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A systematic review of validity procedures used in neuropsychological batteries

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Abstract

This study presents a systematic review of validity evidence for neuropsychological batteries. Studies published in international databases between 2005 and 2012 were examined. Considering the specificity of neuropsychological batteries, the aim of the study was to review the statistical analyses and procedures that have been used to validate these instruments. A total of 1,218 abstracts were read, of which 147 involved studies of neuropsychological batteries or tests that evaluated at least three cognitive processes. The full text of each article was analyzed according to publication year, focal instrument of the study, sample type, sample age range, characterization of the participants, and procedures and analyses used to provide evidence of validity. The results showed that the studies primarily analyzed patterns of convergence and divergence by correlating the instruments with other tests. Measures of reliability, such as internal consistency and test-retest reliability, were also frequently employed. To provide evidence of relationships between test scores and external criteria, the most common procedures were evaluations of sensitivity and specificity, and comparisons were made between contrasting groups. The statistical analyses frequently used were Receiver Operating Characteristic analysis, Pearson correlation, and Cronbach's alpha. We discuss the necessity of incorporating both classic and modern psychometric procedures and presenting a broader scope of validity evidence, which would represent progress in this field. Finally, we hope our findings will help researchers better plan the validation process for new neuropsychological instruments and batteries. **Keywords:** neuropsychological assessment, validity, reliability, systematic review.

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Introduction

Brazilian neuropsychology researchers are increasingly interested in developing and adapting instruments based on evidence of validity (Abrisqueta-Gomez, Ostrosky-Solis, Bertolucci, & Bueno, 2008; Caldas, Zunzunegui, Freire, & Guerra, 2012; Carod-Artal, Martínez-Martin, Kummer, & Ribeiro, 2008; Carvalho, Barbosa, & Caramelli, 2010; Fonseca, Salles, & Parente, 2008; Pawlowski, Fonseca, Salles, Parente, & Bandeira, 2008). The validation process for psychological instruments includes different procedures and statistical techniques to evaluate psychometric properties (Pasquali, 2010; Urbina, 2004). Detailed procedures and techniques are supplied in the *Standards*

for Educational and Psychological Testing (American Educational Research Association, 1999). Several statistical software programs can be used for instrument validation, which can be observed in articles and test manuals. However, the applicability of the techniques depends on the characteristics of the instrument that is being validated. With regard to neuropsychological batteries, instruments show variations in the type and quality of the test items, number of examined cognitive functions, and measured construct.

Many neuropsychological instruments include tasks that evaluate different cognitive domains, and they require distinct validation techniques compared with regular scales, such as the Likert scale. Some procedures or statistical analyses can be difficult to apply in specific situations, such as when the number of items is limited or when a large number of subjects is required but the sample is hard to access. Comparisons of neuropsychological testing research methods and specific guidelines for psychological and neuropsychological test development contribute to the refinement of interpretative, clinical, and psychometric methods (Hunsley, 2009; Brooks, Strauss, Sherman, Iverson, & Slick, 2009; Blakesley et al., 2009). Consistent with most validity frameworks and the current test standards (American Educational Research Association, 1999), tests differ with regard

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to the categories that are most crucial to test meaning, depending on the test's intended use (Embretson, 2007). A brief discussion of psychometric procedures that are used to provide evidence of the validity of neuropsychological assessment batteries can be found in Pawlowski, Trentini, & Bandeira (2007).

Considering the specificity of neuropsychological batteries, the aim of the present study was to review the procedures and statistical analyses that have been used to study evidence of the validity of these tests. This study can contribute to the selection of appropriate statistical techniques and inform professionals about better instrument validation procedures.

Materials and Methods

Abstracts and articles published in indexed periodicals and international databases between 2005 and 2012 were reviewed. The selected publications simultaneously considered neuropsychological assessment and validity.

Study type

The present research involved an integrated and systematic review (Fernández-Ríos, & Bucla-Casal, 2009). Beginning from a set of quantitative studies, the aim was to integrate information about analyses that have examined evidence of the validity of neuropsychological batteries.

Procedures

The PsycINFO and MEDLINE (EBSCO) databases were searched on May 3, 2013. The terms “*neuropsychological assessment*” and “*validity*” (key words used in *Thesaurus*) were used to search for published abstracts between January 2005 and December 2012. The search was conducted without publication language restrictions. A database was created with all abstract titles, and duplication between MEDLINE and PsycINFO databases was removed. Abstracts that involved investigations of evidence of the validity of neuropsychological batteries and assessed at least three cognitive processes were included. For example, the cognitive processes could include memory, language, and praxis (i.e., motor planning). Three independent judges classified each abstract according to the name of the instrument, study type (e.g., empirical, theoretical, or review), instrument type (e.g., battery, single task, or scale), the number of cognitive processes evaluated by the instrument, and whether the study evaluated any evidence of validity. Each abstract was read by at least two of the three judges. In case of disagreement, the abstract was evaluated by all three judges until consensus was reached. The selected abstracts were read again. Articles that assessed evidence of the validity of computerized batteries were excluded. The complete article of each selected abstract was read and classified according to the following criteria: publication year, sample type (clinical or healthy), sample age group (children, teenagers, adults, and elderly), clinical pathology (in the case of

clinical samples), and procedures and statistical analyses employed to provide evidence of validity. The references of the reviewed articles are presented in Appendix 1.

Information analysis

Descriptive analyses (frequency and percentage) were performed to record the publication year, focal instrument of the study, sample type, sample age range, characterization of the participants, and type of procedure and statistical analysis employed to evaluate evidence of validity.

Results

The search for articles with the simultaneous use of the key words “*neuropsychological assessment*” and “*validity*” resulted in 1,218 abstracts published in scientific journals between January 2005 and December 2012. A total of 525 abstracts were published in the PsycINFO database, and 693 abstracts were published in the MEDLINE database. Of the 693 abstracts in MEDLINE, 117 were also published in PsycINFO (one repetition was found in PsycINFO itself). Of the 1,100 total abstracts, 524 were from PsycINFO, and 576 were from MEDLINE. Figure 1 presents a detailed diagram of the selected abstracts.

Only studies of neuropsychological batteries or tests that evaluated at least three cognitive processes and included tasks with face-to-face or traditional paper-and-pencil administration were analyzed. The final selection included 147 abstracts (73 in PsycINFO and 74 in MEDLINE). The distribution of the 147 abstracts by publication year is presented in Figure 2, in which an increase in the number of studies in recent years was found, especially in 2010 and 2012. Because the full-text articles were unavailable for 15 abstracts, 132 articles were fully reviewed. Four abstracts were excluded because information about the analytical criteria was not present. The final review included 132 full-text articles and 11 abstracts. Detailed information for all 143 full-text articles and abstracts is presented in Table 1, including year of publication, journal, authors, quantity and type of participants (clinical and control/comparison), and instrument.

The instrument whose psychometric properties were most often analyzed by studies in this systematic review was the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS), which was cited in 12.5% of the articles. Investigations of the psychometric properties of the Montreal Cognitive Assessment (MoCA) were found in 11.2% of the studies. The Mini-Mental State Examination (MMSE) appeared in 7% of the citations, half of which occurred in association with the MoCA. Addenbrooke's Cognitive Examination (ACE) and Addenbrooke's Cognitive Examination Revised (ACE-R) were cited in 5.6% of the articles. Other instruments that were cited were the Alzheimer's Disease Assessment Scale—Cognitive Part (ADAS-COG; 4.9%), the Consortium to Establish a Registry for Alzheimer's Disease (CERAD; 3.5%), and the Neuropsychological Assessment Battery (NAB; 4.2%).

