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# Methodological Issues Associated with Sign- Based Neuropsychological Assessment

## Abstract

Aspects of neuropsychological assessment are used in a wide range of clinical and research settings. Over the past half century, in conjunction with the recognition that American Sign Language (ASL) is indeed a language and not simply a communication system, research using signed administration of tasks has increased, and clinicians have attempted to adapt or develop instruments for use with deaf clients. However, simply signing instructions or test stimuli does not “translate” a test into ASL even when the instructions or items are interpreted into linguistically accurate ASL. A number of challenges and issues arise when attempting to either modify an English-based measure for use with ASL or develop measures directly in ASL. These challenges and issues are reviewed as they relate to the broad areas of language assessment, the evaluation of mental status, memory testing, and the assessment of executive functioning, and the reader is directed to further materials that address each area in greater depth.

TESTING IS required for both clinical practice and research. Psychological and neuropsychological assessment is used for practice and research in the fields of cognitive science, psychology, medicine,

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psychiatry, and education, as well as a wide array of other areas. Accurate results of such testing depend on the use of appropriate measures. While more than a century of research and development has produced a plethora of measures for hearing individuals using spoken language, the same cannot be said of measures for deaf individuals, particularly those whose preferred mode of communication is ASL or some other sign language or form of signed communication. All too often, deaf individuals are evaluated with standard measures wherein the sole accommodation is the signing of the instructions and the stimuli. Although this may be the only available option at present, it is a problem for both researchers and clinicians and especially for the deaf individuals being evaluated.

Valid assessment of deaf individuals requires tools appropriate to this population. While much has been learned in the half century since Stokoe (1960) clarified the nature of ASL as a language, only a few well-developed ASL-based measures are available for use. When we attempt to develop signed measures, we encounter a number of issues ranging from the heterogeneity of the deaf population to the complexities of ASL itself to the fact that we are continuing to develop our understanding of ASL as a language. Some of the challenges have been discussed in other articles in this issue (Allen and Enns 2013; Morere 2013; Simms, Baker and Clark 2013; Witkin, Morere, and Geer 2013). These challenges are reviewed, and the reader is directed to sources with further discussion of issues that relate to specific types of tests.

### Language Assessment

One of the most obvious areas of difficulty is the assessment of the language skills of deaf individuals, particularly those whose first or preferred language is a sign language, such as ASL. Since its vocabulary, syntax, and grammar all differ significantly from English, ASL certainly cannot be measured simply by signing a standard measure based on spoken language. Early attempts to measure communication skills in deaf children who were being taught using various forms of signing reflected the focus on spoken language rather than structurally correct ASL. For example, the Rhode Island Test of Language Structure (RITLS; Engen and Engen 1983), which is still available, measures deaf children's understanding of English language structures using a

signed test administration. The goal of the RITLS was clearly to use the visual access of signs to represent English rather than to evaluate skills in a fully accessible sign language. Similarly, the Carolina Picture Vocabulary Test (CPVT; Layton and Holmes 1985) was designed to measure receptive vocabulary in deaf children. However, its application was limited due to the use of English-oriented signs and a structure that sequenced the vocabulary based on the related English word regardless of the complexity of the sign involved or the use of an identical sign to represent relatively easy words and, later, more advanced words. Thus, the early attempts to measure sign language skills reflected a focus on English competence and the test designers' lack of understanding of ASL. Additionally, both the RITLS and the CPVT were developed and normed at a time when early identification and intervention were lacking. Thus, even if they had represented valid language measures at the time they were developed, the normative sample would in no way reflect the current cohort of deaf children.

More recently, attempts have been made to develop linguistically accurate and appropriate measures of ASL skills. Enns and Herman (2011) have modified for use with American Sign Language a measure initially designed to evaluate children's skills in British Sign Language. They present an excellent review of the literature on the assessment of children's signing skills and discuss the issues associated with such adaptations. Further insight into this work as well as the impact on the validity of direct translation of spoken-language measures into signed versions is provided by Haug and Mann (2008).

