Assessment protocol for patients with acquired apraxia of speech

Yehia Amin Aboras[a], Ghada Abdelhady Ashmawy[b], Reham Mohamed Elmaghraby[a], Sabah Saeed Gommaa[c]

[a]Phoniatrics Department, [b]Neuropsychiatry Department, [c]Unit of Phoniatrics, Faculty of Medicine, University of Alexandria, Alexandria, Egypt

Correspondence to Reham Mohamed Elmaghraby, Assistant Professor of Phoniatrics, Faculty of Medicine, Alexandria University, 12 Street Elnahda Roushdy, Alexandria, Egypt; Tel: +20 100 152 7360; e-mail: rihamma05@yahoo.com

Received 12 August 2016
Accepted 26 October 2016

The Egyptian Journal of Otolaryngology
2017, 33:528–534

Background
Apraxia of speech can be defined as an articulation disorder that results from impairment of the capacity to order the positioning of speech musculature and the sequencing of muscle movements for volitional production of phonemes and sequences of phonemes.
Objective
The aim of this study was to adapt the Apraxia Battery for Adults II (ABA II) test to suit the Egyptian culture in order to apply this test for assessing Egyptian apraxic patients for proper management of this ailment.
Subjects and methods
This study was conducted on two groups: the first group consisted of 56 adult patients with expressive aphasia and/or dysarthria, who were evaluated with ABA II to detect any apraxic elements. The second group consisted of 100 healthy adults who served as the control group and were evaluated by ABA II to yield cutoff scores. Test reliability was assessed by internal consistency reliability using reliability coefficient α (Cronbach's α). Test validity was measured on the basis of content validity, concurrent validity, and group differentiation.
Results
Reliability of the ABA II test was proved to be high, on the basis of the high values of coefficient α obtained for all test items (0.746–0.937), denoting an intercorrelation between test items. Validity of the ABA II was proven by three methods: content validity, concurrent validity (correlation matrix between different items of the test was determined and there was a strong correlation between the test items), and group differentiation (comparison of the test results between apraxic patients, nonapraxic patients, and controls was done and statistically significant differences were found between the scores of all test items among these groups.) The test was proven to be sensitive and specific.
Conclusion
The results were highly significant and were capable of discriminating between normal subjects and apraxic patients.

Keywords:
apraxia battery for adults II, apraxia of speech, reliability, validity

Egypt J Otolaryngol 33:528–534

1012-5574

Introduction

Apraxia is generally defined as 'a disorder of skilled movement not caused by weakness, akinesia, deafferentation, abnormal tone or posture, movement disorders such as tremor or chorea, intellectual deterioration, poor comprehension, or uncooperativeness' [1].

Apraxia of speech (AOS) can be defined as a motor speech disorder resulting from the impairment of the capacity to program sensorimotor commands for the positioning and movements of muscles for the volitional production of speech. It can occur without significant weakness or neuromuscular slowness, and in the absence of disturbances of thought or language [2].

There are two types of apraxia: acquired AOS, which can occur at any age after full development of language, and childhood AOS [3–5].

AOS results from an insult to the left cerebral hemisphere [2]. Vascular lesions are the most common cause of AOS, but this disorder may also result from head trauma, tumor, or other neurological diseases. It can occur with neurodegenerative diseases [6,7].

A number of brain areas have been associated with AOS, including the following: left inferior frontal (Broca's area), anterior insular cortex, frontosubcortical white matter, temporoparietal cortex, basal ganglia [8,9], and the parietal lobe [10].

Patients with AOS may present with any or all of the following salient signs:

(1) Effortful trial and error groping with attempts at self-correction.
(2) Persistent dysprosody (abnormal rhythm, stress, and intonation).
(3) Articulatory inconsistency on repeated productions of the same utterance.
(4) Obvious difficulty initiating utterances [11].

Diagnosis of AOS tends to be made by clinical judgment with reference to the presence of characteristic apraxic speech behaviors [12]. Motor speech examination has been widely used in the diagnosis of AOS for accurate detection of these speech behaviors [13,14]. This can be done through elementary diagnostic procedures (patient and family interview, clinical examination with motor speech evaluation, which elicits speech samples with tasks as vowel prolongation, repetition of syllables, words, and phrases, oral reading, and picture description), clinical diagnostic aids (formal testing such as with the dysphasia test [15], psychometric tests, articulation test), and intelligibility test, and Apraxia Battery for Adults II (ABA II) [16], with additional instrumental measures in the form of acoustic measures (measurement of speaking rate, vowel and syllable duration, voice-onset time) and physiological measures (such as electromagnetic articulography, electromyography, and electropalatography) [17,18].