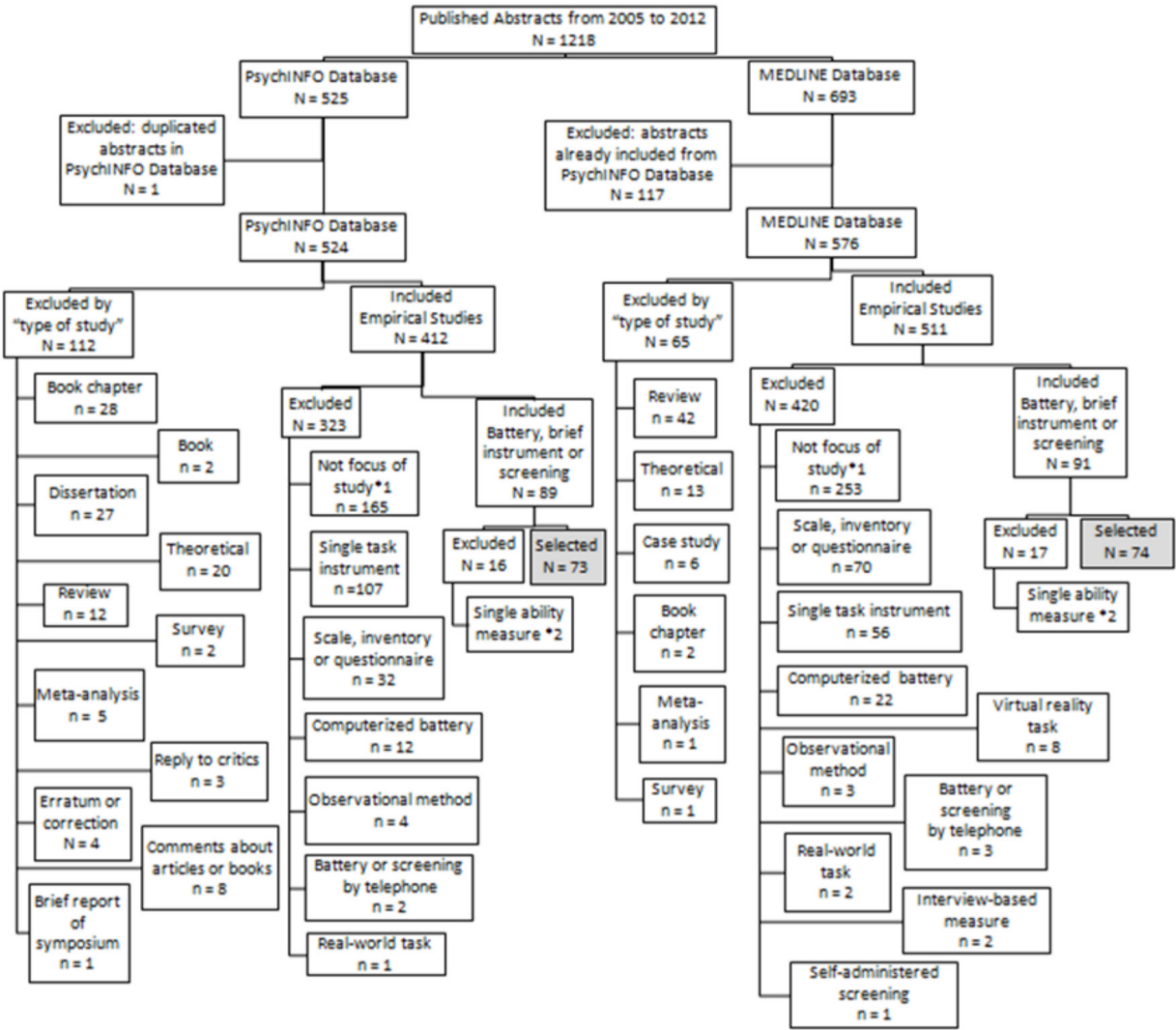


Figure 1. Diagram of the selected abstracts. ¹ Abstracts in the “Not focus of the study” category were excluded because they correspond to (1) studies in which the measuring instrument was not the main focus of analysis, (2) the cognitive assessment instruments were not the research focus, or (3) the validity of the battery was not the main focus of the study. ² Abstract excluded because the final score evaluated only one cognitive function (e.g., a battery of intelligence assessment).

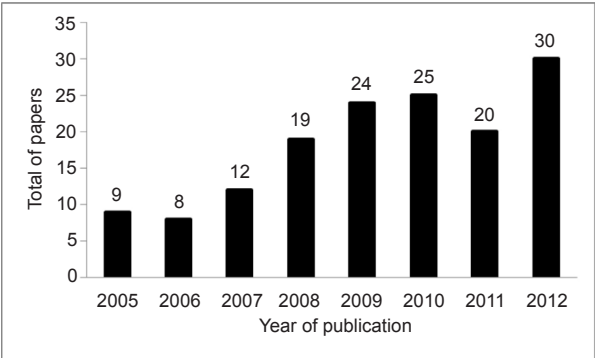


Figure 2. Articles per year of publication.

With regard to sample type, 51.4% of the studies included both a clinical and healthy/control sample. A total of 35.4% of the studies exclusively examined clinical samples, and 13.2% focused on healthy populations. Concerning the age of the samples, 44.4% of the studies were performed with elderly participants, 22.9% included both adults and the elderly, and 18.8% exclusively included adults. Additionally, 4.2% included youth, adults, and the elderly, and 4.9% were performed exclusively with children. Only one study (.7%) included a sample of children, teenagers, and adults, and another study (.7%) exclusively analyzed teenagers. Identification of the age group was not possible in five studies (3.5%). Concerning clinical sample pathologies, the frequencies and percentages are presented in Table 2. The clinical samples were predominantly composed of individuals diagnosed with dementia (18.5%), Alzheimer’s disease (17.9%), and mild cognitive impairment (16.2%). Patients with acquired brain injury and cerebrovascular diseases were also assessed in a large number of studies (15.1%).

Table 1. Years, journals, authors, samples, and instruments of the papers reviewed.

