if the person appears to have adequate oral skills. A person who typically communicates orally in informal settings may also have a need for an oral or sign interpreter for testing. Speechreading is essentially a product of informed guessing based on the incomplete information on the lips and the person's knowledge of the language; about 50% of information is visible on the mouth, with many phonemes appearing identical (e.g. p, b, m). Speechreaders often need to cognitively review speech they have seen before they are able to understand what was said (de Filippo, 1981). Thus, if tests are administered orally, response delays may be due to the cognitive review, and errors may

Downloaded from https://academic.oup.com/acn/article/22/3/389/2947 by guest on 19 April 2024

be based on either phonemic overlap of information resulting in speechreading errors, the increased cognitive load involved in having to review the information while trying to find an appropriate linguistic match, problems with the instructions for the task, or an actual task error.

Instructions should be given in the preferred communication mode of the patient, and modeling or extra practice trials may be needed to ensure the task is understood. If the patient responds orally, caution must be used to avoid scoring articulation errors. Visual distractions are more problematic for the deaf individual than for the typical patient, and should be minimized. Most deaf individuals do have some residual hearing, so auditory distractions should also be avoided. Moreover, on perceptual-motor tasks, it should be noted that asking a deaf person to close their eyes or wear a blindfold is problematic, as it cuts them off from communication. Alternatives, such as barriers, should be used when possible.

4.2. Use of interpreters

While it is always preferable to have the assessment performed by a clinician fluent in the language/communication mode of the patient, when this is not possible, a certified interpreter with experience in mental health interpreting (Vernon & Miller, 2001) should be used. It is critical to understand the linguistic diversity that exists within the deaf community. Not all signing is American Sign Language (ASL); signing skills, dialects, and approaches vary widely (Miller & Vernon, 2001). An interpreter must be able to sign (or use Cued Speech) in a manner accessible to the patient. In addition, the clinician should understand the nature of interpreting. If the task is to interpret from the English stimuli to ASL, the interpreter must alter the stimuli, as the grammar and syntax of ASL are different than English. Additionally, there are many words that do not have sign equivalents; therefore, the interpreter must either fingerspell the word, providing the patient with an English word with which they may not be familiar and by nature transforming a portion of the test into the person's second language, or explain the word. In the latter case, the interpreter must convey to the patient his or her own understanding of the word. Often, entire sentences or sets of instructions must be cognitively processed by the interpreter and then conveyed to the patient. This may place some of the task demands on the interpreter rather than the patient. Additionally, for culturally deaf individuals, the interpreter must adjust the information to make it accessible in the context of that culture; more information may be needed than a literal translation in order to ensure understanding.

In some cases interpretation of test questions provides too much rather than too little information. For example, "point to your nose" is indicated in ASL by the "speaker" pointing to his nose and indicating that the person do the same. In general, body parts are indicated by pointing to that location on the speaker's own body, thus giving answers or altering the task for items such as on measures of praxis. Direct interpretation of test stimuli can often alter the task for a range of measures. For example, if a sentence memory task is administered, it can be administered by using ASL signs in English word order to retain the structure of the task; however, that increases task difficulty for the patient for whom ASL is the primary language. This is comparable to testing a Spanish-speaking individual using Spanish words provided in English word order for the task and expecting accurate English word order in the response. If the sentences are interpreted to ASL, the hierarchical length and complexity across items is lost, and it is difficult to score a response dependant on first interpretation to the patient and then their response having been interpreted from ASL to English for the examiner. An interpreter who does not recognize the significance of preserving the quality of the language may "clean up" the language of the individual during the interpreting process, leaving the clinician with altered information, and resulting in inappropriate diagnostic conclusions and recommendations.

4.3. Selection of appropriate tests and test usage

Examples of commonly-used tests with hearing impaired and deaf persons are presented in Table 3. The neuropsychologist, however, must be aware of several critical issues when choosing tests. First, cognitive measures that are heavily loaded for verbal skills are not appropriate measures for deaf individuals. For example, the Wechsler verbal scales are problematic because, even with interpretation, they depend on both knowledge of English and a knowledge base that has often been diminished due to problems with access. Historically, clinicians have used the Wechsler scales with deaf individuals (Braden, 1994) by basing their estimate of intelligence on the Performance Scales. While this may provide an adequate estimate for typically functioning deaf individuals, the neuropsychologist must consider the fact that it represents only half of the test, and is thus vulnerable to significant under- or over-estimates of cognitive

Downloaded from https://academic.oup.com/acn/article/22/3/389/2947 by guest on 19 April 2024

Table 3
Commonly-used tests with deaf or hard of hearing individuals and limitations regarding use