Treatment approaches for AOS fall into three categories:

(1) Medical intervention to treat the underlying etiology or prevent further impairment (as antibiotics for infection, anticoagulants to prevent stroke, anticonvulsants).
(2) Alternative or augmentative communication devices for patients with severe AOS [2,19].
(3) Behavioral management, which includes the following:
    (a) those that target articulatory movement patterns and sound production in the form of traditional articulation therapy (repetitive exercises involving imitation of speech sounds and words);
    (b) those that focus primarily on prosodic aspects of speech production [19];
    (c) those that use tactile and gestural cues as the primary facilitator.

Aim of the work

The aim of this study was to adapt the ABA II test to suit the Egyptian culture in order to apply this test for assessing Egyptian apraxic patients.

Participants and methods

Each subject was assessed by the following protocol. This protocol consisted of the following:

(1) Elementary diagnostic procedures including complete history taking and complete clinical examination.
(2) Clinical diagnostic aids including the following:
    (a) Auditory perceptual assessment to assess patient speech and voice characteristics. It can detect any abnormalities and determine the presence of dysphasic, dysarthric, and apraxic characteristics.
    (b) Formal testing, which include the following:
        (i) Detection of any associated dysphasia element and diagnose its type by means of the modified scoring system for testing language disability in dysphasic patients [15].
        (ii) Arabic articulation test to detect any pattern of misarticulation [20].
        (iii) ABA II, applied after translation and modifications, which was based on the results of a pilot study. Validity and reliability of the test were assessed [16].
    (c) Evaluation of cognitive and perceptual abilities using the following:
        (i) Stanford Binet intelligent scale to assess the intelligence quotient [21].
        (ii) Test of nonverbal intelligence [22].
        (iii) Taylor test of anxiety to detect any elements of anxiety.
    (d) Visualization and documentation of the glottis and velopharyngeal valve using fiberoptic nasopharyngolaryngoscopy.
(3) Use of additional instrumental tools:
    (a) Acoustic analysis multidimensional voice program (MDVP), to obtain perturbation measures such as jitter and shimmer percentage.
    (b) Spectral analysis computerized speech lab (CSL), to measure voice-onset time, vowel duration, syllable duration, and sentence duration.

(c) Nasometric analysis, to record the nasalance score of oral and nasal sentences.
(d) Aerodynamic measures, to obtain vital capacity and mean flow rate.
(e) Brain imaging (CT–MRI), to detect possible etiological factors and determine the site of the lesion.

The control group was also evaluated by the above protocol to yield cutoff scores and test the validity of the test with its ability to differentiate between those with normal speech and apraxic patients. The control group was also used to obtain normative data for acoustic analysis, spectral analysis, nasometric measures, and aerodynamic measures to be compared with the results of apraxic patients.

Informed consent was taken from all participants in the present study.

In this study ABA II was translated and modified to be used as an assessment tool for Egyptian apraxic patients. The study was conducted on two groups: 56 adult patients with expressive aphasia and/or dysarthria with ages ranging from 18 to 76 years; and 100 normal adult subjects who served as the control group. The patients were collected from the outpatient clinic of the Phoniatrics Unit of the Main University Hospital, Alexandria University, from April 2013 to October 2014. The control sample was chosen mainly from the relatives of the patients coming to the clinic in order to ensure inclusion of subjects from the same cultural background and educational level. A pilot study was conducted on 20 controls and 15 patients to check the suitability and clarity of the materials for Arabic-speaking subjects and the pattern of test presentation. Most changes were made in the word lists of subtest 2 (increasing word length A, B), which were changed to more suitable Arabic words that had progressively increasing number of syllables. Word lists and pictures of subtests 4 and 5 (utterance time for polysyllabic words and repeated trials) were changed to more suitable Arabic multisyllabic words. In subtest 6 (inventory of articulation characteristics of apraxia), the reading passage was changed to a more clear one showing several prosodic variations. Direct linguistic translation was avoided because of the difference in the critical phonemic structure between English and Arabic language, taking into consideration the fact that the complexity and increased number of syllables in the test items would help to more easily elicit apraxic speech behaviors.