Year	Journal	Authors	Sample (N and type)		Instruments
			Clinical	Control/ Healthy	
2012	<i>Iranian Journal of Psychiatry and Clinical Psychology</i>	Abedi, Malekpour, Oraizi, Faramarzi, & Paghale	—	300	Neuropsychological test of NEPSY
2012	<i>Archives of Clinical Neuropsychology</i>	Donders, & Levitt	54 Traumatic brain injury	54	Attention, Executive Function, and Memory modules of the Neuropsychological Assessment Battery (NAB)
2012	<i>Accident Analysis and Prevention</i>	Ferreira, Simões, & Marôco	—	50	Addenbrooke's Cognitive Examination Revised (ACE-R)
2012	<i>Journal of the International Neuropsychological Society</i>	Freitas, Simões, Marôco, Alves, & Santana	90 Alzheimer's disease 90 Mild cognitive impairment	650	Montreal Cognitive Assessment (MoCA)
2012	<i>Journal of the International Neuropsychological Society</i>	Freitas, Simões, Alves, Vicente, & Santana	34 Vascular dementia 34 Alzheimer's disease	34	Montreal Cognitive Assessment (MoCA) and short version of MOCA
2012	<i>Applied Neuropsychology: Adult</i>	Gavett, Lou, Daneshvar, Green, Jefferson, & Stern	65 Alzheimer's disease	211	Seven variables of Neuropsychological Assessment Battery (NAB)
2012	<i>Applied Neuropsychology: Adult</i>	Heo, Lee, Park, Ahn, & Kim	50 Alzheimer's disease 26 Mild cognitive impairment	39	Korean Addenbrooke's Cognitive Examination
2012	<i>Applied Neuropsychology: Adult</i>	Krigbaum, Amin, Virden, Baca, & Uribe	13 Neurological disorder	30	Culture-Fair Assessment of Neurocognitive Abilities (S-S CANA)
2012	<i>Brain Imaging and Behavior</i>	Park et al.	337 Mild cognitive impairment 193 Probable Alzheimer's	229	Alzheimer's Disease Neuroimaging Initiative (ADNI) Neuropsychological Battery
2012	<i>Nervenheilkunde</i>	Rösche, Schley, & Benecke	38 Epilepsy	—	Neuropsychological screening (EpiTrack)
2012	<i>Clinical Neuropsychologist</i>	Smerbeck et al.	—	102	National Multiple Sclerosis Society Consensus Neuropsychological Battery for Pediatric Multiple Sclerosis (NBPMs)
2012	<i>Psychiatria Hungarica</i>	Drótos, Pákási, Papp, & Kálmán	66 Alzheimer's disease 39 Depression	47	Cognitive subscale of the Alzheimer's Disease Assessment Scale (ADAS-Cog)
2012	<i>Vertex - Revista de Experiências Clínicas y Neurociencias</i>	Custodio, Lira, Montesinos, Gleichgerricht, & Manes	40 Alzheimer's disease 18 Frontotemporal dementia	40	Addenbrooke's Cognitive Examination (ACE)
2012	<i>European Journal of Cardiovascular Nursing</i>	Bauer, Pozehl, Hertzog, Johnson, Zimmerman, & Fillipi	80 Chronic heart failure	—	The Repeatable Battery for the Assessment of Neuropsychological Status, Trail Making Test Part A and Part B, and letter fluency
2012	<i>Journal of Clinical Neuroscience</i>	Nie et al.	123 Parkinson's disease	—	Montreal Cognitive Assessment (MOCA)
2012	<i>Archives of Clinical Neuropsychology</i>	Kelly, Coldren, Parish, Dretsch, & Russell	66 Acute concussion	146	Automated Neuropsychological Assessment Metrics (ANAM)
2012b	<i>Journal of Neurology, Neurosurgery, and Psychiatry</i>	Dong et al.	239 Cerebrovascular disease or stroke patients	—	Montreal Cognitive Assessment (MoCA) and the Mini-Mental State Examination (MMSE)
2012	<i>Clinical Neuropsychologist</i>	Dusankova, Kalincik, Havrdova, & Benedict	369 Multiple sclerosis	134	Minimal Assessment of Cognitive Function in MS (MACFIMS) and Brief International Cognitive Assessment of MS (BICAMS)
2012	<i>Aging and Mental Health</i>	Mansbach, & MacDougall	104 Dementia and mild cognitive impairment	—	Brief Cognitive Assessment Tool (BCAT), the BCAT-SF

Year	Journal	Authors	Sample (N and type)		Instruments
			Clinical	Control/ Healthy	
2012	<i>American Journal of Drug and Alcohol Abuse</i>	Copersino et al.	60 Substance use disorders	—	Montreal Cognitive Assessment (MOCA)
2012	<i>Chest</i>	Villeneuve et al.	45 Chronic obstructive pulmonary disease	50	Mini-Mental State Examination (MMSE) and Montreal Cognitive Assessment (MoCA)
2012	<i>Brain Imaging and Behavior</i>	Skinner et al.	187 Alzheimer's disease	229	ADAS-Cog-Plus
2012	<i>Journal of Clinical and Experimental Neuropsychology</i>	Mansbach, MacDougall, & Rosenzweig	394 Mild cognitive impairment	70	Brief Cognitive Assessment Tool (BCAT)
2012	<i>Nordic Journal of Psychiatry</i>	Korner, Brogaard, Wissum, & Petersen	31 Dementia	3	Baylor Profound Mental State Examination
2012a	<i>International Psychogeriatrics</i>	Dong et al.	55 Dementia	—	Montreal Cognitive Assessment (MoCA) and MMSE
2012	<i>Disability & Rehabilitation</i>	Morris, Hacker, & Lincoln	61 Mild cognitive impairment	33	Addenbrooke's Cognitive Examination-Revised (ACE-R)
2012	<i>Journal of Nutrition, Health & Aging</i>	Cruz-Oliver et al.	101 Cerebrovascular disease or stroke patients	—	Saint Louis University Mental Status Exam (Slums Exam) and MMSE
2012	<i>Arquivos de Neuropsiquiatria</i>	Caldas et al.	705/533 patients screened for cognitive dysfunction (dementia and mild cognitive impairment)	43% or 71% of 533	Leganés cognitive test
2012	<i>Clinical Neuropsychologist</i>	Eshaghi et al.	158 Multiple Sclerosis	59	Minimal Assessment of Cognitive Function in Multiple Sclerosis (MACFIMS)
2012	<i>Critical Care Medicine</i>	Lewin et al.	106 Critically ill patients	90	The Johns Hopkins Adapted Cognitive Exam
2011	<i>Archives of Clinical Neuropsychology</i>	Azizian, Yeghiyan, Ishkhanyan, Manukyan, & Khandanyan	77 Schizophrenia and schizoaffective disorder	—	Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) into Armenian
2011	<i>Dementia and Geriatric Cognitive Disorders</i>	Damian et al.	20 Dementia	77	Montreal Cognitive Assessment (MoCA) and Mini-Mental State Examination (MMSE)
2011	<i>Applied Neuropsychology</i>	Duff, Patton, Schoenberg, Mold, Scott, & Adams	326 Mild cognitive impairment	89	Repeatable Battery for the Assessment of Neuropsychological Status (RBANS)
2011	<i>Journal of Clinical and Experimental Neuropsychology</i>	Duff, Schoenberg, Mold, Scott, & Adamss	—	718	Repeatable Battery for the Assessment of Neuropsychological Status (RBANS)
2011	<i>Journal of Clinical Nursing</i>	Ericsson, Malmberg, Langworth, Haglund, & Almborg	220 Dementia	—	Clinical Evaluation of Moderate-to-Severe Dementia (Swedish acronym: KUD)
2011	<i>Applied Neuropsychology: Adult</i>	Lovell, & Solomon	—	1,000	National Football League's Neuropsychological Test Battery
2011	<i>Psychiatry Research</i>	Yoshida et al.	65 Alzheimer's disease 24 Frontotemporal dementia 26 Vascular dementia 11 Lewy body dementia 13 Mild cognitive impairment	62	Addenbrooke's Cognitive Examination (ACE)
2011	<i>Rehabilitation Psychology</i>	Zgaljardic, Yancy, Temple, Watford, & Miller	47 Traumatic brain injury	—	Screening module and the Daily Living tests of the Neuropsychological Assessment Battery (NAB-SM)
2011	<i>Cognitive and Behavioral Neurology</i>	Bugalho, & Vale	75 Parkinson's disease	45	Frontal Assessment Battery (FAB) and Mini-Mental State Examination (MMSE)