Functional Area	Measure	Limitations and Precautions
Intellectual Assessment	WAIS-III, CTONI, WJ-III or UNIT	Use of performance subtests yields only estimates based on functional areas assessed. Use of verbal scales/tests should be restricted to knowledgeable clinicians
Executive Functioning	D-KEFS	Many subtests are not appropriate. Consider individual tests
	Ruff Figural Fluency	Alternative to word fluency tasks
	Word fluency tasks	Select categorical rather than letter, unless individual has high level English skills
	Five Digit Test	Currently under investigation as alternative to the Stroop
	WCST, Towers of Hanoi	Clinical data appear to be comparable with deaf, but instructions may be problematic
	Color Trails	Preferred to standard trails due to variable alphabetic automaticity
	WJ-III Planning, a maze task	Clinical data appear to be comparable for deaf
Fluid Reasoning	Spatial reasoning tasks preferred	Influence of language on instructions and cognitive mediation
Working Memory	Digit Span tasks	Be aware that deaf signers average a forward span of about 5 with equivalent forward and reverse spans
	Visual Span (WAIS-III)	Deaf signers tend to equal or exceed hearing norms
Memory	WMS-III	Some subtests not appropriate. Careful use of visual tasks that have verbal responses or mediation
	WJ-III Visual-Auditory Learning	Is readily signed. English grammar impact
	An object recognition task and a design recall task	Both abstract and concrete visual memory should be evaluated
	Word memory tasks	Some words may need to be modified for signing. Concrete objects are best, but iconicity of signs should be considered. See text
	Sentence recall tasks	English word order is problematic. If used, interpret relative to English skills
	Story recall tasks	Modify signing style to match client, score flexibly and examine the organization of the response
	Signed Paired Associates	Alternative to paired associates
Attention	standard visual scanning and attention tasks	Symbol or object tasks rather than letters. Numbers may be appropriate depending on the individual
	T.O.V.A., CPT II	Inconsistent data with deaf. Interpret with caution
Perceptual – Motor	Standard tasks can be used, but caution must be used with instructions	Be aware that asking a deaf person to close their eyes or wear a blindfold is to cut them off from communication. Use of barriers is preferred
Visual–Motor	Standard visual-motor tasks	Performance appears comparable to norms
	Rey Complex Figure and Recognition Trial	Differences in organizational strategies may occur. Do not interpret unless the product is distorted
Personality/Emotional	Rorschach, TAT, drawing tasks	Responses should be scored directly from ASL and taped to allow for review during scoring
	Objective measures	Extreme caution should be used with all objective measures due to the impact of English and reading skills. Interpretation can change the items

Note: CPT II = Conners' Continuous Performance Test II, CTONI = Comprehensive Test of Nonverbal Intelligence, D-KEFS = Delis-Kaplan Executive Function System, TAT = Thematic Apperception Test, TOVA = Test of Variables of Attention, WCST = Wisconsin Card Sorting Test, WJ–III = Woodcock Johnson III, WAIS = Wechsler Adult Intelligence Scale, WMS = Wechsler Memory Scale.

functioning in individuals with specific strengths and weaknesses. Individuals with nonverbal learning disabilities may test as cognitively impaired, while those with language disorders may have their deficits overlooked.

Appropriate test selection must be based on both the demographic variables noted and on an understanding of the task demands. A test that may be reasonable to administer to an individual who grew up using Cued Speech may not be an appropriate test to use with a person whose primary mode of communication during the developmental years was ASL or an other form of signed communication. Simply interpreting the test into ASL or even an English-based sign system does not necessarily make that test accessible to the deaf client, nor does it necessarily test the same

Downloaded from https://academic.oup.com/acn/article/22/3/389/2947 by guest on 19 April 2024

ability or skill that it does with hearing clients. For example, many memory tests, even those that use symbols or rebus representations of words, depend on English sentence structure to support recall of sentences or stories. If persons' English skills are less than native, they may score poorly despite demonstrating intact verbal memory skills when accessed through their first language or primary mode of communication. Even when individuals sign the responses, the task may require that they use an English-based strategy for an optimal performance. Many retrieval fluency tasks, such as "FAS", require that persons use an alphabetic strategy for optimal retrieval. It is critical that the clinician ensure that the ability or skill intended for evaluation is the one actually being measured.

Having a deaf individual read the instructions or stimuli is not an adequate accommodation as reading skills are highly variable, and generally low in the deaf population. The median reading comprehension grade equivalents for 18 year olds is 4.5 for students with a severe loss and 3.8 for students with a profound loss (Gallaudet Research Institute, 2005) Additionally, using writing for responses may result in English words in ASL word order, which can have the appearance of schizophrenic "word salad." Reading skills can affect test results in a variety of ways. Even a simple task, such as Trails B, which only requires a depth of skill at using the alphabet, may be negatively affected by weak alphabetic automaticity. In contrast, deaf clients may perform well on a task, such as the Stroop, that assumes that reading is a dominant response, although there are contradictory data on this depending on the method of administration (Allen, 1971; Leybaert, Alegria, & Fonck, 1983). On most tasks, reading may interfere with performance; therefore, persons who are tested in print should also be tested on similar material through the air in their primary mode of communication.

Reading and language differences can also affect personality tests. For example, because the MMPI-2 requires a high degree of reading and English sophistication, even persons who test well on reading measures may have difficulty on this task. The clinician must interpret data carefully. Deaf persons may indicate that people on the television tell them what to do, referring to advertisements. Individuals have responded "true" to questions indicating they hear sounds or voices and don't know where they are coming from, accurately representing not psychosis, but residual hearing that makes the person aware of sounds without ability to localize them. Similarly, caution must be used when selecting, administering, and interpreting personality tests that appear to be relatively "language free" (i.e. reading is not required). If interpretation is used, make sure that *all* information (e.g., non-manual cues such as facial expression) is included in the interpretation. The Rorschach has often been used with deaf clients due to the lack of English stimuli; however, Santistevan (1998) found that protocols scored from English translations indicated more pathology than those same protocols when scored directly from the ASL by a clinician fluent in ASL. Many of the differences were due to the English translation omitting relevant details (e.g. "a flowing gown" being translated as simply "a gown").

