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REVIEW

Neuropsychological Measures in the Arab World: A Systematic Review

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Abstract Although Arabic is one of the most widely used languages in the world, little is known on the availability of standardized neuropsychological tests in Arabic. We review the literature published before 2016, using the keywords *Arab**, *cogniti**, and *neuropsycholo**, as well as keywords for each Arab country. PubMed, PsycINFO, Education Source, Academic Search Complete, Education Resources Information Center, Shamaa, and Arabpsynet databases were searched, in addition to a selected number of Arabic medical and educational journals. After excluding case reports, studies conducted on Arab groups residing outside the Arab world or Israel, and studies that employed intelligence scales or cognitive screens without standardization, 384 studies were eventually reviewed. Tests with most extensive use, adaptation, validation and norming were identified. The Raven Matrices, with its variants, was the most normed cognitive test for Arab individuals (normed in 16 countries). The rate of neuropsychology publications from the Arab countries combined, per year, was less than half of that of each American journal (top 10 journals pertaining to cognition). Nonetheless, the rate in Arab countries has increased after 2010. Publications were mostly from Egypt and Saudi Arabia, but the ratio of test adaptation-to-publication was the largest in Jordan and Lebanon. Approximately half of these publications did not employ cognitive tests that were developed, translated, adapted, or standardized according to international guidelines of psychological measurement. We provide recommendations on improving clinical neuropsychology to better serve Arab patients.

Keywords Arab neuropsychology · Arabic cognitive tests · Arabic cognitive assessment · Arabic tests review · Arabic neurocognitive testing

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Since the 1930s, Luria and Vygotsky have demonstrated the role of socio-historical and cultural contexts in neurocognitive performance (Luria 1976; Vygotsky 1978). However, the application of such principles to mainstream clinical neuropsychology only gained interest in the early 1990s (Ardila 1995; Nell 2000; Puente 1990). Decades after Luria, studies have suggested that people perform differently on cognitive tests according to the importance of the tested cognitive skill in their own culture. For example, indigenous groups produced higher scores on visuospatial tests than non-indigenous individuals with no education, suggesting that culture might dedicate strength in certain skills related to survival (Ostrosky-Solis et al. 2004). Simple sensory processes, such as categorical color perception in toddlers learning color terms (Franklin et al. 2008; Özgen and Davies 2002) and other nonverbal

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skills (such as drawing figures and maps; Rosselli and Ardila 2003), are affected by early experiences and by one's primary language. As a product of their cultural experience, individuals process information differently, which influences neural function and even structure. This has been demonstrated in functional neuroimaging studies of perception and higher cognitive functions (see Park and Huang 2010 for a review).

Furthermore, recent standards for testing, such as the Standards for Educational and Psychological Tests (American Educational Research Association, American Psychological Association, and National Council on Measurement in Education 2014:hereafter referred to as the *Standards)* provide clarification to the concept of "Fairness." In chapter three of the *Standards*, specific focus is made on the concept of construct irrelevance, which is broadly defined as the measurement of confounding variables, and interpreting these external variables as the construct which is intended to be measured. In situations where linguistic and cultural variables play a role, these variables need to be understood as to how they are impacting the measurement of the intended construct. To do otherwise, simply adds to error in measurement and a cascade of unintended consequences.

Despite aspirations to make neuropsychology more international (e.g., International Neuropsychological Society), modern neuropsychological science and practice has yet realized these aspirations. Outside North America, Australia, Europe, and Russia, neuropsychology is not well developed or recognized. This is illustrated by the relatively small number of neuropsychology conventions held outside of these four geographic areas, the small percentage of authors publishing in major neuropsychology journals residing outside of these areas, and the paucity of personnel and services available in developing, non-industrialized countries (Ahmad and Komai 2016; Pinquart and Bernardo 2014). Indeed, when cultural-neuropsychological studies have been performed, the vast majority have involved groups that reside in the preceding mentioned four areas (e.g. Jacobs et al. 1997), with many specifically targeting Spanish-speakers, or comprised a comparison with an English-speaking group (Agranovich and Puente 2007; Ardila et al. 1994; Ostrosky-Solis et al. 1999). Despite the fact that native English speakers are approximately 350 million, no more than a fourth of the world's population, the vast majority of neuropsychological services and knowledge are in English. Inhabitants of the Arab world, on the other hand, are 370 million (Ethnologue; Lewis et al. 2015; World Bank 2014), in addition to eight million Arab immigrants living outside their country of origin (Migration Policy Institute et al. 2015).

Arabic is the liturgical language of Islam, the dominant religion in the Middle East. Despite the large numbers of Arab groups and the vast regions they occupy, the number of neuropsychological measures in Arabic is unknown, though anticipated to be extremely small compared to Western measures. This ambiguity hinders the accessibility of tests for practitioners, creates a tendency to seek alternative tests that may not be relevant to the examinee, and encourages neglect of non-neurological factors influencing performance with lower scores being attributed to brain injury or cognitive dysfunction. This type of practice inevitably decreases "fairness" in testing resulting in increased influence of measurement error, an unintended consequence, and has serious implications for generalizing brain theories within a discipline pertinent to all humans.

To our knowledge, this is the first attempt to review literature on the state of clinical neuropsychology in the Arab world. This review has three main objectives. First, to survey neuropsychological tests in all Arab countries. Second, to evaluate the extent to which these tests were translated and adapted to their respective countries. Third, to provide directions and suggestions for improving the state of clinical neuropsychology in the Arab world. The overall goal of this review is to make neuropsychologists working with Arab groups aware of the existence of standardized tests for this population, facilitate their use, and attempt to overcome obstacles in the path of delivering suitable neuropsychological services to Arabic speaking individuals.

Since characteristics of normative samples are crucial for selecting appropriate neuropsychological tests, some differences between Arabs are briefly reviewed here: The Arab world consists of twelve countries in Asia (Bahrain, Iraq, Jordan, Kuwait, Lebanon, Oman, Palestine, Qatar, Saudi Arabia, Syria, United Arab Emirates, Yemen) and ten in Africa (Algeria, Comoros, Djibouti, Egypt, Libya, Mauritania, Morocco, Sudan, Somalia, Tunisia).