Year	Journal	Authors	Sample (N and type)		Instruments
			Clinical	Control/ Healthy	
2011	<i>Schizophrenia Research</i>	Cuesta et al.	65 Bipolar disorder 96 Schizophrenia 156 Mild cognitive impairment	76	Brief Cognitive Assessment Tool for Schizophrenia (B-CATS) and the Screen for Cognitive Impairment in Psychiatry (SCIP)
2011	<i>International Psychogeriatrics</i>	Konsztowicz, Xie, Higgins, Mayo, & Koski	147 Dementia 27 Psychiatric disorders 57 Cognitive impairment unspecified	52	Geriatric Rapid Adaptive Cognitive Estimate (GRACE)
2011	<i>International Psychogeriatrics</i>	Liu et al.	—	187	The Consortium to Establish a Registry for Alzheimer's Disease Neuropsychological Assessment Battery
2011	<i>Research in Developmental Disabilities</i>	Deng, Liu, Wei, Chan & Das	18 Attention-deficit/hyperactivity disorder 18 Reading disabilities 157 Mild cognitive impairment	567	Das-Naglieri Cognitive Assessment System
2011	<i>Neuroepidemiology</i>	Wege et al.	162 Borderline memory impairment	211	Abbreviated cognitive performance assessment
2011	<i>European Psychiatry</i>	Segarra et al.	117 Schizophrenia	36	Brief Assessment of Cognition in Schizophrenia (BACS)
2011	<i>Clinical Neuropsychologist</i>	Libon et al.	46 Alzheimer's disease 152 Frontotemporal dementia	15	Philadelphia Brief Assessment of Cognition (PBAC)
2011	<i>Epilepsy and Behaviour</i>	Walterfang et al.	161 Seizures	—	Neuropsychiatry Unit Cognitive Assessment Tool (NUCOG)
2011	<i>International Psychogeriatrics</i>	Choi et al.	152 Literate and illiterate dementia patients 66 Mild cognitive impairment	639	Literacy Independent Cognitive Assessment (LICA)
2011	<i>Journal of Geriatric Psychiatry and Neurology</i>	McLennan, Mathias, Brennan, & Stewart	110 Cardiovascular disease or risk factor for cardiovascular disease	—	Montreal Cognitive Assessment (MOCA)
2011	<i>Archives of Medical Science</i>	Cheng, Wu, Wang, Feng, Wu, & Li	—	236	Repeatable Battery for the Assessment of Neuropsychological Status (RBANS)
2010	<i>Cognitive and Behavioral Neurology</i>	Carvalho et al.	31 Alzheimer's disease	62	Brazilian version of the Addenbrooke Cognitive Examination-Revised (ACE-R)
2010	<i>Journal of Neurodevelopmental Disorders</i>	Edgin et al.	74 Down syndrome	36	Arizona Cognitive Test Battery
2010	<i>International Journal of Geriatric Psychiatry</i>	Hobson, Hall, Humphreys-Clark, Schrimsher, & O'Bryant	51 Alzheimer's disease 48 Mild cognitive impairment	—	Repeatable Battery for the Assessment of Neuropsychological Status (RBANS)
2010	<i>Schizophrenia Bulletin</i>	Holmén, Juuhl-Langseth, Thormodsen, Melle, & Rund	31 Schizophrenia spectrum disorders	67	MATRICES battery
2010	<i>Journal of Clinical and Experimental Neuropsychology</i>	Jones et al.	210 Cardiac surgery patients	—	Neuropsychological battery using nine assessments
2010	<i>Clinical Neuropsychologist</i>	Miller, Fichtenberg, & Millis	81 Neurological disorder	—	Ability-Focused Battery (AFB)
2010	<i>Journal of Alzheimer's Disease</i>	Paajanen et al.	224 Mild cognitive impairment	223	Consortium to Establish a Registry for Alzheimer's Disease Neuropsychological Battery (CERAD-NB)

Year	Journal	Authors	Sample (N and type)		Instruments
			Clinical	Control/ Healthy	
2010	<i>Journal of the International Neuropsychological Society</i>	Parmenter, Testa, Schretlen, Weinstock-Guttman, & Benedict	395 Multiple sclerosis	100	Minimal Assessment of Cognitive Function in Multiple Sclerosis (MACFIMS)
2010	<i>Alzheimer Disease and Associated Disorders</i>	Rossetti, Munro Cullum, Hynan, & Lacritz	655 Alzheimer's disease	383	Consortium to Establish a Registry for Alzheimer's Disease Neuropsychological Battery (CERAD-NB)
2010	<i>Applied Neuropsychology</i>	Schmitt et al.	636 Cognitive impairment unspecified	—	Repeatable Battery for the Assessment of Neuropsychological Status (RBANS)
2010	<i>Journal of Neurology, Neurosurgery & Psychiatry</i>	Schofield et al.	25 Dementia 33 Cognitive impairment (no dementia)	675	Audio Recorded Cognitive Screen (ARCS)
2010	<i>American Journal of Geriatric Psychiatry</i>	Seo et al.	583 Dementia 250 Mild cognitive impairment	—	Consortium to Establish a Registry for Alzheimer's Disease Neuropsychological Battery (CERAD-NB)
2010	<i>Clinical Neuropsychologist</i>	Wilde	164 Cerebrovascular disease or stroke patients	—	Repeatable Battery for the Assessment of Neuropsychological Status (RBANS)
2010	<i>Chinese Mental Health Journal</i>	Yang et al.	—	60	Repeatable Battery for the Assessment of Neuropsychological Status (RBANS)
2010a	<i>Applied Neuropsychology</i>	Zgaljardic, & Temple	20 Traumatic brain injury	—	Neuropsychological Assessment Battery (NAB)
2010b	<i>Applied Neuropsychology</i>	Zgaljardic & Temple	42 Acquired brain injury	—	Screening module from the Neuropsychological Assessment Battery (NAB-SM)
2010	<i>Tijdschrift voor Gerontologie en Geriatrie</i>	Thissen, van Bergen, de Jonghe, Kessels, & Dautzenberg	37 Dementia 32 Mild cognitive impairment	30	Montreal Cognitive Assessment (MOCA)
2010	<i>British Journal of Educational Psychology</i>	Nampijja et al.	—	64	Western Measures of Cognition
2010	<i>Geriatrics & Gerontology International</i>	Fujiwara et al.	30 Alzheimer's disease 30 Mild cognitive impairment	36	Japanese version of the MoCA (MoCA-J)
2010	<i>American Journal of Alzheimer's Disease & Other Dementias</i>	Harvey et al.	55 Parkinson's disease 58 Alzheimer's disease	—	Alzheimer's Disease Assessment Scale-Cognitive Subscale (ADAS-Cog)
2010	<i>Journal of Neurology, Neurosurgery & Psychiatry</i>	Cano et al.	1,421 Alzheimer's disease	—	ADAS-Cog
2010	<i>International Psychogeriatrics</i>	Pirani, Brodaty, Martini, Zaccherini, Neviani, & Neri	132 Dementia	68	General Practitioner Cognitive Assessment of Cognition (GPCOG)
2010	<i>Dementia and Geriatric Cognitive Disorders</i>	Barekatain et al.	33 Dementia 30 Neurological disorder 61 Psychiatric disorder	60	Neuropsychiatry Unit Cognitive Assessment Tool (NUCOG)
2009	<i>American Journal of Geriatric Psychiatry</i>	Kessels, Mimpfen, Melis, & Rikkert	36 Dementia and cognitive impairment	24	Revised Cambridge Cognitive Examination (CAMCOG-R)
2009	<i>Journal of Neurology, Neurosurgery & Psychiatry</i>	de Jonghe, Wetzels, Mulders, Zuidema, & Koopmans	264 Dementia	—	Severe Impairment Battery Short Version (SIB-S)
2009	<i>Journal of the International Neuropsychological Society</i>	Bender et al.	127 Epilepsy	—	Neuropsychological Screening Battery for Hispanics (NeSBHIS)