Even when the response mode of a measure is nonverbal, instructions for tasks can be complex and difficult to interpret, and may require understanding of English grammar to make them clear. Tests administered to deaf clients may also be affected by the communication needs of the client; tasks such as Picture Arrangement are typically administered by the clinician laying out the cards while giving the instructions. The client is expected to look at the cards while listening to the instructions, thus gaining some exposure to the stimuli before the timed portion of the task begins. The deaf client must watch the instructions, and does not get access to the stimuli until the instructions are complete, at which point the timing of the task begins.

4.4. Demographic factors influencing test interpretation

Individuals whose hearing loss occurs prior to approximately 18 months of age function significantly differently than those whose deafness occurs following the development of language (Braden, 1994; Marschark and Clark, 1993; Meadow, 1980). It is likely that these early deaf individuals have experienced "severe sensory, oral-aural language and emotional deprivation" (Roda & Grove, 1987, p.2). Related demographic factors that should be taken into consideration include etiology of deafness, presence of neurological or physical comorbidities (Braden, 1994; Tekin, Arnos, & Pandya, 2001; Schildroth, 1994; Spreen, Risser, & Edgell, 1995; Vernon & Andrews, 1990), and whether the hearing loss is progressive, as the person's current identified level of hearing loss may not represent the level during critical developmental periods.

Over 90% of deaf individuals are born to parents with normal hearing (Center for Demographic Studies, 1990; Marschark, 1997). Parental hearing status affects development, and therefore adult functioning. When a deaf child is born to hearing parents it affects a range of factors, including language development, access to information, and emotional adjustment. Historically, studies have suggested that deaf children with deaf parents have higher cognitive

Downloaded from https://academic.oup.com/acn/article/22/3/389/2947 by guest on 19 April 2024

functioning than those with hearing parents, although the reasons for such findings are the subject of ongoing debate (Braden, 1994, Vernon, 2005). Indirect effects of deafness include the mode of communication used during childhood, such as American Sign Language (ASL) or other sign systems, oral communication, combined methods, or Cued Speech. These influence ability of the parents to communicate with and model language for the child, having widespread implications for knowledge, language and cognitive development, and social skills development (Moores & Meadow-Orleans, 1990).

4.5. Impact of deafness on neuropsychological performance

Deafness differentially impacts performance on neuropsychological tests. The Comprehensive Test of Nonverbal Intelligence (CTONI) is useful for comparison of verbally- and nonverbally-mediated intellectual functioning. However, the manual indicates that deaf children earned composite scores approximately 10 points below hearing subjects in the norming sample (Hammill, Pearson, & Wiederholt, 1997).

A number of studies have suggested that deaf adults who were early users of signed communication may have enhanced performance on visual tests that present visual tasks with attentional load (Rettenbach, Diller, & Sireteanu, 1999), visual imagery (Emmorey, Kosslyn, & Bellugi, 1993) and visual search (Stivalet, Moreno, Richard, Barraud, & Raphel, 1998). Further, studies suggest that deaf subjects may have enhanced peripheral and inferior field vision, and that signers, regardless of hearing status, have a left visual field advantage for motion sensitivity (Bosworth & Dobkins, 1999). Enhanced peripheral attention with reduced central attention is a common finding in deaf signers (Neville & Lawson, 1987; Proksch & Bavelier, 2002), as is improved performance on mental rotation tasks (Emmorey et al., 1993; McKee, 1988). When there is an option to choose between tasks using symbols or letters, symbols are preferred, as Clark (1985) found that on a perceptual task, deaf adults performed more poorly than hearing peers when letters were used as the stimuli, while the two groups performed equally when symbols were used.

Deaf signers generally perform below hearing standards on verbal sequential processing tasks, such as digit and word spans regardless of whether the stimuli are spoken, written or signed (Coryell, 2002; McKee, 1987; Morere & Marcotte, 1991; Wilson & Emmorey, 1997), however spatial spans meet or exceed those of deaf subjects (Morere & Marcotte, 1991; Wilson, Bettger, Niculae, & Klima, 1997) and forward and reverse spans are often comparable. In contrast, recall for unordered word lists is comparable to hearing subjects given language access (Hanson, 1982). Studies indicate that deaf signers may encode signed stimuli using a sign-based code, which affects the types of errors seen (Poizner, Bellugi, & Tweney, 1981). Paired associate learning can now be given in a signed version (Pollard, Rediess & DeMatteo, 2005).