Results

(1) A pilot study was conducted on 20 healthy individual and 15 patients with expressive aphasia and or dysarthria aged from 18 to 76 years who were randomly chosen. The test was applied after translation and modification to check the clarity and suitability of the materials used.
(2) Demographic distribution of the studied groups: The subjects in this study were divided into two groups: 100 normal controls and 56 aphasic (expressive affection) and/or dysarthric patients. The patient group was subdivided into apraxic patients and nonapraxic patients on the basis of clinical diagnosis. Apraxic patients constituted 37.5% (21 cases) of the patient group, whereas nonapraxic patients constituted 62.5% (Table 1).
   (a) *Age*: The ages in the control and patient groups ranged from 18 to 76 years, with a mean age of 47.5±15.7 years for apraxic patients, 48.7±12.5 years for nonapraxic patients, and 48.0±13.5 years in the control group. No statistically significant differences were found between patients (both apraxic and nonapraxic) and controls (P=0.779).
   (b) *Sex*: Twelve (57.1%) apraxic patients, 27 (77.1%) nonapraxic patients, and 55 (55%) controls were male. Nine (42.9%) apraxic patients, eight (22.9%) nonapraxic patients, and 45 (45%) controls were female. The P value was 0.067, which was statistically nonsignificant between the groups.
   (c) *Educational level*: The sample was divided into three groups according to educational level: the illiterate group, the middle education (from primary school to secondary education) group, and the high education group (university and above). Illiterate patients constituted 19% of apraxic patients and 22.9% of nonapraxic patients; patients with middle education constituted 52.4% of apraxic patients and 65.7% of nonapraxic patients, and patients with high education constituted 28.6% of apraxic patients and 11.4% of nonapraxic patients. The P value was 0.268, which was statistically nonsignificant.

Table 1 Apraxia of speech distribution in the patient group (n=56)

Apraxia of speech	n (%)
Nonapraxic patients	35 (62.5)
Apraxic patients	21 (37.5)

(3) Characteristics of the patient group:
   (a) On the basis of diagnosis, patients were divided into:
      (i) those with expressive aphasia, comprising 20 patients (35.7%);
      (ii) those with dysarthria, comprising 27 patients (48.3%);
      (iii) those with expressive dysphasia and spastic dysarthria, comprising five patients (8.9%); and
      (iv) those with expressive dysphasia and UMN dysarthria, comprising four patients (7.1%).

The distribution of AOS among the patient groups was as follows: 13 apraxic patients (61.9%) had expressive aphasia; four apraxic patients (19%) had expressive aphasia and flaccid dysarthria, and only two apraxic patients (9.5%) had spastic dysarthria; one apraxic patient had unilateral UMN dysarthria; and one apraxic patient had UMN dysarthria associated with expressive aphasia. Thus, expressive aphasia (either isolated or associated with dysarthria) was present in 18 apraxic patients (85.7%) and dysarthria (either isolated or associated with expressive aphasia) was present in eight apraxic patients (38%).

(1) Duration of the condition ranged from 2 to 30 months, with a mean of 6 months.
(2) The cause of the neurological insult among the patients with AOS was vascular (90.4%) [either brain hemorrhage (4.7%) or nonhemorrhagic infarction (85.7%)], head trauma (4.7%), or brain infection (4.7%).
(3) The site of the lesion was determined by CT and MRI. The sites affected were as follows: left inferior frontal gyrus (42.9%), left temporoparietal region (19%), left frontoparietal (insula) and left temporoparietal region (14%), left parietal lobe (14%), left frontoparietal (insula) cortical and subcortical regions and basal ganglia (4.8%), and left inferior frontal gyrus with frontoparietal area (4.8%).
(4) The clinical features of patients with AOS included the following: highly inconsistent errors (95%); visible/audible searching (95%); effortful trial and error groping with attempts at self-correction (90%); marked difficulty in initiating speech (90%); fewer errors with automatic speech than with volitional speech (90%); errors increase as phonemic sequence increases (90%); abnormal prosodic features (85%) (including equalized and difficult varying stress, restricted or altered pitch, durational and loudness contour, and slow rate), awareness of errors and inability to correct them (85%), phonemic transposition errors (61%), intrusion of schwa sound between syllables or in consonant clusters (28%), phonemic perseverative errors (23%), phonemic anticipatory errors (19%), phonemic voicing errors (14%), and phonemic vowel errors (9%).
(5) Performance of the patient group on psychometric tests: The difference in psychometric results between the apraxic and nonapraxic groups revealed a statistically nonsignificant P value. It was found that verbal IQ was markedly affected, especially among apraxic patients (no one had average or below average verbal IQ, whereas 23.8% of apraxic patients were nontestable). TONI results among apraxic patients were as follows: average IQ was 9.5%, below average IQ was 19.0%, slow learner IQ was 47.6%, and mild IQ was 23.8%. The results of the Taylor test of anxiety were as follows: no anxiety in 52.4%, mild anxiety in 14.3%, moderate anxiety in 9.5%, and severe anxiety in 23.8%.
(6) Performance of the apraxic patient group on fiberoptic nasopharyngolaryngoscopy: One apraxic patient had unilateral vocal fold immobility and another had velopharyngeal incompetence. Both cases had spastic dysarthria in addition to AOS, which can reflect the unremarkable effect of AOS on phonation and resonance.
(7) Performance of the patient group on MDVP, nasometer, aerodynamics, and CSL studies: The difference in MDVP, nasometer results, and aerodynamics parameters between the apraxic patients and controls revealed a statistically significant P value for jitter percentage, shimmer percentage, and mean flow rate. This result may be due to the associated dysarthria, which can affect all speech components. When the CSL results were compared between apraxic patients and controls, the *P* value was found to be statistically significant for vowel duration, syllable duration, and sentence duration.