Generally, Arab people read and write Arabic (classical orformal "*fushá*"), but each country has its dialect(s). Each dialect is considered the informal version of classic Arabic in each region. Classical Arabic differs greatly from the common vernacular in each country, and could even resemble learning a second language (Ibrahim and Aharon-Peretz 2005). This complicates establishing unified tests or normative data for all Arab countries. However, classical Arabic and its colloquial form Modern Standard Arabic (MSA), both neutral and not specific to region, have been the preferred language for Arabic books, newspapers, and major television networks (Buckwalter and Parkinson 2010). Thus, there could be some value in using either form in developing and adapting neuropsychological tests for Arabic examinees (Al-Joudi 2015).

Due to historical factors largely related to Western occupation, some Arab countries have a high percentage of bilinguals (e.g., Morocco, Lebanon). Many schools in Arab countries utilize foreign languages for instruction. Many undergraduate and graduate programs in some Arabic countries are taught in English or French. This highlights the need for bilingual assessment for this population (Mahmoud 2015), as bilingualism was found to be critical for test- and norms selection (Ardila 2003; Puente et al. 2013; Ransdell and Fischler 1987).

Arab countries also differ in economic status and educational systems. Those who completed high school presumably possess better ability to understand and speak Arabic than those with less formal education. However, there are differences in the quality of education between Arab countries, and between regions within countries, rendering the simple use of "years of education," as a factor in norms selection, of modest value (O. Mahmoud 2015). In other words, the heterogeneity of the Arab world is significant and may, in its own right, complicate the understanding of this large and growing segment of the world's population. Given these differences, growth, heterogeneity, and the paucity of literature on cultural neuropsychology pertaining to Arab individuals, this review presents an initial attempt to address this increasingly critical issue for clinical neuropsychology.

Method

To our knowledge, a review protocol does not exist for the objectives of this review. Nonetheless, the methodology below is in accordance with the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA; Liberati et al. 2009; Moher et al. 2009).

Eligibility criteria

Criteria for inclusion were (1) journal articles, papers presented in scientific conferences, and dissertations, (2) available in the English, Arabic, or French languages, (3) medical or school neuropsychological studies for Arab groups, (4) use of globally known neuropsychological tests including cognitive screens and intellectual measures (or select intellectual subtests), or neuropsychological tests developed specifically for Arabic speakers. Indexing case studies and studies using cognitive screens, such as the Mini Mental State Examination (MMSE), or intellectual measures to classify or exclude participants without using other neuropsychological tests, or without examining the psychometric properties of these measures is of modest value for neuropsychologists working with Arab patients. and were also excluded. Finally, neuropsychological studies conducted on Arab samples residing outside Arab countries or Israel (i.e., Arab immigrants in non-Arab countries or Israel) likely yield data for people with unique sample characteristics (e.g. large impact of bilingualism and socioeconomic factors) which is outside the scope of this review. These studies are worthy of a separate review and were excluded from the present review.

Information Sources

To obtain information on neuropsychological tests in the Arab world, three authors conducted a literature search using PubMed/MEDLINE, PsycINFO, Education Source, Academic Search Complete, Education Resources Information Center (ERIC), Arab Educational Information Network (Shamaa; Arabic), and Arabpsynet (Arabic) databases. This was supplemented by searches of websites of the Middle East Psychiatry Current, Middle East Journal of Psychiatry and Alzheimer's, Middle East Journal for Age and Aging, Egyptian Journal of Neurology, Psychiatry and Neurosurgery, Jordanian Academic Journal, Tunisian Medical Journal, and Iraqi Academic Scientific Journals. When a study validating a neuropsychological test was cross-referenced (referenced in a study found using original key terms), a search with the title was performed in an attempt to locate it. No search was conducted after December 28, 2015. All located studies meeting inclusion criteria and published by this date were included in the review. The first and fourth authors developed the search strategy collaboratively.

Search and Risk Bias in Individual Studies First, two searches (*Arab* & cogniti*; Arab* & neuropsycholo*;* two keywords each) were used. These only yielded a small number of studies as most articles did not include the word "Arab" or "Arabic," but rather the country's name or nationality (e.g., Egypt or Egyptian). Thus, two additional searches (two keywords each) for each Arab country (e.g., *cogniti** & *Egypt** and *neuropsycholo** & *Egypt**) were added. The filter used was ALL TEXT. As a result, 25 keywords were used to conduct this literature search. It is worth mentioning that searching in Arabic was difficult. One main complicating factor is that the word "neuropsychology" translates to the Arabic equivalent of "the neurological science of psychology," which renders the generated data difficult to contain. The word "cognition" translates to the Arabic word "knowledge," which is clearly not specific to neuropsychology. Searching two known Arabic databases in English, as English language abstracts are generally provided, was taken as a measure to reduce the risk of excluding literature published in Arabic.

Study Selection Three authors conducted the aforementioned search (AF and MPG, and separately, HA). The first and second authors (AF and HA) reviewed each article for eligibility, independently, and according to the aforementioned inclusion and exclusion criteria (see Eligibility Criteria). When study eligibility was not straightforward, the first and second authors consulted each other, and this was resolved through discussion. Study authors were contacted via e-mail when there was not enough data to determine study selection or rejection (e.g. unclear whether the sample was collected in an Arab country).

Data Collection Process Two authors (AF and HA), from different Arab countries have extracted and reviewed studies independently to minimize bias. The two sets were eventually

combined by the second author. Microsoft Excel was used for indexing studies and calculating totals.

Data Items Data generated from each study included names of tests used, country of publication, number of healthy controls or size of normative sample, male-to-female ratio, age range or average, education range or average, and availability of means and standard deviations for healthy control or normative data in the published report. To assess the extent of which a study has adapted a test to a respective culture, an algorithm was assigned to each study based on commonly used methods of adaptation. Each method was symbolized by a letter: T = translated; BT = back translated; AD = adapted to suit the respective culture, R = assessed reliability (regardless of quality), V = assessed validity (regardless of quality), and N = normative data was collected. Each study was assigned one, or a combination, of these abbreviations depending on whether it has attempted these methods. When tests do not call for one or more of these methods (back translating an Arabic vocabulary test for instance), then tests were marked to denote such exemption.