The mode of communication during development appears to impact cognitive processing, with higher performances on sequential recall, phonemic skills, rhyming, and reading for individuals who use Cued Speech compared to those whose primary language during childhood involved signed communication (Charlier & Leybaert, 2000; LaSasso, Crain, & Leybaert, 2003). Cuers appear to base their approach to phonology on the oral-manual cues (Koo, 2003), while oral deaf individuals use a speechreading phonemic code (de Filippo, 1981) and deaf native users of ASL use phonemic decoding strategies for English that differ from those of hearing individuals (Hauser, 2000). Even within signing systems, differences in factors such as story comprehension and memory are seen (Altenbach, 1992). Studies of functional neuroanatomy have found altered lateralization for language in deaf signers; however, there are conflicting data depending on the methodology, stimuli used, and subject population. (Corina, Jose-Robertson, Guillemin, High, & Braun, 2003; Corina, Vaid, & Bellugi, 1992; Marcotte & LaBarba, 1987) Current data suggest more bilateral processing of sign language. Other atypical lateralization findings include left hemisphere preference on memory for location (Cattani & Clibbens, 2005) and motion processing (Bosworth & Dobkins, 1999) in deaf signers.

In sum, it is important that a clinician working with deaf patients be aware of the cultural aspects of deafness (e.g. Roda & Grove, 1987; Vernon & Andrews, 1990) and of the demographic, communication, and differential neurological/neurodevelopmental factors that impact neuropsychological assessment administration, performance, and interpretation of results.

5. Conclusion

When using traditional tests and batteries with individuals with physical or sensory disability, the neuropsychologist will increase certainty of nondiscrimination in testing by selecting tests and modifications based on an awareness of

Downloaded from https://academic.oup.com/acn/article/22/3/389/2947 by guest on 19 April 2024

Table 4
Common factors for consideration when selecting neuropsychological evaluation procedures and accommodations, and interpreting evaluation results

Characteristic of interest	Descriptions/Factors			Influence on Neuropsychological Evaluation
	Physical Disability	Visual Impairment/Blindness	Deaf or Hard of Hearing	
Age at Onset and Stability	Differential influence based on congenital, early or late childhood, adulthood or older adulthood age at onset; stable, fluctuating, or progressive impairment or disability	Non-linear differential influence based on age at onset; e.g., congenital, pre-school, early or late school or adult; direct and interaction effects related to level of visual function, etiology and whether condition is static or progressive	Differential influence based on pre- or post-lingual onset; static, fluctuating or progressive	Early vs. late onset impacts development (physical, neurological) and skill acquisition. Factor to consider in interpretation of test results
Etiology and Comorbidity	Genetic/hereditary, acquired injury, illness, comorbid medical conditions related or unrelated to etiology of disability	Multiple genetic/hereditary and acquired etiologies; disease versus trauma. Multiple comorbidities related and unrelated to etiology	Genetic/hereditary/familial, syndromic, acquired, unknown	Differentially impacts expression of impairment or disability. Critical factors to consider in interpretation of test results
Degree of Impairment; Quality of Impairment	Absence of motor function (paralysis) vs. weakness; mild, moderate, or severe functional impairment; bilateral or unilateral. Level and type of assistance needed for function (continuum of assistance needs from independent to fully dependent)	Refractory, visual field, retinal, neuro-visual system and ocularmotor interactions determine degree of impairment: visually impaired; legally blind and totally blind	Mild, moderate, severe or profound	Determines modality(ies) for test administration, and response format options and appropriateness
Adaptive Equipment	Equipment used to facilitate motor responding (e.g. hand weights, grips, handles, clips, weighted holders) or to compensate for absence of motor response (e.g. head stick, light beam, switching mechanism). Consistency of use and effectiveness of use	Multiple visual aids for magnification (CCTV, magnifiers, telescopes); adaptive technology for computer screen reading; voice recognition software; adaptive technology and use of trained assistive working animals (guide dogs) for travel	Amplification or other listening equipment use, type (hearing aid, cochlear implant, other), age when began use, consistency of use, perceived benefit	Determines modality(ies) for test administration, and response format options and appropriateness
Primary mode of Communication (receptive, expressive) or Response	Affected dominant limb motor responding (residual reponse), unaffected nondominant limb motor responding; or compensatory strategies not utilizing motor responding	Oral, written, Braille, ASL, manual coded or other signed system depending on level of functional vision and the presence of comorbidities	Oral, ASL, Simultaneous Communication/Total Communication/Manually Coded English, other signed systems (e.g. home signs, morphemic signs), Cued Speech; Age when each modality was learned	Determines modality (ies) for test administration, and response format options and appropriateness. May influence familiarity with “common” cultural experiences/exposures assumed in some tests
Educational Setting (for congenital or childhood onset)	Mainstream, special education, day program, residential	Mainstream, special education, school for the visually impaired or blind; alternative private placement depending on presence and severity of comorbidity	Residential, day program, mainstream; school for the deaf	Influences cultural development, experiences, and access. May influence familiarity with “common” experiences/exposures assumed in some tests

Downloaded from https://academic.oup.com/acn/article/22/3/389/2947 by guest on 19 April 2024

level of disability and knowledge of accommodations for imparment in mobility, vision, or hearing. The clinician must remain aware, however, that by virtue of using a nonstandardized test administration or response format, validity of normative data and interpretation guidelines are breached. Accurate interpretation of findings will require the neuropsychologist's understanding of the complex influence of demographic, etiological, and disability-related factors on neuropsychological performance; key factors and their importance in neuropsychological test administration and interpretation are summarized in Table 4. There remains a paucity of research on methodological aspects of test accommodation and modification for persons with physical disabilities. Although important steps have been made with test development for VI/B persons, and progress is evidenced in research on neuropsychological testing and performance in deaf persons, there remains a need for specific practice guidelines or normative data pertaining to test use. Primary directions for future research are development of empirically-based parameters for neuropsychological test modification with various subgroups, and further development and validation of neuropsychological test versions designed specifically for use with persons with physical and sensory disabilities.