Paludneviciene et al. (2012) review the complexities of ASL assessment, outline the process that is considered appropriate for the development of such measures, and address the need for ASL standards to guide the training in and analysis of this language. They provide an overview of the types of measures available (e.g., checklists, interviews, performance-based and objective tests) and discuss a number of instruments that have been developed to date for the assessment of ASL skills. They also discuss a range of issues associated with both translating signed measures from one language to another and adapting spoken-language tests for use with signed languages. In particular, they consider the complexities of adapting spoken-language measures at the sentence level due to the structural differences between signed

and spoken languages. The visuospatial nature of signed languages provides them with unique means of depicting actions, relationships, duration, and emphasis, techniques that are not available in spoken languages. Furthermore, a sentence that may be simple in a spoken language may become complex in a signed language due to these characteristics, and vice versa.

Paludnevičienė et al. (2012) note that difficulties associated with differential sentence complexity can affect measures other than simple language tasks. They explain how such linguistic differences can affect items on measures of skills such as math and provide an example that demonstrates how simply signing the item content in English word order (a common practice) may make a test item significantly more difficult for a deaf student than the identical item presented in spoken English to a hearing student. In contrast, it is possible that a true ASL translation may also affect item difficulty—either positively or negatively. Thus, the impact of language can be broadly seen on measures used in both clinical practice and research, and the need for further research into the development of linguistically appropriate measures of both language and other areas of assessment that involve language is clear.

### Mental Status

The assessment of mental status is a core task for neurologists, psychiatrists, and other physicians; psychologists; researchers; and a range of other professionals. The Mini-Mental State Exam (MMSE; Folstein, Folstein, and McHugh 1975) is one of the most commonly used screening measures in clinical settings, particularly in the assessment of the cognitive functioning of older adults (Vertesi et al. 2001). It is used as a quick screening of the broad cognitive functioning of individuals with suspected dementia or other brain diseases, as well as of psychiatric and other medical patients, and Vertesi and colleagues note that it is employed in a range of settings from hospitals to patients' homes. It provides a rapid estimate of mental control (e.g., saying the alphabet and counting backward by a set amount), language skills (e.g., naming, repeating, reading, writing, and following directions), memory and attention, orientation, and drawing. It has been extensively translated and adapted, and the apparent simplicity of this measure has led to its

use with a wide range of patients. However, recent studies question its validity with cultural and linguistic minorities (Ramírez et al. 2005).

Dean et al. (2009) investigate the use of a signed administration of the MMSE with healthy, older deaf adults (mean age 69) attending an event for culturally Deaf senior citizens who reported themselves to be severely or profoundly deaf from an early age and use ASL as their primary language. Individuals with diagnosed cognitive or psychiatric impairment were excluded from the study. The sample was relatively highly educated, with an average of more than one year of college education, and more than half reported having attended a residential school for deaf students.

Despite the relatively high educational level, intact status of the participants, and the adaptation of the tasks for the signed administration, the mean scores were low, and approximately two-thirds of the participants' scores would typically be interpreted as representing some degree of cognitive impairment. This suggests that the use of this measure, even by clinicians who have some awareness of the issues associated with working with deaf individuals and provide a signed administration, could lead to an overdiagnosis of impairment. Further analysis of the tasks revealed specific items that were problematic due to linguistic influences. On one item that required the individual to count back from 100 by sevens (e.g., 100, 93, 86, etc.), the issue of the complexity of instructions noted earlier appeared to influence the outcome despite alteration of the instructions to represent an ASL format. Surprisingly, on a task that can be substituted for an item that involved spelling a word in reverse sequence, the participants excelled. This suggests that the latter task would be preferable despite typical expectations that an English-based item might be more problematic for deaf individuals than one involving mental math. This emphasizes the importance of direct evaluation of tasks rather than making assumptions based on the superficial linguistic involvement of the item.

The authors note that the sentence- and phrase-repetition items were problematic due to the English focus of the items; they maintain that either ASL equivalents should be developed to substitute for these items or their effect on scores should be taken into account during interpretation of the results. Additionally, the writing task requires English skills that may not reflect expressive ASL skills and

therefore the degree to which the individual is cognitively intact. A number of items used to screen for language impairment included idioms that did not translate into ASL; moreover, the use of such English-based items was observed to be problematic for the majority of deaf participants despite their high level of education. A similar pattern of outcomes was found with a more comprehensive measure of functioning used with individuals with suspected dementia (Dean et al. 2013). Although both of these tasks raised a number of issues, more appropriate measures are not yet available. Thus, the authors conclude that even though efforts should continue to further adjust these measures, in the hands of clinicians or researchers competent to work with deaf individuals, they could be used with caution and the understanding that standard interpretations of scores should be modified to avoid misclassification. Furthermore, the cultural and linguistic status of the individual must be taken into consideration in the process of test administration and interpretation.