Year	Journal	Authors	Sample (N and type)		Instruments
			Clinical	Control/ Healthy	
2009	<i>Acta Neuropsychiatrica</i>	Sanz, Vargas, & Marín	30 Schizophrenia	30	Repeatable Battery for the Assessment of Neuropsychological Status (RBANS)
2009	<i>Brain Injury</i>	Temple et al.	70 Non-psychotic psychiatric patients	—	Neuropsychological Assessment Battery Screening Module (NAB-SM)
2009	<i>Neurology</i>	Hoops et al.	17 Parkinson's disease	92	MoCA, MMSE, and a neuropsychological battery
2009	<i>Chinese Journal of Clinical Psychology</i>	Cheng, Li, Wu, & Department of Psychiatry	23 Mild cognitive impairment	49	Chinese version of Repeatable Battery for the Assessment of Neuropsychological Status (RBANS)
2009	<i>Chinese Journal of Clinical Psychology</i>	Li, Xiao, & Xiao	135 Alzheimer's disease	78	Chinese version of Alzheimer's Disease Assessment Scale-Cognitive part (ADAS-Cog)
2009	<i>Dementia and Geriatric Cognitive Disorders</i>	Abizanda et al.	173/100 Alzheimer's disease	—	FMLL Mini-Battery
2009	<i>International Journal of Geriatric Psychiatry</i>	Zhou, & Jia	137/87 Mild cognitive impairment	80	Comprehensive assessment tool
2009	<i>Epilepsy & Behavior</i>	Barr, Bender, Morrison, Cruz-Laureano, Vazquez, & Kuzniecky	80 Cognitive impairment (no dementia)	—	Neuropsychological Screening Battery for Hispanics (NeSBHIS)
2009	<i>Experimental and Clinical Psychopharmacology</i>	Copersino, Fals-Stewart, Fitzmaurice, Schretlen, & Weiss	115 Epilepsy	—	Montreal Cognitive Assessment (MoCA)
2009	<i>Archives of Physical Medicine and Rehabilitation</i>	Mate-Kole et al.	60 Substance use disorders	201	Quick Cognitive Screening Test Revised (QCST)
2009	<i>Multiple Sclerosis</i>	Strober, Englert, Munschauer, Weinstock-Guttman, Rao, & Benedict	93 Dementia,	46	Rao Brief Repeatable Neuropsychological Battery and the Minimal Assessment of Cognitive Function
2009	<i>Alzheimer Disease and Associated Disorders</i>	Schneider et al.	48 Neurological disorders	—	Alzheimer's Disease Cooperative Study-Clinical Global Impression of Change (ADCS-CGIC)
2009	<i>Alzheimer Disease and Associated Disorders</i>	Basic et al.	35 Psychiatric disorders	60	Rowland Universal Dementia Assessment Scale (RUDAS)
2009	<i>Acta Neurologica Scandinavica</i>	Hoffmann, Schmitt, & Bromley	65 Multiple sclerosis	27	Coconuts (Comprehensive Cognitive Neurological Test in Stroke)
2009	<i>European Journal of Physical and Rehabilitation Medicine</i>	Lunardelli, Mengotti, Pesavento, Sverzut, & Zadini	769 Mild cognitive impairment	247	Brief Neuropsychological Screening (BNS)
2009	<i>Dementia and Geriatric Cognitive Disorders</i>	Wong et al.	58 Dementia	40	Hong Kong Montreal Cognitive Assessment (HK-MoCA)
2009	<i>BMC Neurology</i>	Sosa et al.	33 Mild cognitive impairment	13,649	Community Screening Instrument for Dementia (CSI 'D'), CERAD and memory list
2009	<i>African Health Sciences</i>	Bangirana et al.	65 Cerebrovascular disease or stroke patients	—	Kaufman Assessment Battery for Children, Second Edition (KABC-II)

Year	Journal	Authors	Sample (N and type)		Instruments
			Clinical	Control/ Healthy	
2009	<i>Psychology Research and Behavior Management</i>	McCrea	33 Cerebrovascular disease or stroke patients	—	DN-CAS PASS scale (Das Naglieri-cognitive assessment system on the Planning–Attention–Simultaneous–Successive)
2009	<i>European Journal of Neurology</i>	Reyes, Perez-Lloret, Roldan Gerschovich, Martin, Leiguarda, & Merello	44 Parkinson's disease	—	Addenbrooke's Cognitive Examination (ACE)
2008	<i>Chinese Mental Health Journal</i>	Zhang et al.	—	451	Repeatable Battery for the Assessment of Neuropsychological Status (RBANS)
2008	<i>Clinical Rehabilitation</i>	Nøkleby et al.	49 Cerebrovascular disease or stroke patients	—	Cognistat, Screening Instrument for Neuropsychological Impairments in Stroke and Clock Drawing
2008	<i>International Journal of Geriatric Psychiatry</i>	Nunes et al.	30 Dementia 65 Mild cognitive impairment	62	Cambridge Cognitive Examination (CAMCOG)
2008	<i>Archives of Clinical Neuropsychology</i>	Duff, Humphreys Clark, O'Bryant, Mold, Schiffer, & Sutker	69 Alzheimer's disease	69	Repeatable Battery for the Assessment of Neuropsychological Status (RBANS)
2008	<i>Archives of Clinical Neuropsychology</i>	Pietrzak, Maruff, Mayes, Roman, Sosa, & Snyder	252 Patients undergoing parathyroidectomy or thyroidectomy	49	Groton Maze Learning Test (GMLT)
2008	<i>International Journal of Geriatric Psychiatry</i>	Zhou, & Jia	80 Cognitive impairment (no dementia)	80	Mini-Mental State Examination (MMSE) and Clock Drawing Test (CDT)
2008	<i>Clinical Neuropsychologist</i>	McKay, Wertheimer, Fichtenberg, & Casey	51 Traumatic brain injury	34	Repeatable Battery for the Assessment of Neuropsychological Status (RBANS)
2008	<i>Applied Neuropsychology</i>	Reitan, & Wolfson	35 Acquired brain injury patients	35	Reitan-Wolfson Neuropsychological Preliminary Battery for Older Children, Retain-Indiana Aphasia Test, Trail Making Test
2008	<i>Alzheimer Disease and Associated Disorders</i>	Abrisqueta-Gomez et al.	53 Alzheimer's disease	25	Abbreviated Neuropsychologic Battery (NEUROPSI)
2008	<i>Psychology & Neuroscience</i>	Fonseca et al.	—	16	Brazilian Brief Neuropsychological Assessment
2008	<i>Archives of Physical Medicine and Rehabilitation</i>	Green et al.	63 Traumatic brain injury	—	Neuropsychological composite scores
2008	<i>International Journal of Geriatric Psychiatry</i>	Mesbah, Grass-Kapanke, & Ihl	58 Alzheimer's disease and depression	98	Training Target Test Dementia (3TD)
2008	<i>Revista de Neurología</i>	Martínez-Martín, Frades-Payo, Rodríguez-Blázquez, Forjaz, & de Pedro-Cuesta	387 Parkinson's disease		Scales for Outcomes in Parkinson's Disease-Cognition
2008	<i>Neurología</i>	Adrián, Hermoso, Buiza, Rodríguez-Parra, & González	—	273	PRO-NEURO
2008	<i>Journal of Geriatric Psychiatry and Neurology</i>	Lee et al.	81 Alzheimer's disease and mild cognitive impairment	115	Korean version of the MoCA (MoCA-K)
2008	<i>Archives of Physical Medicine and Rehabilitation</i>	Hanks et al.	174 Traumatic brain injury	—	A brief neuropsychologic test battery
2008	<i>Journal of Speech, Language and Hearing Research</i>	Milman, Holland, Kaszniak, D'Agostino, Garrett, & Rapcsak	20 Left hemisphere pathology 15 Right hemisphere pathology 16 Probable Alzheimer's	40	Scales of Cognitive and Communicative Ability for Neurohabilitation (SCCAN)
2008	<i>Dementia and Geriatric Cognitive Disorders</i>	Choe et al.	202 Alzheimer's disease	65	Severe Cognitive Impairment Profile (SCIP)