References

Allen, D. V. (1971). Color-word interference in deaf and hearing children. *Psychonomic Science*, *24*, 295–296.

Altenbach, J. F. (1992). A comparative investigation of the differential effects of American Sign Language and total communication on story comprehension and memory in deaf children. (Doctoral dissertation, Loyola University of Chicago). *Dissertations Abstracts International*, *53*, 05.

American Educational Research Association. (1999). *Standards for educational and psychological testing*. Washington, DC: American Educational Research Association, American Psychological Association, and National Council on Measurement in Education.

Bigler, E. D., & Tucker, D. M. (1981). Comparison of verbal I.Q., tactual performance, seashore rhythm, and finer oscillation tests in the blind and brain-damaged. *Journal of Clinical Psychology*, *37*(4), 849–851.

Bosworth, R. G., & Dobkins, K. R. (1999). Left-hemisphere dominance for motion processing in deaf signers. *Psychological Science*, *10*(3), 256–262.

Braden, J. P. (1994). *Deafness, deprivation, and IQ*. New York: Plenum Press.

Briggs, P. F. (1960). The validity of the WAIS performance subtest completed with one hand. *Journal of Clinical Psychology*, *16*, 318–320.

Briggs, P. F. (1963). The validity of the Porteus Maze Test completed with the non-dominant hand. *Journal of Clinical Psychology*, *19*, 427–429.

Cattani, A., & Clibbens, J. (2005). Atypical lateralization of memory for location: Effects of deafness and sign language use. *Brain & Cognition*, *58*(2), 226–239.

Chan, F., Lynch, R. T., Dial, J. G., Wong, D. W., & Kates, D. (1993). Applications of the McCarron-Dial System in vocational evaluation: An overview of its operational framework and empirical findings. *Vocational Evaluation and Work Adjustment Bulletin*, *26*(2), 57–65.

Charlier, B. L., & Leybaert, J. (2000). The rhyming skills of deaf children educated with phonetically augmented speechreading. *The Quarterly Journal Of Experimental Psychology*, *53a*, 349–375.

Clark, M. D. (1985). A tachistoscopic recognition task with deaf and hearing adults (sensory register, familiarity effect). (Doctoral Dissertation, University of North Carolina at Greensboro). *Dissertations Abstracts International*, *47*, 09.

Corina, D. P., Jose-Robertson, L. S., Guillemin, A., High, J., & Braun, A. R. (2003). Language lateralization in a bimanual language. *Journal of Cognitive Neuroscience*, *15*, 718–730.

Corina, D. P., Vaid, J., & Bellugi, U. (1992). The linguistic basis of left hemisphere specialization. *Science*, *255*, 1258–1260.

Coryell, H. R. (2002). Verbal sequential processing skills and reading ability in deaf individuals using cued speech and signed communicaton. (Doctoral Dissertation, Gallaudet University). *Dissertations Abstracts International*, *62*, 10B.

Davidoff, G. N., Roth, E. J., & Richards, J. S. (1992). Cognitive deficits in spinal cord injury: Epidemiology and outcome. *Archives of Physical Medicine and Rehabilitation*, *73*, 275–284.

Dee, H. L. (1970). Visuocontruction and visuoperceptive deficits in patients with unilateral cerebral lesions. *Neuropsychologia*, *8*, 305–314.

Dee, H. L., & Fontenot, D. J. (1969). Use of the non-preferred hand in graphomotor performance: A methodological study. *Confinia Neurologica*, *31*, 273–280.

de Filippo, C. L. (1981). Memory for articulated sequences and lipreading performance of deaf observers. (Doctoral dissertation: Washington University, St. Louis Missouri). *Dissertation Abstracts International*, *41*, 8-A.

Dial, J. G., Chan, F., Mezger, C., Parker, H. J., Zangla, K., Wong, D. W., & Gray, S. (1991). Comprehensive Vocational Evaluation System for visually impaired and blind persons. *Journal of Visual Impairment and Blindness*, *85*, 153–157.

Dial, J. G., Chan, F., Tunick, R., Gray, S. G., & Marme, M. (1991). Neuropsychological evaluation: A functional and behavioral approach. In B. T. McMahon & L. R. Shaw (Eds.), *Work worth doing: Advances in brain injury rehabilitation* (pp. 47–76). Orlando, FL: Paul M. Deutsch Press, Inc.

Dial, J. G., Mezger, C., Gray, S., Massey, T., Chan, F., & Hull, J. (1990). *Manual: Comprehensive vocational evaluation system*. Dallas, TX: McCarron-Dial Systems, Inc..

Dowler, R. N., Harrington, D. L., Haaland, K. Y., Swanda, R. M., Fee, F., & Fiedler, K. (1997). Profiles of cognitive functioning in chronic spinal cord injury and the role of moderating variables. *Journal of the International Neuropsychological Society*, *3*, 464–472.