Summary Measures, Synthesis of Results, and Risk Bias Across Studies The number of studies meeting inclusion criteria was identified. The total number of studies for each country was calculated. Studies from the same authors, publishing using the same sample more than once, were included once in the latter count. An Excel sheet was created for each country to facilitate the ease of identifying tests and studies for each country, as well as to minimize the risk of counting duplicates. Excel's feature for identifying duplicates was utilized for countries publishing on more than 12 tests. The number of inaccessible studies was identified. The number of studies providing *normative data* for neuropsychological tests was calculated. The number of studies that reported normative data but were inaccessible was calculated, and divided by country. The rate of publication for all Arab countries combined was calculated by dividing the number of total publications by the number of years since the first publication (until year 2015). This included all publications from authors publishing using the same sample more than once. The most used tests in the Arab world were identified. Tests with most extensive adaptation, validation, and norming for Arabic speakers were identified. Studies investigating differences in neuropsychological performance between healthy Arab and Israeli or Western groups, and between Arab groups were identified and indexed together. Studies examining bilingualism in Arabic speaking examinees were also identified and indexed.

Additional Analysis In an effort to identify countries with most extensive validation, adaptation and norming work, the test ratio for normed or validated (or both normed and validated) tests to the overall number of published tests for each country was calculated. Additionally, the rate of neuropsychological publications from Arab countries from the year 2000 until the year 2015, was compared to that of top 10 American journals pertaining to cognition. The average for each American journal was derived from "document per year" information collected from SCImago website (SCImago 2007).

Results

Of a total of 497 studies screened, 384 studies met our inclusion criteria. Of the 384 studies, 54 were cross referenced, but we were unable to retrieve, or limited to the abstract only. Studies from the same authors, publishing using the same sample more than once, were included once in the 384 count. The 384 studies have applied 117 neuropsychological measures on healthy controls, clinical samples, or both, from Algeria (N = 4), Bahrain (N = 5), Egypt (N = 176), Iraq (N = 9), Jordan (N = 17), Kuwait (N = 18), Lebanon (N = 14), Libya (N = 6), Morocco (N = 13), Oman (N = 13), Palestine (N = 9), Qatar (N = 2), Saudi Arabia (N = 34), Sudan (N = 11), Syria (N = 8), Tunisia (N = 30), United Arab Emirates (N = 11), and Yemen (N = 4). That is, 18 out of the 22 Arab countries. Studies that have used cognitive measures with Arabic speakers in the span of 54 years, and met our inclusion criteria, had the rate of approximately 7.7 publications per year: 22 studies from 1961 to 1989, 44 from 1990 to 1999, 47 from 2000 to 2005, 100 from 2006 to 2010, and 204 from 2011 to 2015. Studies from the same authors, publishing using the same sample more than once, were included in this latter count. Table S1 (available as a supplemental material) includes tests utilized in the Arab world between 1961 and 2015. Arabic and French language publications and dissertations that were identified using our English keywords or were referenced in English language publications are included in Table S1. The table contains basic demographic information of the healthy control or normative sample that the published studies have enrolled, as well as whether the study has provided an average for their performance. When studies did not include healthy controls or a normative sample, cells for demographic information were marked "NA." Table 1 lists the most frequently used neuropsychological tests in Arab countries, divided by cognitive domain.

Studies in which tests have qualified for *three* or more of our adaptation algorithm, and have enrolled over 40

Table 1 Most used neuropsychological tests in the Arab region by cognitive domain

Language (*n*)	Visuospatial-constructional skills (*n*)	Memory (*n*)	Executive function and information processing speed (*n*)
Verbal fluency[a] (28)	Beery VMI[b] (8)	WMS[b] (37)	TMT (53)
PPVT[b] (6)	ROCF (4)	BVRT (17)	WCST (26)
ALT (6)	MVPT (2)	IIMT (8)	Stroop CWT (20)
Token Test (4)		RAVLT (6)	PASAT[b] (15)
AREVT (2)		BSRT (5)	FAB (7)

n number of studies that has used the test, *ALT* Arabic Language Test, *AREVET* Arabic Receptive-Expressive Vocabulary Test, *Beery VMI* Beery Visual-Motor Integration Test, *BVRT* Benton Visual Retention Test, *BSRT* Buschke Selective Reminding Test, *FAB* Frontal Assessment Battery, *IIMT* Incidental & Intentional Memory Test, *MVPT* Motor-Free Visual Perception Test, *PASAT* Paced Auditory Serial Addition Test, *PPVT* Peabody Picture Vocabulary Test, *RAVLT* Rey Auditory Verbal Learning Test, *ROCF* Rey-Osterrieth Complex Figure, *Stroop CWT* Stroop Color-Word Test, *TMT* Trail Making Test, *WMS* Wechsler Memory Scale, *WCST* Wisconsin Card Sorting Test

[a] This includes studies the used letter- or category-based word fluency

[b] Different versions or formats of the test were used

neurologically and psychiatric healthy participants, are listed in Tables 2, 3, 4, 5, 6, 7 and 8, each table pertaining to a cognitive domain. Due to the large number and extensive norming of intellectual tests for Arabic speakers, only those studies which qualified for *four* or more of our suggested algorithm and measured intelligence were listed in Table 3. Studies adapting intellectual tests that qualified for *three* or less methods are nonetheless listed in Table S1 in the supplemental material.

Arab norms for 57 cognitive measures were identified. We were able to access 78 sets of norms, while 44 norming efforts were referenced in some of the reviewed studies, but were inaccessible. The Raven Matrices, with its variants, was the most normed cognitive test for Arab individuals (normed in 16 countries; see Table S1). Norming for the Wechsler intelligence scales, in contrast, was not as extensive. None of the normative data for the Wechsler intelligence scales was accessible, apart from the Emirati study for the Wechsler Abbreviated Scale of Intelligence, and the Libyan norming for parts of the Wechsler Intelligence Scale for Children (WISC), both listed in Table 3. Few studies referenced Egyptian norming for the WAIS and the WISC by Melika (1991, 1996), Melika and Ismail (1999), as well as for the Stanford-Binet Intelligence Scale (SB) by Melika (1998) and Hanoura (2002). All of the respective manuals are published locally in Egypt. In addition to intelligence test norms listed in Table 3, there are also Emirati (Albaili and Abu-Hilal 1993), Kuwaiti (not accessed; Mursi 1999), and Saudi (Al-Ghatani et al. 2011) norms for different editions of the Test of Nonverbal Intelligence (TONI).