## Memory

Memory evaluation is one of the cornerstones of neuropsychological assessment. Elsewhere in this issue, Morere (2013) elaborates on the issues associated with the influence of language on the examination of linguistic memory. To date, three ASL-based memory tasks have been published: the Signed Paired Associates Test (SPAT; Pollard, Redies, and DeMatteo 2005), the ASL Stories Test (Pollard et al. 2007), and the Signed Verbal Learning Test (SVLT; Morere 2012). The lack of adequate measures and the demand for appropriate assessment are emphasized by the fact that, although it was only recently published, the SPAT has been in clinical use since the 1980s based on word of mouth and a preliminary report at a professional meeting (DeMatteo, Pollard, and Lentz 1987, May). Although there is clearly a need for valid measures of memory for ASL, linguistic recall of deaf signers has been an area of controversy.

One of the areas of greatest disagreement relates to the consistent finding that deaf signers recall fewer digits, words, and letters than their hearing peers when the items must be recalled in the order of presentation despite equal outcomes when serial order of recall was not required (see Morere 2012 for a review of the literature on this

controversy). The fact that deaf individuals perform at least as well as their hearing peers on visual sequential memory tasks suggests that this relates to the linguistic nature of these serial recall tasks rather than a general difference in memory for sequences. Further emphasizing the linguistic nature of this difference is the fact that deaf individuals are able to repeat nonlinguistic sequences of hand movements on a par with their hearing peers (Tomlinson-Keasey, Smith, and Hale 1981; Ulissi, Brice, and Gibbins 1989). One hypothetical source of this difference consisted of a “sign-length” effect similar to the word-length effect that accounts for span differences among many spoken languages (Wilson and Emmorey 1998). However, even though differences in the time required to produce longer signs can result in reduced recall compared to shorter signs, the production of signed letters and words is comparable to the speech production of numbers and letters. Another hypothesis is that since the spoken words for the numbers one through ten are phonemically quite distinct, the similarity of the handshapes used for signed numbers might lead to interference effects, resulting in lower spans (Caplan and Waters 1994). Attempts to address potential effects of factors such as formational similarities between signed numbers on the original digit-span tasks led to the use of signed letters that were visually distinct. However, as Morere (2012) notes, outcomes of such research have been conflicting, and the controversy continues.

Several issues in this discussion are relevant for the current review. One is the fact that a simple translation (signing) of the stimuli has not produced comparable performances on this widely used task with deaf and hearing cohorts. The underlying source of the difference remains unclear, but clinicians using these measures must be cautioned not to interpret differential outcomes as representative of deficits in deaf patients provided with signed “access” to the test. Two other important issues raised in the disagreement over linguistic serial recall in deaf individuals are the impacts of sign-production time and formational similarity on recall. These effects are relevant across all linguistic memory tasks. Morere (2013) discusses at length the need for management of formational characteristics on signed memory stimuli due to potential influence on recognition and recall of signs. Although the sign-length effect can influence the recall of lists of signs, the fact that



signs often condense statements may alter the outcomes on sentence and story recall. For example, the English sentence “Close the door” is produced as a single sign. In addition to the impact of differential production time, the reduction of the sentence from three items to one item would be expected to enhance recall, particularly if this were imbedded in a larger set of stimuli. This relates to the discussion of relative sentence complexity. A sentence of a certain level of linguistic complexity in English may be either more or less complex when translated into ASL. Since sentence-recall tasks are typically sequenced with increasing levels of complexity and the scores are expected to reflect these levels, sentence memory tasks designed for ASL must reflect the levels of complexity specific to ASL. Simple translation of English items into ASL cannot produce a comparable task. On the other hand, simple transliteration of the English sentences that retain the English order represents a measurement not of linguistic memory but of a combination of memory and the individual’s English skills.