Year	Journal	Authors	Sample (N and type)		Instruments
			Clinical	Control/ Healthy	
2008	<i>Movement Disorders</i>	Carod-Artal et al.	152 Parkinson's disease	—	Scales for Outcomes in Parkinson's disease-Cognition
2007	<i>Archives of Neurology</i>	Harrison, Minassian, Jenkins, Black, Koller, & Grundman	372 Alzheimer's disease	—	Neuropsychological Test Battery (NTB)
2007	<i>Clinical Neuropsychologist</i>	Pachet	37 Acquired brain injury patients	—	Repeatable Battery for the Assessment of Neuropsychological Status (RBANS)
2007	<i>Archives of Clinical Neuropsychology</i>	McKay, Casey, Wertheimer, & Fichtenberg	57 Traumatic brain injury	—	Repeatable Battery for the Assessment of Neuropsychological Status (RBANS)
2007	<i>Psychiatry and Clinical Neurosciences</i>	Kaneda, Sumiyoshi, Keefe, Ishimoto, Numata, & Ohmori	30 Schizophrenia	—	Brief Assessment of Cognition in Schizophrenia (BACS)
2007	<i>Arthritis & Rheumatism (Arthritis Care & Research)</i>	Brunner et al.	16 Systemic lupus erythematosus	11	Pediatric Automated Neuropsychological Assessment Metrics (PED ANAM)
2007	<i>Neurología</i>	Monllau et al.	197 Alzheimer's disease and mild cognitive impairment	254	Alzheimer's Disease Assessment Scale (ADAS-Cog)
2007	<i>European Psychiatry</i>	Bralet, Falissard, Neveu, Lucas-Ross, Eskenazi, & Keefe	50 Schizophrenia	—	Brief Assessment of Cognition in Schizophrenia (BACS)
2007	<i>Journal of Alzheimer's Disease</i>	Trenkle, Shankle, & Azen	254 Alzheimer's disease	—	Mini-Mental State Exam (MMSE), Clock Drawing Test (CDT), MCI Screen (MCIS)
2007	<i>Canadian Journal of Psychiatry</i>	Smith, Gildeh, & Holmes	55 Dementia and mild cognitive impairment	12	Montreal Cognitive Assessment (MoCA)
2007	<i>Psycho-Oncology</i>	Mystakidou, Tsilika, Parpa, Galanos, & Vlahos	103 Cancer	—	Mini-Mental State Examination (MMSE)
2007	<i>Disability and Rehabilitation</i>	Kutlay, Kuçukdeveci, Elhan, Yavuzer, & Tennant	155 Traumatic brain injury	—	Middlesex Elderly Assessment of Mental State (MEAMS)
2007	<i>Health and Quality of Life Outcomes - BioMed Central Neurology</i>	Wolfs, Dirksen, Kessels, Willems, Verhey, & Severens	234 Mild cognitive impairment, Alzheimer's disease, and dementia	—	EQ-5D+C (cognitive dimension of EQ-5D)
2006	<i>Clinical Neuropsychologist</i>	Wilde	210 Cerebrovascular disease or stroke patients	—	Repeatable Battery for the Assessment of Neuropsychological Status (RBANS)
2006	<i>Australian and New Zealand Journal of Psychiatry</i>	Walterfang, Siu, & Velakoulis	265 Dementia, neurological disorders, and psychiatric disorders	82	Neuropsychiatry Unit Cognitive Assessment Tool (NUCOG)
2006	<i>International Journal of Geriatric Psychiatry</i>	Mioshi, Dawson, Mitchell, Arnold, & Hodges	178 Dementia and mild cognitive impairment	63	Addenbrooke's Cognitive Examination Revised (ACE-R)
2006	<i>Journal of Clinical and Experimental Neuropsychology</i>	Schmidt, Lieto, Kiryankova, & Salvucci	35 Dementia	84	Dementia Rating Scale-2: Alternate Form (DRS-2: AF)
2006	<i>Journal of the International Neuropsychological Society</i>	Benedict et al.	291 Multiple sclerosis	56	Minimal Assessment of Cognitive Function in Multiple Sclerosis (MACFIMS)
2006	<i>Dementia and Geriatric Cognitive Disorders</i>	Del Ser, Sánchez-Sánchez, Yébenes, Otero, & Munoz	48 Dementia	368	Seven-Minute Screen Neurocognitive Battery (7MS)
2006	<i>International Journal of Geriatric Psychiatry</i>	Suh, & Kang	65 Alzheimer's disease	—	Korean version of Severe Impairment Battery (SIB-K)
2006	<i>International Journal of Geriatric Psychiatry</i>	Mavioglu, Gedizlioglu, Akyel, Aslaner, & Eser	39 Probable Alzheimer's disease	27	Alzheimer's Disease Assessment Scale- Cognitive Subscale (ADAS-Cog)
2005	<i>International Psychogeriatrics</i>	de Leonni Stanonik et al.	42 Alzheimer's disease	41	Self Test (ST)

Year	Journal	Authors	Sample (N and type)		Instruments
			Clinical	Control/ Healthy	
2005b	<i>Journal of the International Neuropsychological Society</i>	Mungas, Reed, Tomaszewski Farias, & Decarli	34 Dementia 58 Mild cognitive impairment	62	Neuropsychological Assessment Scales (SENAS)
2005	<i>Zeitschrift für Gerontopsychologie & -psychiatrie</i>	Gutzmann, Schmidt, Rapp, Rieckmann, & Folstein	125 Dementia	43	Micro-Mental Test
2005a	<i>Neuropsychology</i>	Mungas et al.	—	527	Neuropsychological Assessment Scales (SENAS)
2005	<i>Canadian Journal of Neurological Sciences</i>	Darvesh, Leach, Black, Kaplan, & Freedman	29 Dementia	115	Behavioural Neurology Assessment (BNA)
2005	<i>Journal of the International Neuropsychological Society</i>	Pedraza et al.	—	289	Mayo battery of neuropsychological tests
2005	<i>Journal of Clinical and Experimental Neuropsychology</i>	Larson, Kirschner, Bode, Heinemann, & Goodman	158 Cerebrovascular disease or stroke patients	—	Repeatable Battery for the Assessment of Neuropsychological Status (RBANS)
2005	<i>International Journal of Geriatric Psychiatry</i>	Mahoney, Johnston, Katona, Maxmin, & Livingston	178 Alzheimer's disease	25	Test for the Early Detection of Dementia from Depression

Table 2. Frequencies and percentages of clinical pathology samples in the reviewed articles.