Among the inaccessible studies, there were frequently reported Egyptian standardizations of the MMSE (Elokl 2002) and the Cambridge Cognitive Examination (CAMCOG; A. Mahmoud 2002), both in unpublished theses. The Halstead-Reitan Neuropsychological Battery and the Luria-Nebraska Neuropsychological Battery were normed and validated in Egypt, nonetheless on small samples of university students (El-Sheikh et al. 1987). Overall, studies that have reported norming processes and were inaccessible, were mostly from Egypt (13), followed by Jordan (8), Sudan (8), and Tunisia (5).

Eight studies investigated differences in neuropsychological performance between healthy Arab and Israeli or Western groups, and three among Arab groups (see Table S2 in the supplemental material). The majority has examined executive functioning and psychomotor-visuospatial skills and were conducted on children. Five studies compared Arab groups to Western groups (Alansari and Baroun 2004; Shebani et al. 2008; Sobeh and Spijkers 2012, 2013; Stanczak et al. 2001) and three to Israeli groups (Josman et al. 2006; Lieblich and Kugelmass 1981; Parush et al. 2000). One of the three studies comparing performances between Arab groups examined psychomotor speed and set shifting (as measured by the Trail Making Test; Abdul Razzak 2013), another examined IQ (largely measured by the Raven Matrices; Khaleefa et al. 2012), and the third studied working memory (Alansari and Soliman 2012).

The nine studies that assessed the effect of bilingualism or language dominance on the performance of Arabic speakers, differed in methodology. Four studies tested bilinguals in Arabic, one in English, and four once in English and once in Arabic (listed in Table S3 in the supplemental material). These studies assessed processing speed (Abdelgafar and Moawad 2015; Abdul Razzak 2013; Tahan et al. 2011), and auditory working memory (Abdelgafar and Moawad 2015; Balilah and Archibald 2015, May). A reference list, including references of studies listed in Table S1, Tables 1, 2, 3, 4, 5, 6, 7, 8 and Tables S2 and S3, is available in the supplemental material.

Table 2 Cognitive screens and multi-domain cognitive measures with most extensive adaptation, validation and norming for Arabs

Instrument	Country[a]	Criteria met	*M (SD)*[b]	Study reference
3MS	LBN	T, BT, AD, V, N	Y	Zamrini et al. 2014; Abou-Mrad et al. 2015
ACE-R	SAU	T, BT, R, V, N	NP	Al Salman 2013
	EGY	T, BT, R	Y	Zawilla et al. 2014
ACE-III	EGY	T, BT, AD, N	NP	Qassem et al. 2015
ADAS-Cog	TUN	T, AD, R, V	GR	Ben Jemaa et al. 2008
BEC96	MOR	T, AD, N	Y[c]	Tezitia et al. 2011
BENCI	MOR	T, BT, AD, R, V, N	Y	Fasfous et al. 2015
BCST	PAL, ISR	T, AD, N	Y	Inzelberg et al. 2007
Clock Drawing	EGY	T, AD, R, V	Y	Farhan 2006
CERAD (J1-J2)	EGY	T, BT, AD, R, V	NP	Elokl 2001, 2011
Mattis DRS	MOR	T, AD, N	Y	Benabdeljlil et al. 2014
MMSE	PAL, ISR	T, AD, N	Y	Inzelberg et al. 2007
	TUN	T, BT, AD, R, V, N	Y	Bellaj et al. 2008
	TUN	T, AD, N	Y[d]	Chatti Lammouchi and Ben Ammou 2009
MoCA	EGY	T, AD, R, V	NP	Abdel Rahman and El Gaafary 2009
	LBN	T, BT, AD, V, N	Y	Zamrini et al. 2014; Abou-Mrad et al. 2015
RBANS	EGY	T, AD, R, V	NA[e]	Abdel Salam 2012
RUDAS	LBN	T, BT, AD, R, V	Y	Nielsen et al. 2014; Chaaya et al. 2015
SLUMS	EGY	T, BT, R, V	NP	Abdel Rahman and El Gaafary 2014

ALG Algeria, *BHR* Bahrain, *EGY* Egypt, *IRQ* Iraq, *ISR* Israel, *JOR* Jordan, *KWT* Kuwait, *LBN* Lebanon, *LBY* Libya; MOR Morocco, *OMN* Oman, *PAL* Palestine, *SAU* Saudi Arabia, *SDN* Sudan, *SYR* Syria, *TUN* Tunisia, *UAE* United Arab Emirates, *YEM* Yemen, *T* translated, *BT* back translated, *AD* adapted, *R* reliability assessed, *V* validity assessed, *N* normative data provided, *Y* yes, *NP* not provided, *GR* within graphs, *3MS* Modified Mini Mental State Examination, *ACE-III* Addenbrooke's Cognitive Examination – Third Edition, *ACE-R* Addenbrooke's Cognitive Examination – Revised, *ADAS-Cog* Alzheimer's Disease Assessment Scale–Cognitive subscale, *BEC96* Signoret's Battery of Cognitive Efficacy, *BENCI* Bateria de Evaluacion Neuropsicologica Infantil, *BCST* Brookdale Cognitive Screening Test, *CERAD* Consortium to Establish a Registry for Alzheimer's Disease– Parts J1-J8, *Mattis DRS* Mattis Dementia Rating Scale, *MMSE* Mini Mental State Examination, *MoCA* Montreal Cognitive Assessment, *RBANS* Repeatable Battery for the Assessment of Neuropsychological Status, *RUDAS* Rowland Universal Dementia Assessment Scale, *SLUMS* Saint-Louis University Mental Status

[a] Country in which the sample was collected

[b] Whether means and standard deviations for norms were provided

[c] Overall mean score was provided without standard deviations

[d] means and medians are provided with no standard deviations

[e] Not accessed but cited elsewhere as fulfilling criteria (see Table S1)

Discussion

The purpose of this review was to assess the status of scientific literature involving neuropsychological assessment of Arabic speaking individuals. The review included 384 studies that have used or examined clinical neuropsychological tests with Arab groups. This number was higher than expected, given that we predicted a scarcity in cognitive measures in Arabic, and lack of studies examining the neuropsychological function of Arabs. By listing a great number of these publications in this study, as well as their adaptive and normative methods, this review reduces the ambiguity regarding availability of tests for Arabic speakers. Using studies listed here, neuropsychologists working with Arab groups are better equipped to identify more suitable tests according to their patients' demographics.