Downloaded from https://academic.oup.com/acn/article/22/3/389/2947 by guest on 19 April 2024

Emmorey, K., Kosslyn, S. M., & Bellugi, U. (1993). Visual imagery and visual-spatial language: Enhanced imagery abilities in deaf and hearing ASL signers. *Cognition*, *46*, 139–181.

Gallaudet Research Institute. (2005). http://gri.gallaudet.edu/Assessment/sat-read.html.

Gannon, J. R. (1981). *Deaf heritage—a narrative history of deaf America*. Washington, DC: Gallaudet University Press.

Garahan, M. B., Waller, J. A., Houghton, M., Tisdale, W. A., & Runge, C. F. (1992). Hearing loss prevalence and management in nursing home residents. *Journal of the American Geriatric Society*, *40*, 130–134.

Gutterman, J., Ward, M., & Genshaft, J. (1985). Correlations of scores of low vision children on the Perkins-Binet tests of intelligence for the blind, the WISC-R and the WRAT. *Journal of Visual Impairment & Blindness*, 55–58. Feb

Hammill, D. D., Pearson, N. A., & Wiederholt, J. L. (1997). *Examiner's manual Comprehensive Test of Nonverbal Intelligence*. Austin: Pro-ed.

Hanson, V. L. (1982). Short-term recall by deaf signers of American Sign Language: Implications of encoding strategy for order recall. *Journal of Experimental Psychology: Learning, Memory and Cognition*, *8*, 572–583.

Hauser, P. C. (2000). Deaf readers' phonological encoding: An electromyogram study of covert reading behavior (Doctoral Dissertation, Gallaudet University). *Dissertation Abstracts International*, *41*, 08.

Hayes, S. P. (1942). Alternative scales for the mental measurement of the visually handicapped. *Outlook for the Blind*, *36*, 225–230.

Hayes, S. P. (1943). A second test scale for the mental measurement of the visually handicapped. *Outlook for the Blind*, *37*(2), 37–41.

Holm, M. B., & Rogers, J. C. (1998). Occupational therapy assessment of adult brain function. In A. Puente, G. Goldstein, & E. D. Bigler (Series Eds.), G. Goldstein & S. R. Beers (Vol. Eds.), *Human brain function: Assessment and rehabilitation*: *Rehabilitation* (Vol. 4, pp. 9–31). New York: Plenum Press.

Iezzoni, L. I., McCarthy, E. P., Davis, R. B., & Siebens, H. (2001). Mobility difficulties are not only a problem of old age. *Journal of General Internal Medicine*, *16*, 235–243.

Joyce, A., Isom, R., Dial, J. G., & Sandel, M. G. (2004). Implications of perceptual-motor differences within blind populations. *Journal of Applied Rehabilitation Counseling*, *35*(3), 3–7.

Kaskel, L. M. (1994). Neuropsychological assessment for persons with sensory impairments. *Directions in Rehabilitation Counseling*, *5*(8).

Kaskel, L. M., Dial, J. G., Chan, F., & Roldan, G. (1991). Evaluating work potential of persons with visual impairments: The Comprehensive Vocational Evaluation System (CVES) approach. In R. Fry (Ed.), *The issues papers. Fifth national forum on issues in vocational assessment* (pp. 167–173). Menomonie, WI: University of Wisconsin-Stout, Materials Development Center.

Koo, D. S. (2003). On the nature of phonological representations and processing strategies in deaf cuers of English. (Doctoral Dissertation, University of Rochester). *Dissertations Abstracts International*, *64*, 04.

Kuo, H. K., Jone, R. N., Milberg, W. P., Tennstedt, S. S., Talbot, L., Morris, J. N., & Lopsitz, L. A. (2005). Effect of blood pressure and diabetes mellitus on cognitive and physical functions in older adults: A longitudinal analysis of the advanced cognitive training for independent and vital elderly cohort. *Journal of the American Geriatrics Society*, *53*, 1154–1161.

LaSasso, C., Crain, K., & Leybaert, J. (2003). Rhyme generation in deaf students: The Effect of exposure to cued speech. *Journal of Deaf Studies and Deaf Education*, *8*, 250–270.

Leybaert, J., Alegria, J., & Foncke, E. (1983). Automaticity in word recognition and word naming by the deaf. *Cahiers de Psychologie Cognitive*, *3*, 255–272.

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

MacCluskie, K. C., Tunick, R. H., Dial, J. G., & Paul, D. S. (1998). The role of vision in the development of abstraction ability. *Journal of Visual Impairment and Blindness*, *92*(3), 189–199.

Macciocchi, S. N., Bowman, B., Coker, J., Apple, D., & Leslie, D. (2004). Effect of co-morbid traumatic brain injury on functional outcome of persons with spinal cord injuries. *American Journal of Physical Medicine and Rehabilitation*, *83*, 22–26.

Maller, S. J. (2003). Intellectual Assessment of Deaf People: A Critical Review of Core Concepts and Issues. In M. Marshark & P. E. Spencer (Eds.), *Oxford Handbook of deaf studies, language, and education* (4th ed., pp. 451–463). New York: Oxford University Press.