### Executive Functions

Executive functions (EF) represent a set of higher-order processes responsible for, among other things, reasoning, planning, problem solving, creativity, and flexibility in thinking, organization, and cognitive and emotional control. Even though many tasks used to measure these processes involve the use of manipulatives (e.g., problem-solving tasks involving towers of rings or beads) or visual stimuli (e.g., card-sorting tasks), the instructions must be clearly communicated so that the test taker’s performance represents the ability to do the task rather than the individual’s understanding of what is required. Experience with such tasks in the VL2 Psychometric Toolkit study suggests that these tasks can be administered with the standard instructions signed and the standard modeling/practice trials administered (Morere, Goodman, et al. 2012). Similarly, mazes, construction tasks, and comparable items may be administered through a combination of simple signed instructions and demonstration/modeling. However, many EF tasks involve either overt linguistic content or covert linguistic mediation. Even relatively simple tasks may present problems. For example, measures of praxis, or cognitive control of movement, include items such as “Point to your left elbow.” Since copying a movement and responding to a

command are different tasks, this presents a problem when the person is being tested using ASL.

Tasks that investigate abstract reasoning may include items that present proverbs or common sayings to the individual and ask what they mean. The idea is that if the person responds with a concrete interpretation, this reflects more limited EF than a more abstract interpretation; however, proverbs and similar items are unique to the language and culture in which they develop. Asking the meaning of the saying “Shallow brooks are noisy” simply does not work as a means of tapping higher-order reasoning for most deaf individuals. This is not a matter of the ASL translation alone but also of a difference in the underlying cultural and life experiences of deaf individuals compared to those of their hearing peers. At this time, there are no standardized measures of ASL “sayings,” although in clinical practice, clients may be asked the meaning of idioms such as “train gone, zoom.” One issue with the development of such a measure is the widely varied experience of deaf individuals in the general population. Although use of ASL idioms may in this manner provide appropriate reflections of the abstraction abilities of culturally Deaf individuals, many deaf individuals—even those adults who report that ASL is their preferred language—may not have been exposed to the idioms and therefore lack the context needed provide more abstract explanations.

One of the most commonly used measures of EF is word fluency. Tasks of this sort ask the person to report as many items as possible from a specific category (e.g., “things you eat”) within a time frame (usually one minute) or to say as many words as possible starting with a specific letter within the time limit. The former are considered semantic fluency tasks, the latter lexical, or phonemic, fluency. Both require the person to perform efficient cognitive searches and to filter out inappropriate responses (e.g., proper nouns are not allowed). These types of tasks are used widely in research and clinical work and are represented in many batteries of cognitive and executive functioning. A range of factors, including the individuals’ linguistic competence and bilingual capabilities, affect their performance (Portocarrero, Burright and Donovan, 2007).

Simply asking individuals to sign their responses may not be an adequate accommodation even for semantic fluency tasks. The phonemic

fluency task involves several major issues, not the least of which is that while the response may be produced in the individual's preferred modality, the items themselves must be generated in their nonpreferred language. Thus, as part of the VL2 Toolkit Project, an ASL version of the phonemic fluency task was developed: 5-1-U (Morere, Witkin, and Murphy, 2012). Since the probes in the spoken-language versions of this task are letter or phoneme probes, those used for the ASL task were handshapes. The probe selection was based on research indicating the salience of the various formational characteristics of ASL and the frequency of the handshapes in the ASL lexicon. One of the issues in this process was the limited information available on handshape and sign frequency in the literature. These considerations are discussed by Morere, Witkin, and Murphy (2012) and Witkin, Morere, and Geer (2013).

Within the VL2 Psychometric Toolkit, 5-1-U was used in addition to two semantic fluency tasks (foods and animals) and a standard English-based phonemic fluency task (FAS) with some interesting outcomes (Morere, Witkin, and Murphy 2012). The semantic fluency results were consistent with but slightly lower than expectations for hearing peers. Factors that may have influenced this are sign production times and the differences in the lexicons of English and ASL. When reporting foods, an English speaker might start a category such as "fish" and list salmon, mackerel, cod, flounder, and so on, whereas a deaf person would have to list the individual species in their English form and fingerspell them—a more time-consuming process than the speech-based response. Thus, ASL-English differences may affect the semantic fluency task despite the fact that the participant is free to perform the cognitive search and respond solely in ASL.