Despite growth in publication rate for this type of articles, the rate of neuropsychology-related publications of Arab countries since 1961, was 7.7 publication per year. The publication rate of Arab countries since 2000, was 21.9 publication per year. For the sake of comparison, we derived an average-rate-estimate for each of the ten most recognized journals pertaining to neuropsychology, that have been publishing from the United States since the year 2000 (*Applied Neuropsychology– Adult, Brain and Cognition, Cognitive and Behavioral Neurology, Cognitive Psychology, Journal of Memory and Language, Learning and Memory, Memory and Cognition, Neuropsychology, and Neuropsychology Review*). This was 68.8 documents per year for each journal

Table 3 Measures of general cognitive ability and intellectual functioning with most extensive adaptation, validation and norming for Arabs

Instrument	Country[a]	Criteria met	*M (SD)*[b]	Study reference
Bayley-II	JOR	T, BT, AD, R, V, N †	Y	Al-Razouq 2006
C-TONI	JOR	AD, R, V, N †	Y	Gharaibeh Al-Natour and El-Mneizel 2006
Das-Naglieri CAS	PAL	T, BT, AD, R, V	Y	Natur 2009
KABC	JOR	T, AD, R, V, N	NA[c]	El-Mneizel 1987
	EGY	T, AD, R, V	NP	F. Z. Elwan 1992, 1995, 1996, 1997
OLSAT[d]	KWT	T, AD R, V	Y	Elkorashy 1995, 1997
	OMN	T, AD, R, V, N	Y	Al-Shukri 2002
	SYR	T, AD, R, V	NP	Qassab 2014
PIT	EGY	AD, R, V, N †	NA[e]	Salih 1978
R-APM	OMN	AD, R, V, N †	Y	Ibrahim et al. 2013; Bakhiet and Lynn 2014d
R-SPM	KWT	AD, R, V, N †	Y	Abdel-Khalek 2005; Abdel-Khalek and Lynn 2006; Abdel-Khalek and Raven 2006
	LBY	AD, R, V, N †	Y	Al-Shahomee 2012
SB	JOR	T, AD, V, R, N	NA[e]	AlKeelani 1979
WASI	UAE	T, AD, R, V, N	Y	Abu-Hilal et al. 2011
WISC[d]	JOR	T, AD, R, V, N	NA[e]	Elyan and Alkeelani 1988
	SDN	T, BT, AD, R, V	NA[e]	Hussain 2005[e] Khaleefa 2006
	LBY	T, BT, AD, N	Y	Lynn et al. 2009[f]

Please refer to Table 2 for a key of abbreviations relating to country name and criteria met

Y yes, *NP* not provided, *Bayley-II* Bayley Scale of Infant Development–Second Edition, *C-TONI* Comprehensive Test of Nonverbal Intelligence, *Das-Naglieri CAS* Das-Naglieri Cognitive Assessment System, *KABC* Kaufman Assessment Battery for Children, *OLSAT* Otis-Lennon Mental ability Test, *PIT* Pictorial Intelligence Test, *R-APM* Raven's Advanced Progressive Matrices, *R-SPM* Raven's Standard Progressive Matrices, *SB* Stanford-Binet Intelligence Scale, *WASI* Wechsler Abbreviated Scale of Intelligence, *WISC* Wechsler Intelligence Scale for Children

[a] Country in which the sample was collected

[b] Whether means and standard deviations for norms were provided

[c] Only thesis abstract was accessed

[d] Various versions. [e] Not accessed but cited elsewhere as fulfilling criteria (see Table S1)

[f] Verbal and Working Memory Scales only

† Some of our suggested adaptation quality criteria may not apply to this test.

(ranking and "document per year" information collected from SCImago 2007). If we assume that editors notes and other "non-study" documents form 15% of that figure, the rate reduces to 58.5 studies per year. The rate of 21.9 for all Arab countries combined, appears negligible in comparison. Further, the Arabic rate included dissertations whereas the American did not. It was revealed that the rate of cognitive publications in Arab countries has jumped from 9.4 studies per year in the first five years of the millennium, to 19.8 in the years 2006 to 2010, and doubled (40.8) in the years 2011 to 2015, a finding that is rather promising.

Of the 117 neuropsychological measures used with Arab groups, 57 were normed. Of the 57 normed tests, 53 were adapted and validated (fulfilling three or more of our adapting criteria). Consequently, roughly 55% of the neuropsychological measures published in cognitive studies for Arab groups were not appropriately used. The implication of such finding is concerning. When we exclude cognitive screens and intelligence tests, the Trail Making Test becomes the most used neuropsychological measure with Arab groups. The first so called "normative" use of this test was with prison inmates (Soueif 1976), with no single study reporting its validity for Arab individuals, and only one recent study reporting its reliability (Alqahtani 2015). Another alarming example is the Wechsler Memory Scale. This test is the second most used neuropsychological measure in the present review, having been used since 2002 and in 37 studies, with only one study reporting an Arabic adaptation reference (Hassan 2012), and none reporting normative data. This could be due to (i) using a "local translation" that is not commercially available for formal use (a phenomenon that has been previously observed in the assessment of Spanish speakers; Artiola i Fortuny and Mullaney 1997), (ii) being published locally with little international access, or (iii) true failure in applying the appropriate adaptation and norming that the cause deserves. Moreover, we found no studies examining the psychometric properties of the Wisconsin Card Sorting Test with Arab individuals, the third most used neuropsychological test in Arab countries.