Clinical pathology	f	%
Dementia	33	18.5
Alzheimer's disease (includes probable Alzheimer's disease)	32	17.9
Mild cognitive impairment	29	16.2
Acquired brain injury (includes traumatic brain injury and acute concussion)	15	8.4
Cerebrovascular disease or stroke patients	11	6.2
Schizophrenia (includes schizoaffective disorder)	8	4.5
Parkinson's disease	7	3.9
Cognitive and memory impairment (no dementia)	7	3.9
Neurological disorders	5	2.8
Multiple sclerosis	5	2.8
Epilepsy	5	2.8
Psychiatric disorders (psychotic/nonpsychotic patients)	5	2.8
Cardiovascular diseases	3	1.7
Depression and bipolar disorder	3	1.7
Substance use disorders	2	1.1
Patients undergoing parathyroidectomy or thyroidectomy	1	0.6
Cancer	1	0.6
Systemic lupus erythematosus	1	0.6
Down syndrome	1	0.6
Critically ill patients	1	0.6
Attention-deficit/hyperactivity disorder (ADHA)	1	0.6
Chronic obstructive pulmonary disease	1	0.6
Reading disabilities	1	0.6
Total	178	100.0

To evaluate the validity of the batteries, the articles incorporated from one to eight distinct procedures. Most of the studies completed two (25%), three (21.5%), or just one (20.8%) procedure. Four procedures were employed by 13.2% of the studies, five were employed by 10.4%, and six were employed by 6.3%. Only 1.4% of the studies presented seven procedures, and .7% presented eight procedures. The most frequently used procedures included the evaluation of sensitivity

and specificity (17.6%), correlations with other tests (15.6%), comparisons between groups (12.3%), analyses of internal consistency (12.1%), test-retest reliability (8.6%), and factor structure analysis (8.6%). The procedures are presented in Table 3.

Table 3. Frequencies and percentages of validity evidence procedures.

Procedures	f	%
Sensitivity and specificity	76	17.6
Correlation with other tests	67	15.6
Comparison between contrasting groups	53	12.3
Internal consistency (total instrument or subscales)	52	12.1
Test-retest reliability	37	8.6
Factor structure analysis	37	8.6
Inter-rater reliability	17	4.0
Effect or influence of demographical variables	17	4.0
Predictive analysis	15	3.5
Correlation or comparison with other measures (not tests)	13	3.0
Item-total correlation or correlation between items and cognitive domains	11	2.6
Correlation between subscales or subtests of instrument	7	1.6
Effect of demographical variables in cognitive measures by region or differences among cultures (cultural and incremental validity)	6	1.4
Comparison with performance in functional abilities (ecological validity)	4	.9
Qualitative evaluation	4	.9
Item analysis	4	.9
Comparison or discrepancies between tests or subtests	3	.7
Parallel forms reliability	2	.5
Regression-based norms	1	.2
Data completeness	1	.2
Targeting	1	.2
Rater's opinion of the instrument - face validity	1	.2
Practice effects in test-retest	1	.2
Effect size estimates	1	.2
Total	431	100

The most frequently used statistical analyses for neuropsychological battery validation were the Receiver Operating Characteristic (ROC) analysis (13.1%), Pearson product-moment correlation coefficient (12.9%), Cronbach's alpha coefficient (10.9%), analysis of variance or covariance (9.3%), and regression analysis (7.2%). The frequencies and percentages of the statistical analyses are presented in Table 4.

Table 4. Statistical analyses employed in the reviewed validity procedures.

Statistical analysis	<i>f</i>	%
Receiver Operating Characteristic analysis	60	13.1
Pearson Product-Moment Correlation Coefficient	59	12.9
Cronbach's alpha coefficient	50	10.9
Analysis of variance or covariance	43	9.3
Regression analysis	33	7.2
Pearson's or Spearman's rank correlation	32	7.0
Spearman's rank correlation coefficient	25	5.4
Intraclass correlation coefficient	23	5.0
<i>t</i> -test: independent or paired sample	22	4.8
Principal Component Analysis	18	3.9
Descriptive analysis	18	3.9
Exploratory factor analysis	10	2.2
Confirmatory factor analysis	10	2.2
Mann-Whitney <i>U</i> test	9	2.0
Percentage of agreement	7	1.5
Discriminant analysis	6	1.3
χ^2 analysis	6	1.3
Kappa index	6	1.3
Rasch analysis	4	.9
Fisher's exact test	3	.7
Pearson's partial correlation coefficient	3	.7
Kendall's tau correlation coefficient	3	.7
Wilcoxon test	2	.4
Kruskal-Wallis test	2	.4
Cluster analysis	1	.2
Kaplan-Meier method	1	.2
Cox Proportional-Hazards regression	1	.2
Mokken-Loevinger coefficients	1	.2
Coehn's <i>d</i> values	1	.2
Total	459	100.0

Discussion

This paper presents a systematic review of studies that assessed evidence of the validity of neuropsychological assessment batteries published in international databases between 2005 and 2012. The increase in the number of papers in recent years indicates a growing scientific concern about providing evidence of the validity of neuropsychological batteries.

The main findings demonstrate that the typical procedures and statistical analyses employed in psychological test validation are also present in neuropsychological battery validation studies. Specifically, sensitivity and specificity, correlations with other tests, comparisons between groups, reliability, and factor structure analysis were commonly employed. With regard to statistical techniques, the same was observed, with a major prevalence of ROC analysis,

Pearson correlation, Cronbach's alpha, analysis of variance, and regression analysis.

The assessment of the validity of instrument scores usually considers sources of evidence of construct validity (American Educational Research Association, 1999; Embretson, 2007), which are also related to content, criteria, and patterns of convergence and divergence (Urbina, 2004). In this systematic review, the studies primarily assessed different sources of validity by searching for patterns of convergence and divergence.

The main sources of patterns of convergence and divergence were correlations with other tests and measures of reliability, such as internal consistency and test-retest reliability. The pattern of correlations with other measures, considering theoretical relationships, is frequently employed by researchers as a source of evidence of construct validity (Westen, & Rosenthal, 2003). In addition to correlation studies that provide additional support for the validity of an instrument, Urbina (2004) noted that an instrument should also measure the construct in a precise and reliable way in order to be valid. This is consistent with the idea of minimizing the role of external sources of validity and emphasizing internal sources of evidence to establish test meaning. Such procedures would include item design principles, domain structure, item interrelationship, and reliability (Embretson, 2007).