Mangiameli, L. J., Roderick, R., Moses, J. A., & Dohen, D. A. (1999). The Limited Vision Block Sorting Tests: A vision independent test of executive functioning [Abstract]. *Archives of Clinical Neuropsychology*, *14*(8), 701–702.

Mangiameli, L. J., & Peters, L. J. (1998). A non-visual battery for assessment of spatial abilities [Abstract]. *Archives of Clinical Neuropsychology*, *14*(1), 86.

Marcotte, A. C., & LaBarba, R. C. (1987). The effects of linguistic experience on cerebral lateralization for speech production in normal hearing and deaf adolescents. *Brain and Language*, *31*, 276–300.

Marschark, M. (1997). *Raising and educating a deaf child*. New York: Oxford University Press.

McGee, J. M. (1994). Neuropsychological functioning of adult subjects with diabetic retinopathy compared to a normal blind population. Unpublished doctoral dissertation, University of North Texas, Denton.

McKee, D. E. (1988). An analysis of specialized cognitive functions in deaf and hearing signers. (Doctoral Dissertation, University of Pittsburgh). *Dissertation Abstracts International*, *49*, 4.

Meadow, K. P. (1980). *Deafness and child development*. Los Angeles: Univ. Califronia Press.

Miller, J. C., & Skillman, G. D. (2003). Assessors' satisfaction with measures of cognitive ability applied to persons with visual impairments. *Journal of Visual Impairment and Blindness*, *97*(12), 769–774.

Miller, K. R., & Vernon, M. (2001). Linguistic diversity in deaf defendants and due process rights. *Journal of Deaf Studies and Deaf Education*, *6*(3), 226–234.

Mooradian, A. D. (1997). Pathophysiology of central nervous system complications in diabetes mellitus. *Clinical Neuroscience*, *4*, 322–326.

Moores, D.F. & Meadow-Orleans, K.P. (1990). *Educational and developmental aspects of Deafness*. Washington: Gallaudet.

Morere, D. A., & Marcotte, A. C. (1991). Serial and simultaneous Information processing in deaf vs. hearing adolescents. *The Clinical Neuropsychologist*, *5*(3), 249.

Downloaded from https://academic.oup.com/acn/article/22/3/389/2947 by guest on 19 April 2024

Nelson, P. A., Dial, J. G., & Joyce, A. (2002). Validation of the Cognitive Test for the Blind as an assessment of intellectual functioning. *Rehabilitation Psychology*, *47*(2), 184–193.

Nelson, P. A., O'Brien, E. P., Dial, J. G., & Joyce, A. (2001). Neuropsychological correlates of retinopathy of prematurity (ROP) compared to other causes of blindness [Abstract]. *Archives of Clinical Neuropsychology*, *16*, 766–767.

Nester, M. A. (1994). Psychometric testing and reasonable accommodation for persons with disabilities. In S. M. Bruyere & J. O'Keefe (Eds.), *Implications of the Americans with Disabilities Act for Psychology* (pp. 25–36). New York: Springer Publishing Company and American Psychological Association.

Neville, H. J., & Lawson, D. S. (1987). Attention to central and peripheral visual space in a movement decision task: III. Separate effects of auditory deprivation and acquisition of a visual language. *Brain Research*, *405*, 284–294.

O'Keefe, J. (1994). Disability, discrimination, and the Americans with Disabilities Act. In S. M. Bruyere & J. O'Keefe (Eds.), *Implications of the Americans with Disabilities Act for Psychology* (pp. 1–14). New York: Springer Publishing Company and American Psychological Association.

Park, W. L., Mayer, R. S., Moghimi, C., Park, J. M., & Deremeik, J. T. (2005). Rehabilitation of hospital inpatients with visual impairments and disabilities from systemic illness. *Archives of Physical Medicine and Rehabilitation*, *86*, 79–81.

Poizner, H., Bellugi, U., & Tweney, R. D. (1981). Processing of formational, semantic, and iconic information in American Sign Language. *Journal of Experimental Psychology: Human Perception and Performance*, *7*, 1146–1159.

Pollard, R. Q., Rediess, S., & DeMatteo, A. (2005). Development and validation of the Signed Paired Associates Test. *Rehabilitation Psychology*, *50*(3), 258–265.

Proksch, J., & Bavelier, D. (2002). Changes in the spatial distribution of visual attention after early deafness. *Journal of Cognitive Neuroscience*, *14*, 687–701.

Pratt, S. I., & Moreland, K. L. (1998). Individuals with other characteristics. In J. Sandoval, C. L. Frisby, K. F. Geisinger, J. D. Scheuneman, & J. R. Grenier (Eds.), *Test Interpretation and Diversity* (pp. 349–371). Washington, DC: American Psychological Association.

Price, J. R., Mount, G. R., & Coles, E. A. (1987). Evaluating the visually impaired: Neuropsychological techniques. *Journal of Visual Impairment and Blindness*, *81*, 28–30.

Rabeck, D.D. (1994). Neuropsychological functioning of blind subjects with learning disabilities compared to those with blindness alone. Unpublished doctoral dissertation, University of North Texas, Denton.

Reid, J. M. (1997). Standardized ability testing for vocational rehabilitation in visually impaired adults: A literature review. *Journal of Visual Impairment & Blindness*, *91*(6), 546–554.