Table 4 Measures of language functioning with most extensive adaptation, validation and norming for Arabs

Instrument	Country[a]	Criteria met	*M (SD)*[b]	Study reference
ACTAW	TUN	T, AD, R †	Y	Batnini and Uno 2015
AREVT	JOR, PAL	AD, R, V, N †	Y	Wiig and Al-Halees 2000
LLNT	LBN	T, BT, V, N	Y	Zamrini et al. 2014; Abou-Mrad et al. 2015
PPVT	JOR	AD, R, V, N †	NA[c]	Khammash and Dun 1985
	OMN	AD, R, V, N †	NP	Khammash 1995
Token Test[d]	JOR	T, BT, R, V, N	Y	Alkhamra and Al-Jazi 2015
Verbal fluency – Phonemic[e]	TUN	T, AD, N †	GR	Ben azouz et al. 2009
	SAU	T, AD, N †	Y	Al-Ghatani et al. 2009; Al-Ghatani et al. 2011
	SAU	T, AD, N †	Y	Khalil 2010
	LBN	T, AD, V, N †	Y	Zamrini et al. 2014; Abou-Mrad et al. 2015
Verbal fluency – Semantic[f]	LBN	T, V, N †	Y	Zamrini et al. 2014; Abou-Mrad et al. 2015

Please refer to Table 2 for a key of abbreviations relating to country name and criteria met

Y yes, *NP* not provided, *GR* within graphs, *ACTAW* Arabic Comprehension Test of Abstract Words, *AREVT* Arabic Receptive-Expressive Vocabulary Test, *LLNT* Lebanese Linguistic Naming Task, *PPVT* Peabody Picture Vocabulary Test

[a] Country in which the sample was collected

[b] Whether means and standard deviations for norms were provided

[c] Not accessed but reported in Khammash, 1995 as fulfilling criteria

[d] Token Test for children-II

[e] Various versions

[f] Ben azouz et al. (2009) and Khalil (2010) provided norms and means for semantic verbal fluency derived from the same samples described above

† Some of our suggested adaptation quality criteria may not apply to this test (e.g. translation and back translation may not apply if the stimuli were specifically created for the given culture, or when aspects of the test did not require linguistic adaptation).

In the field of Arab-related cognition, Egypt took the lead historically (Soueif and Metwally 1961) and still does currently. Egypt published 45% of the studies in this review, followed by Saudi Arabia, 8.9%, and Tunisia, 7.8%. The number of universities and advanced medical training institutions may play a role in the advancement of cognitive science in these countries. However, when examining the number of tests that met most of our criteria in relation to the total number of tests used in publications, Jordan took the lead. Validating or norming (or both) was reported for 63% of cognitive tests used in Jordanian publications, followed by Lebanon, 53%, and Libya, 50%, whereas Egypt (17%) and Saudi Arabia (12%) fell at the very bottom of the ranking. Despite the near exclusion of adults in Jordanian studies, the high quality standardization of the Jordanian Bayley Scale of Infant Development-II (Al-Razouq 2006), Beery Visual-Motor Integration Test (Al-Razouq 2014; Al-Waqfi 1998), Arabic Receptive-Expressive Vocabulary Test (Wiig and Al-Halees 2000), and the Token Test (Alkhamra and Al-Jazi 2015) is commendable.

Table 5 Measures of visuospatial and constructional functioning with most extensive adaptation, validation and norming for Arabs

Instrument	Country[a]	Criteria met	*M (SD)*[b]	Study reference
Beery VMI[c]	JOR	T, AD, R, V, N †	NA[d]	Al-Waqfi 1998
	JOR	T, BT, AD, R, V, N †	Y	Al-Razouq 2014
ROCF	EGY	T, AD, R, V †	Y	Farhan 2006

Please refer to Table 2 for a key of abbreviations relating to country name and criteria met

Y yes, *Beery VMI* Beery Visual-Motor Integration Test, *ROCF* Rey-Osterrieth Complex Figure

[a] Country in which the sample was collected

[b] Whether means and standard deviations for norms were provided

[c] Various versions

[d] Not accessed but cited elsewhere as fulfilling criteria (see Table S1)

† Some of our suggested adaptation quality criteria may not apply to this test (e.g. when aspects of the test did not require linguistic adaptation).

Table 6 Measures of learning and memory with most extensive adaptation, validation and norming for Arabs

Instrument	Country[a]	Criteria met	*M (SD)*[b]	Study reference
BVRT	UAE	T, R, N	Y	Amir 2001
BVMT-R	LBN	T, BT, V, N	Y	Zamrini et al. 2014; Abou-Mrad et al. 2015
BSRT	MOR	T, AD, N	Y	Benabdeljlil et al. 2014
	LBN	T, BT, AD	NA[c]	Abou-Mrad et al. 2015
EM5	TUN	T, AD, V	Cut offs	Bennys et al.; 2003; Mrabet Khiari et al. 2008
RAVLT	EGY	T, AD, R, V	Y	Farhan 2006
	OMN	T, BT, AD, N	Y	Poreh et al. 2012
TYM	EGY	T, AD, R, V, N	Y	Abd-Al-Atty 2012
WMS-III	SAU	T, AD, V	NP	Escandall 2002; Hassan 2012

Please refer to Table 2 for a key of abbreviations relating to country name and criteria met

Y yes, *NP* not provided, *BVRT* Benton Visual Retention Test, *BVMT-R* Brief Visuospatial Memory Test-Revised, *BSRT* Buschke Selective Reminding Test (aka RL/RI-16), *EM5* Five-Word Test, *RAVLT* Rey Auditory Verbal Learning Test, *TYM* "Test Your Memory" Test, *WMS-III* Wechsler Memory Scale – Third Edition