Consistent with this notion, factor structure and correlation among instrument subscales should also be investigated. Factor analysis can contribute to investigations of the dimensionality of a particular assessment instrument or battery or to confirm the theory that underlies the battery by considering the identified weightings of the variables (Floyd, & Widaman, 1995; Schmitt, Livingston, Smernoff, Reese, Hafer, & Harris, 2010). Considering that a neuropsychological battery is composed of tasks or tests with an unequal number of items through which different constructs are examined, factor analysis is not recommended to assess test validity when a small number of items are present because there must be at least three variables for each dimension of an instrument to endorse the use of this technique (Brown, 2006; Fabrigar, Wegener, MacCallum, & Strahan, 1999).

Pearson product-moment correlation coefficient and Cronbach's alpha are statistical tests often used to estimate patterns of the convergence and divergence of psychological and educational instruments (Creswell, 2008). The frequent use of these techniques emphasizes the popularity of traditional procedures in the validity assessment of instruments. Few studies employed alternative models from classical test theory, such as Item Response Theory (IRT). In IRT, different properties of items are evaluated to provide more complete characterizations of the items, the instrument as a whole, and the performance of each subject. Thus, these models offer improved accuracy and precision in neuropsychological evaluation tests; however, IRT

has had a limited impact on neuropsychological tests, possibly because this type of use has only been recently adopted (Thomas, 2011). The use of IRT to study the validity of neuropsychological tests could contribute to selecting the most representative items for evaluating a specific cognitive function. Item Response Theory also has the potential to identify items with superior discriminatory power in relation to specific deficits (Pedraza et al., 2009; Schultz-Larsen, Kreiner, & Lomholt, 2007).

Regarding criterion validity, Urbina (2004) suggests assessing the precision of decisions related to concurrent and predictive validation. Concurrent validation can be achieved by correlating test scores with the predicted criteria. By studying differences between clinical groups and controls (or healthy samples), information about the precision of concurrent validation decisions can be obtained. In the present review, the evaluation of sensitivity and specificity and comparisons between contrasting groups were most often applied as evidence of concurrent validity. For evaluations of sensitivity and specificity, an analysis of the ROC curve was frequently employed. Receiver operating characteristic curve analysis contributes to the diagnostic validation of neuropsychological instruments by evaluating the ability of the instrument to predict false positives in relation to a diagnosis or specific criterion (Burgueño, García-Bastos, & González-Buitrago, 1995).

With regard to sample types, many studies analyzed groups of patients diagnosed with dementia, Alzheimer's disease, and mild cognitive impairment. One common characteristic between these groups is memory loss as the main symptom, although these patients remain heterogeneous in other ways (Pike, Rowe, Moss, & Savage, 2008). Generally, when a patient undergoes a neuropsychological assessment, decreased memory capacity is a common complaint. The choice of these clinical groups may be related to this pattern. The predominance of studies with elderly samples, which included more than half of the articles in this review, also supports this pattern.

Regression analysis also stands out in studies that assessed an instrument's specificity, but most of its frequency was observed in analyses of the effect or influence of demographical variables on neuropsychological instruments. Other studies of the effect of demographic variables compared groups from distinct regions or cultures also using regression analyses. These studies have the potential to contribute to validity assessments of the cultural or incremental type (Mungas, Reed, Haan, & González, 2005a). Additionally, ecological validity can be assessed, which would include studies that compare patient test performance with their practical daily activities (Chaytor, & Schmitter-Edgecombe, 2003; Temple, Zgaljardic, Abreu, Seale, Ostir, & Ottenbacher, 2009).

Still with regard to criterion validity, a small number of studies investigated other forms of concurrent validity, such as an item's agreement with an external variable

(i.e., the absence/presence of a deficit), the detection of clinical improvement using posttreatment scales, and the prediction of other test results. Few studies analyzed predictive validity, which refers to the evaluation of future criteria. The prediction of the capacity to return to work and the ability to predict future cognitive deficits can be considered future criteria. Survival analysis or the power of an instrument to predict future outcomes, such as death or institutionalization, was also employed in one of the studies (Cruz-Oliver, Malmstrom, Allen, Tumosa, & Morley, 2012). The limited number of studies that focused on future criteria corroborates the difficulty implementing viable predictive studies (Urbina, 2004). Despite the complexity implementing such studies, analyses that predict such factors as the patient's prognosis or capacity to return to work are necessary and viable for assessing the validity of neuropsychological tasks.

Specifying homogeneous criteria in clinical neuropsychology samples is a difficult goal to achieve (Benedet, 2003). Validity studies often include samples with a wide range of cognitive deficits with neurological involvement. This review indicates that researchers are looking for alternative groups of patients, which is highlighted by the presence of validity studies with samples of traumatic brain injury, cerebrovascular disease or stroke, schizophrenia, and Parkinson's disease. Notably, many neurological or psychiatric disorders, such as multiple sclerosis, attention-deficit/hyperactivity disorder, and bipolar disorder, are still under investigation and do not have a determined homogeneous profile of cognitive deficits. The lack of a homogeneous pattern of deficits in such samples interferes with their viability in validity studies, which demands a solid symptom profile.

Evidence related to content validity was mentioned in a small number of the reviewed studies. Some procedures or analyses employed in item development or translation included interrater reliability, the percentage of agreement, and qualitative evaluation. Assessments of content validity could provide evidence of relevant and representative items of the different constructs that are being investigated (Urbina, 2004). One explanation for the absence of studies related to test content could be that these studies have been published in previous articles about instrument development or the original test manuals, rather than as standalone articles; the former often focus on more fundamental aspects of instrument development. Nonetheless, from a psychometric point of view, the evaluation of item representativeness remains important for ensuring the validity of neuropsychological instrument scores. This is especially true if we consider the complexity of the evaluated functions.

Some studies employed other statistical analyses or procedures to search for evidence of validity and present the relevance of data completeness, scaling assumptions, targeting, and effect size. The extent to which a scale's components are completed in the target sample and the percentage of people for whom reporting a single score is

possible denote data completeness. Scaling assumptions determine whether summing subscales of the instrument to create a single scale score is appropriate. Targeting evaluates whether the range of cognitive performance measured by the battery corresponds to the range of the sample (Cano et al., 2010). Effect size correlations can provide convenient and informative indices of construct validity (Westen, & Rosenthal, 2003).

Considering the results of this review, the most common procedures refer to external sources of validity, such as correlations with other measures, sensitivity, and specificity. With regard to internal validity, reliability procedures are commonly employed, but few studies have emphasized item development or used modern techniques as validity procedures. In our view, a balance between external and internal sources of validity evidence could improve the psychometric quality of neuropsychological batteries. Additionally, more careful attention to item and test development according to standards from both classic and modern techniques is useful and viable for providing validity evidence for instruments that assess very diverse domains, such as neuropsychological batteries. Finally, this approach could also minimize the difficulty studying very heterogeneous samples, such as neurological patients.

Finally, some limitations should be considered when analyzing the results of this review. First, we did not include truncation or word variation when the search was conducted. Instead, we decided to rely on established keywords from the Thesaurus. Second, we decided to exclude computerized neuropsychological batteries because they have specifics that are beyond the scope of this review.

In conclusion, our study suggests that improving evidence of the validity of neuropsychological instruments is possible. Incorporating both classic and modern psychometric procedures and presenting a broader scope of validity evidence would represent progress in neuropsychological battery validation. By highlighting the most common procedures and statistical analyses employed in this context and the observed limitations, this study may help researchers better plan the validation process for new instruments in the field.

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