On the surface, it is not surprising that more responses were produced for the 5-1-U than the FAS task; however, it should be noted that simply creating a task that uses a sign-based search does not make this equivalent to the spoken phonemic fluency task. Aside from the differences in the sizes of the ASL and English lexicons, there is the issue of practice using search strategies. From an early age, children—both deaf and hearing—are taught to organize words based on their alphabetic relationships. The arrangement of dictionaries, encyclopedias, and other educational materials is based on this process, and the

relevant relationships are emphasized on a regular basis. This focus on alphabetic searches likely enhances performance on phonemic fluency tasks, and absent training for deaf children related to the organization of signs according to their formational characteristics, it is impressive that, even for college-educated participants, the ASL-based task produced greater numbers of signs than the English-based task.

The relationships among the Toolkit's verbal fluency tasks and other measures suggest that use of the English-based phonemic fluency task prior to administration of the semantic fluency tasks elicited different cognitive processes and search strategies than were used when the semantic fluency tasks followed the ASL-based phonemic fluency task. The underlying processes involved may be elucidated somewhat by the additional scoring technique developed by Witkin, Morere, and Geer (2013), which further investigates the participants' sign-based responses. Witkin and colleagues discuss the complexities and challenges of developing that scoring system due to the intricacies of ASL, and I refer the reader to that article for greater detail on this topic.

## Conclusions

ASL is a complex language that differs from spoken languages not only in vocabulary, grammar, and syntax but also in its visuospatial, rather than acoustic, nature. The use of space and the simultaneous production of the formational components of signs change the very nature of many neuropsychological measures. The differences in the lexicons of the two languages mean that even equivalent tasks may produce dissimilar outcomes for deaf and hearing individuals. Most important, the fact that the study of ASL as a language is in its relative infancy makes the development of valid measures difficult. Much more needs to be known about this language before a full complement of truly valid neuropsychological measures that are properly grounded in ASL can be developed. Awareness of the issues involved may at least provide clinicians and researchers with caveats to consider when using standard—or even modified—measures with deaf signers. At best, it may encourage continued research in this area and the further development of more appropriate tools for scientists and practitioners working with users of ASL.

## References

- Allen, T. E., and C. Enns. 2013. A Psychometric Study of the ASL Receptive Skills Test When Administered to Deaf 3-, 4-, and 5-Year-Old Children. *Sign Language Studies* (Summer).
- Caplan, D., and G. S. Waters. 1994. Articulatory Length and Phonological Similarity in Span Tasks: A Reply to Baddeley and Andrade. *Quarterly Journal of Experimental Psychology* 47A: 1055–62.
- Dean, P., D. Feldman, D. Morere, and D. Morton. 2009. The Mini-Mental State Exam as a Cognitive Screening Tool for Culturally Deaf Older Adults. *Archives of Clinical Neuropsychology* 24(8): 753–60.
- Dean, P., D. Morere, D. Feldman, F. Funayama, and P. Gilbert. 2013. Effects of Education and Linguistic Factors on the Mattis Dementia Rating Scale with Deaf Older Adults. Manuscript submitted for publication.
- DeMatteo, A., R. Q. Pollard Jr., and E. Lentz. 1987. Assessment of Linguistic Functions in Brain-Impaired and Brain-Intact Prelingually Deaf Users of American Sign Language: A Preliminary Report. Paper presented at the biennial meeting of the American Deafness and Rehabilitation Association, Minneapolis, MN, May 26–29.
- Engen, E., and T. Engen. 1983. Rhode Island Test of Language Structure (RITLS). Austin: PRO-ED.
- Enns, C. J., and R. C. Herman. 2011. Adapting the Assessing British Sign Language Development: Receptive Skills Test into American Sign Language. *Journal of Deaf Studies and Deaf Education* 16(3): 362–74.
- Folstein, M. F., S. E. Folstein, and P. R. McHugh. 1975. Mini-Mental State: A Practical Method for Grading the State of Patients for the Clinician. *Journal of Psychiatric Research* 12: 189–98.
- Haug, T., and W. Mann. 2008. Adapting Tests of Sign Language Assessment for Other Sign Languages: A Review of Linguistic, Cultural, and Psychometric Problems. *Journal of Deaf Studies and Deaf Education* 13: 138–47.
- Layton, T., and D. Holmes. 1985. Carolina Picture Vocabulary Test (CPVT). Austin: PRO-ED.
- Morere, D. A. 2012. Measures of Memory and Learning. In *Assessing Literacy in Deaf Individuals: Neurocognitive Measurement and Predictors*, ed. D. A. Morere and T. E. Allen, 75–104. New York: Springer.
- . 2013. The Signed Verbal Learning Test: Assessing Verbal Memory of Deaf Signers. *Sign Language Studies* (Summer).
- , E. Goodman, S. Hanumantha, and T. E. Allen. 2012. Measures of General Cognitive Functioning. In *Assessing Literacy in Deaf Individuals: Neurocognitive Measurement and Predictors*, ed. D. A. Morere and T. E. Allen, 39–58. New York: Springer.
- , G. Witkin, and L. Murphy. 2012. Measures of Expressive Language. In *Assessing Literacy in Deaf Individuals: Neurocognitive Measurement and Predictors*, ed. D. A. Morere and T. E. Allen, 141–57. New York: Springer.