[a] Country in which the sample was collected

[b] Whether means and standard deviations for norms were provided

[c] No clinical or normative data was collected as per report

Many of the reviewed studies have put emphasis on appropriate cultural adaptation, but adaptation across tests varied in quality. Among the 12 cognitive screening measures meeting three or more of our criteria, the quality of adapting the Tunisian MMSE (Bellaj et al. 2008) and its Lebanese modified version (3MS; Abou-Mrad et al., 2015; Zamrini et al. 2014) was exceptional. Bellaj and colleagues followed the guidelines for test translation by van de Vijver and Hambleton (1996) as well as the *Standards* (American Educational Research Association, American Psychological Association, and National Council on Measurement in Education 1999), which included back translation and piloting, and ensured cultural adaptation of both verbal and nonverbal tasks. While keeping Orientation items 'month,' 'year,' 'day of the week,' and 'season,' the item 'date' was replaced by 'time of day,' to avoid the divergence between using the Islamic and the Gregorian calendars. Serial-7 subtractions, a measure of attention, was replaced by 'days of the week in reverse,' to suit the low educated elderly. Pentagon copy was replaced by an item from the stick test (Butters and Barton 1970; constructing using matches) to suit illiterates who are not accustomed to holding pencils. Abou-Mrad and

Table 7 Measures of executive functioning and motor skills with most extensive adaptation, validation and norming for Arabs

Instrument	Country[a]	Criteria met	*M (SD)*[b]	Study reference
AWMA	EGY, KWT	T, BT, AD, R, V	Y	Alansari and Soliman 2012
	KWT	T, R, V	Y	Soliman 2014
BOT	UAE	T, AD, R, V	Y	Hassan 2001
FAB	TUN	T, AD, R, V, N	Cut offs	Ben Jemaa et al. 2008
GPT	YEM	T, AD R †	NP	Al Serouri et al. 2000
Stroop CWT	EGY	T, R, V †	Y	Farhan 2006
	SAU	T, AD, N †	Y	Al-Ghatani et al. 2010, 2011
TMT	BHR, SAU, & KWT	T, AD, N †	Y	Abdul Razzak 2013
Alternating Verbal Fluency	TUN	T, AD, N †	Y	Bellaj et al. 2015

Please refer to Table 2 for a key of abbreviations relating to country name and criteria met

Y yes, *NP* not provided, *AWMA* Automated Working Memory Assessment (select subtests), *BOT* Bruininks-Oseretsky Test of Motor Proficiency, *FAB* Frontal Assessment Battery, *GPT* Grooved Pegboard, *Stroop CWT* Stroop Color-Word Test, *TMT* Trail Making Test

[a] Country in which the sample was collected

[b] Whether means and standard deviations for norms were provided

† Some of our suggested adaptation quality criteria may not apply to this test (e.g. when aspects of the test did not require linguistic adaptation)

Table 8 Functional rating scales with most extensive adaptation, validation and norming for Arabs

Instrument	Country[a]	Criteria met	*M (SD)*[b]	Study reference
AD8	LBN	T, BT, AD, V, N	Y	Zamrini et al. 2014; Abou-Mrad et al. 2015
IQCODE	LBN	T, BT, AD, V, N	Y	Phung et al. 2015
Katz ADL	LBN	T, BT, AD, V	Y	Nasser and Doumit 2009
Lawton IADL	TUN	T, R, V, N	Cut offs	Attia-Romdhane et al. 2008[c]

Please refer to Table 2 for a key of abbreviations relating to country name and criteria met

Y yes, *AD8* Eight-Item Informant Interview to Differentiate Aging & Dementia, *IQCODE* Informant Questionnaire on Cognitive Decline in the Elderly, *Katz ADL* Katz Index of Independence in Activities of Daily Living, *Lawton IADL* Lawton Instrumental Activities of Daily Living

[a] Country in which the sample was collected

[b] Whether means and standard deviations for norms were provided

[c] Translated from English to French for use with the Tunisian population

his colleagues replaced the sentence "no ifs ands or buts" with a sentence that (1) measured the construct that the English sentence has intended to measure (novel andhigh - attention demand), and (2) was culturally appropriate: "Ella eza, la wa lan, ma'az Allah." However, others either replaced it with a sentence that is appropriate culturally, but does not realize the purpose of the task (repeating Arabic proverbs that virtually demands remote knowledge: "ala qad lehafak mid reglaik" such as in the Egyptian Addenbrooke's Cognitive Examination-III and Montreal Cognitive Assessment). Others merely translated the sentence, which produced a meaningless sentence in Arabic as Abou Mrad and his colleagues have pointed out. In essence, by making the test more culturally appropriate, the construct that was intended to be measured was lost.

A large number of the identified adaptations did not follow the guidelines of the International Test Commission (2010), or the *Standards* (American Educational Research Association et al. 1999; 2014). Serious methodological problems were noted when using maladapted measures, such as using Western norms to qualify the performance of participants, or classifying groups based on poorly adapted tests. Several studies did not specify versions of tests used or even included reference to the respective test publication in the reference list (see the Wechsler measures in Table S1). Method of administration and test instructions were often not described, or lacked sufficient details when mentioned. Exact stimuli, for example wordlists, were frequently not specified. The latter three problems render replication studies or accurate, cumulative research impossible. The majority of the studies utilized "nonverbal tests." This was at the expense of thorough examination of verbal skills, assuming that nonverbal abilities are culture free, a historically held idea that has been recently debunked (Agranovich and Puente 2007; Ardila and Moreno 2001; Mahurin et al. 1992). For instance, the literature review on cognitive assessment of Arab people revealed only one validated confrontation naming test specific to the Lebanese population (Abou-Mrad et al. 2015; Zamrini et al. 2014), despite the known sensitivity of confrontation naming to dementia and temporal lobe epilepsy. In addition, the majority of available verbal norms were mostly for wordlist generation tasks (verbal fluency), likely due to the feasibility of their administration.

The currently small number of Arabic speaking neuropsychologists limits the availability of neuropsychological measures and studies for Arab patients. Until recently, graduate psychology in many Arab countries was largely taught in Arabic, not requiring students to have working proficiency for English or French. This educational model, in turn, complicates access to English language research. Neuropsychology specialization is not common in the region, and those who were specialized, were mainly educated in Western countries. Further, there are few Arab speaking clinical neuropsychologists in English speaking countries, especially in research and training settings. Consequently, the role of evaluating cognitive impairment or any type of dementia and related brain disorders in Arab countries has largely been handled by neurologists and psychiatrists, as they were the most qualified clinicians to diagnose such conditions. With the increasing number of comprehensive tests, and the rising numbers of post-graduate, assessment-specialist psychologists, this responsibility may appropriately shift to psychologists. Another factor that may explain the lack of standardized tests for Arab individuals, is the low economic status of most Arab countries, which limits research resources. However, only two cognitive studies attempting an adaption of the same intellectual measure have been published in Qatar, one of the richest countries in the world. It could be the case that, even in such wealthy countries, there is not enough awareness of, or emphasis on developing cognitive tests, and thus meagre financial resources are allocated. Additionally, there are no neuropsychological organizations that provide cohesion for Arabic speaking neuropsychology professionals.