Reitan, R. M., & Davison, L. A. (1974). *Clinical neuropsychology: Current status and applications*. Washington, DC: Winston & Sons.

Reitan, R. M., & Wolfson, D. (1993). *The Halstead-Reitan Neuropsychological Test Battery: Theory and clinical interpretation*. Tucson, Arizona: Neuropsychology Press.

Rettenbach, R., Diller, G., & Sireteanu, R. (1999). Do deaf people see better? Texture segmentation and visual search compensate in adult but not juvenile subjects. *Journal of Cognitive Neuroscience*, *11*(5), 560–583.

Rich, C. C., & Anderson, R. P. (1965). A tactual form of the progressive matrices for use with blind children. *Personnel & Guidance Journal*, *43*(9), 912–919.

Richards, J. S., Brown, L., Hagglund, K., Bua, G., & Reeder, K. (1988). Spinal cord injury and concomitant traumatic brain injury: results of a longitudinal investigation. *American Journal of Physical Medicine and Rehabilitation*, *67*, 211–216.

Roda, M., & Grove, C. (1987). *Language, cognition and deafness*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Roth, E., Davidoff, G., Thomas, P., Doljanac, R., Dijkers, M., Berent, S., Morris, J., & Yarkony, G. (1989). A controlled study of neuropsychological deficits in acute spinal cord injury patients. *Paraplegia*, *27*, 480–489.

Santistevan, E. F. (1998). The linguistic mode of scoring the Exner Comprehensive System of the Rorschach protocol for deaf individuals. (Doctoral dissertation, Gallaudet University). *Dissertations Abstracts International*, *59*, 02.

Schildroth, A. (1994). Congenital cytomegalovirus and deafness. *American Journal of Audiology*, 27–38. July.

Shapiro, B. K. (2004). Cerebral palsy: A reconceptualization of the spectrum. *Journal of Pediatrics*, *145*(2 Suppl), S3–S7.

Smith, D. K., & Stovall, D. L. (2002). Individual norm-referenced ability testing. In R. B. Ekstrom & D. K. Smith (Eds.), *Assessing individuals with disabilities in educational, employment, and counseling settings* (pp. 147–171). Washington, DC: American Psychological Association.

Spreen, O., Risser, A. T., & Edgell, D. (1995). *Developmental neuropsychology*. New York: Oxford University.

Stivalet, P., Moreno, Y., Richard, J., Barraud, P., & Raphel, C. (1998). Differences in visual search tasks between congenitally deaf and normally hearing adults. *Cognitive Brain Research*, *6*, 227–232.

Tate, D. G., Forchheimer, M. B., Krause, J. S., Meade, M. A., & Bombardier, C. H. (2004). Patterns of alcohol and substance use and abuse in persons with spinal cord injury: Risk factors and correlates. *Archives of Physical Medicine and Rehabilitation*, *85*, 1837–1847.

Tekin, M., Arnos, K. S., & Pandya, A. (2001). Advances in hereditary deafness. *Lancet*, *358*, 1082–1090.

Turner, A. P., Bombardier, C. H., & Rimmele, C. T. (2003). A typology of alcohol use patterns among persons with recent traumatic brain injury or spinal cord injury: Implications for treatment matching. *Archives of Physical Medicine and Rehabilitation*, *84*, 358–364.

U.S. Census Bureau (2000). Disability status: 2000. (http://www.census.gov) Retrieved August 15, 2005.

Vernon, M. (2005). Fifty years of research on intelligence of deaf and hard-of-hearing children: A review of literature and discussion of implications. *Journal of Deaf Studies and Deaf Education*, *10*(3), 225–231.

Vernon, M., & Andrews, J. F. (1990). *The psychology of deafness: Understanding deaf and hard-of-hearing people*. New York: Longman.

Vernon, M., & Miller, K. R. (2001). Interpreting in mental health settings: Issues and concerns. *American Annals of the Deaf*, *146, 5*, 429–434.

Wainapel, S. F., Kwon, Y. S., & Fazzari, P. J. (1989). Severe visual impairment on a rehabilitation unit: Incidence and implications. *Archives of Physical Medicine and Rehabilitation*, *70*, 439–441.

Wechsler, D. (1997). *WAIS-III Manual*. New York: The Psychological Corporation.

Weshsler, D. (1997). *Wechsler Memory Scale–III Manual*. New York: The Psychological Corporation.

Downloaded from https://academic.oup.com/acn/article/22/3/389/2947 by guest on 19 April 2024

Wilson, M., Bettger, J., Niculae, I., & Klima, E. (1997). Modality of language shapes working memory: Evidence form digit span and spatial span in ASL signers. *Journal of Deaf Studies and Deaf Education*, *2*, 150–160.

Wilson, M., & Emmorey, K. (1997). Working memory for sign language: A window into the architecture of the working memory system. *Journal of Deaf Studies & Deaf Education*, *2*, 121–130.

Yaffe, K., Blackwell, T., Kanaya, A. M., Davidowitz, N., Barrett-Connor, E., & Krueger, K. (2004). Diabetes, impaired fasting glucose, and development of cognitive impairment in older women. *Neurology*, *63*, 658–663.

Downloaded from https://academic.oup.com/acn/article/22/3/389/2947 by guest on 19 April 2024