- Paludnevičienė, R., P. C. Hauser, D. Daggett, and K. B. Kurz. 2012. Issues and Trends in Sign Language Assessment. In *Assessing Literacy in Deaf Individuals: Neurocognitive Measurement and Predictors*, ed. D.A. Morere and T. E. Allen, 191–207. New York: Springer.
- Pollard, R. Q., Jr., S. Rediess, and A. DeMatteo. 2005. Development and Validation of the Signed Paired Associates Test. *Rehabilitation Psychology* 50(3): 258–65. doi: 10.1037/0090-5550.50.3.258.
- , and E. Lentz. 2007. A Prose Recall Test Using Stories in American Sign Language. *Rehabilitation Psychology* 52(1): 11–24. DOI: 10.1037/0090-5550.52.1.11.
- Portocarrero, J. S., R. G. Burreight, and P. J. Donovan. 2007. Vocabulary and Verbal Fluency of Bilingual and Monolingual College Students. *Archives of Clinical Neuropsychology* 22: 415–22.
- Ramírez, M., M. E. Ford, A. L. Stewart, and J. A. Teresi. 2005. Measurement Issues in Health Disparities Research. *Health Services Research* 40(5), pt. 2: 1640–57. doi: 10.1111/j.1475-6773.2005.00450.x PMID: PMC1361222.
- Simms, L., S. Baker, and M. D. Clark. 2013. The Standardized Visual Communication and Sign Language Checklist for Signing Children. *Sign Language Studies* (Summer).
- Stokoe, W. C. 1960. Sign Language Structure: An Outline of the Visual Communication System of the American Deaf. *Studies in Linguistics: Occasional Papers*, no. 8. Buffalo, NY: Department of Anthropology and Linguistics, University of Buffalo.
- Tomlinson-Keasey, C., C. Smith, and S. Hale. 1981. Can Deaf Individuals Process Sequential Material? Paper presented at the Ninth Annual International Neuropsychological Society, Atlanta, GA, February 5–7.
- Ulissi, S. M., P. S. Brice, and S. Gibbins. 1989. Use of the Kaufman Assessment Battery for Children with the Hearing Impaired. *American Annals of the Deaf* 134(4): 283–86.
- Vertesi, A., J. A. Lever, D. W. Molloy, B. Sanderson, I. Tuttle, L. Pokoradi, and E. Principi. 2001. Standardized Mini-Mental State Examination: Use and Interpretation. *Canadian Family Physician* 47: 2018–23.
- Wilson, M., and K. Emmorey. 1998. A “Word-Length Effect” for Sign Language: Further Evidence for the Role of Language in Structuring Working Memory. *Memory and Cognition* 26: 584–90.
- Witkin, G. A., D. A. Morere, and L. C. Geer. 2013. Establishment of a Phonemic Clustering System for American Sign Language. *Sign Language Studies* (Summer).