Reviewed studies that have examined cognitive test performance contrasting Arab and other cultural groups have generally utilized "nonverbal" tests (intellectual and visuomotor) and executive functioning tasks, and were conducted on children (Abdul Razzak 2013; Alansari and Baroun 2004; Josman

et al. 2006; Khaleefa et al. 2012; Parush et al. 2000; Shebani et al. 2008; Sobeh and Spijkers 2012, 2013; Stanczak et al. 2001). Studies on bilingualism and language dominance (Abdelgafar and Moawad 2015; Abdul Razzak 2013; Al-Ghatani et al. 2010; Alansari and Soliman 2012; Alkhamra and Al-Jazi 2015; Bahri and Bendania 1997; Balilah and Archibald 2015, May; Geldmacher and Alhaj 1999; Soliman 2014; Tahan et al. 2011) differed in methodology, which makes it difficult to draw generalizable conclusions on the cognitive performance of Arab bilinguals. Cultural differences and bilingualism in other cognitive domains, and in adult Arab populations require further investigation, and acculturation and urbanization factors should be examined (Boone et al. 2007). In contrast to numerous studies comparing Spanish speaking cultures (Ardila et al. 1989; Artiola i Fortuny et al. 1998; Bure-Reyes et al. 2013; Daugherty et al. 2016), only three studies compared neuropsychological performances of Arab groups from different Arab countries (Abdul Razzak 2013; Alansari and Soliman 2012; Khaleefa et al. 2012), and further research in this area is evidently needed.

The results of this review are limited by several constraints. First, search keywords and countries were entered in English. Although most Arabic and French articles provide abstracts in English to facilitate accessibility, searching in English inevitably excludes some literature published in Arabic and French. The latter is a language that many North African countries such as Morocco, Tunisia, and Algeria commonly use for publication. Second, we searched few known international and Arab databases and search engines, while other important databases might have been excluded. The possibility exists further that some studies were published in non-indexed journals or non-peer reviewed outlets that are not accessible through Internet or standard citation sources. There is a wealth of Egyptian, Saudi, and Jordanian dissertations that we were unable to access. Further, some of the more remote publications may have not been captured in PsycInfo or PubMed. Psychological journals publishing in Arabic were also difficult to identify and access. Finally, it was not possible to obtain locally published manuals of Arabic-language tests in order to evaluate the quality of their adaptation and standardization.

Improving the State of Clinical Neuropsychology in the Arab World

Improving the state of graduate-level psychology in Arabic academia Arabic speaking neuropsychologists should aim to spread awareness of the importance of valid cognitive assessment, and consequently securing funding for proper educational programs and research. They can attempt establishing local collaborations to approach decision-makers with the purpose of enhancing quality and quantity of clinical psychology programs at the graduate level. These programs can be created with the goal of being accredited by the American Psychological Association or similar accreditation bodies. Clinical internships at hospitals and clinics should be incorporated within the programs. Organizing conferences in Arab countries, attending international neuropsychological events, and participating in academic exchange programs (Arab or foreign) will be of advantage for Arabic speaking neuropsychologists and students.

Improving neuropsychological test development and adaptation Arabic speaking neuropsychologists can create professional groups for test development. This is ideally organized at a cross-country level. These groups should agree on teaching, applying, and adhering to, standard international guidelines for test development such as those by the (American Educational Research Association et al. 1999; 2014) as well as the International Test Commission (2010). A broad survey on the every-day practice of Arabic speaking neuropsychologists can shed light on their individual strategies of adapting neuropsychological tests to their local patient population (e.g. translating tests, using "in house" norms etc.). Because of the heavy reliance on "nonverbal measures" revealed in the present review, Arabic speaking neuropsychologists are encouraged to validate more language-based neuropsychological tools while considering dialects and cultural variables. Due to its neutrality, the use of the MSA form of Arabic should be considered for developing tests intended to be used with Arabic speakers from all backgrounds. Further, Arabic speaking neuropsychologists can collaborate with linguists to create Arabic word-databases (word counts) to better develop language-based cognitive measures, such as vocabulary or wordlist memory tasks.

Improving accessibility of publications Arabic speaking neuropsychologists should consider publishing in both Arabic (locally) and English (in mainstream international journals). This pulication strategy would facilitate data accessibility for Arabic speaking students or professionals who do not speak English, and at the same time, make findings available to neuropsychologists internationally working with Arabic speaking patients. Psychologists working in Arabic academia can coordinate with universities and information technology specialists to improve the quality, and increase the number of Arabic databases dedicated to Arabic psychological journals, dissertations, and theses.

Improving cross-cultural neuropsychological research Research is lacking on examining cultural differences among Arabs and between Arabs and other groups. Based on this review, executive function and visuoconstruction were the most examined domains, and children were more examined than adults. Neuropsychologists are encouraged to further study other neuropsychological domains as well as individuals above 18 years of age.. Bilingualism, acculturation, and

urbanization factors in relation to cognitive performance should also be examined in cross-cultural research.

Conclusion

The lack of information on clinical validity of many tests available for Arabic speaking individuals has implications at the heart of neuropsychological service provision. Using such measures will result in errors of measurement, which will consequently reveal false brain impairment, over pathologize conditions, and judge patients based on constructs that may not pertain to their cultures. The current situation gives rise to the conclusion that clinical neuropsychology has a long ways to go in making assessments "fair" and applicable to other cultures and languages besides the English speaking world. To develop universal practice, science, and theories of neuropsychological function, increased focus needs to be placed on expanding and revising valid neuropsychological tests for all the world's populations.

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