Test result analysis

Reliability

The internal consistency reliability was tested using reliability coefficient α (Cronbach's α). The high values of α in all test items (0.746–0.937) denote an intercorrelation between test items (Table 2).

Validity

Validity was measured on the basis of the following:

(1) Content validity (expert opinion): Experts (five phoniatricians) examined the content validity by relying on the concept tested by each subtest and

its aim; they checked whether the test included all relevant and important items and excluded irrelevant ones.

(2) Concurrent validity: Correlation matrix between different items of the test was performed and a strong correlation was found between the test items. The results are shown in Table 3.

(3) Group differentiation: Comparison of the test results between apraxic patients, nonapraxic patients (dysarthric or aphasic), and controls was done. Statistically significant differences were found between the scores of all test items among these groups.

(4) Comparison between performance of the Egyptian sample and that of the English sample on ABA II revealed statistically nonsignificant differences in the scores of all test items.

(5) Sensitivity, specificity, and cutoff scores of the test items: The receiver operating characteristic curves with the areas under the curves (AUC) and their statistical significance were used as an indicator for scale and subscale performances. Cutoff values for diagnosis was applied only for statistically significant AUCs, where the value that maximized both sensitivity and specificity of the scale was chosen (Table 4).

Table 2 Reliability coefficient (α) values of various test items

Item	Cronbach's α
Diadochokinetic rate	0.812**
Increasing word length (part A)	0.805**
Increasing word length (part B)	0.830**
Limb apraxia	0.914*
Oral apraxia	0.889**
Utterance time for polysyllabic words	0.746***
Repeated trials	0.937*
Inventory of articulation characteristics of apraxia patients	0.884**

*Excellent: $\alpha \geq 0.9$. **Good: $0.8 \leq \alpha < 0.9$. ***Acceptable: $0.7 \leq \alpha < 0.8$.

Discussion

An accurate diagnosis of AOS is very important, which depends on accurate evaluation of the patient during various speech tasks such as automatic speech, spontaneous speech, and oral reading [23]. ABA II was designed to provide clinicians with a measure to assess AOS; it can give a measure about the severity of the disorder, and it can be used to direct therapeutic approaches for the treatment of apraxia. The diagnostic aim of apraxia testing is met in ABA II by comprehensively sampling all variables in the speech performance of apraxic patients.

Clinical diagnosis was used to identify apraxic patients from dysarthric and aphasic groups. It was found that 37.5% of the patient group was apraxic on the basis of the presence of various apraxic features. The age range of the sample was between 18 and 76 years; on the basis

Table 3 Correlation between different test items

	Diadochokinetic rate	Increasing word length (part A)	Increasing word length (part B)	Limb apraxia	Oral apraxia	Utterance time for polysyllabic words	Repeated trials
Diadochokinetic rate	1						
Increasing word length (part A)	–0.509*	1					
Increasing word length (part B)	–0.538*	0.899*	1				
Limb apraxia	0.332*	–0.274*	–0.241*	1			
Oral apraxia	0.579*	–0.478*	–0.483*	0.616*	1		
Utterance time for polysyllabic words	–0.672*	0.725*	0.764*	–0.313*	–0.602*	1	
Repeated trials	0.619*	–0.713*	–0.674*	0.143*	0.449*	–0.681*	1

*Significant correlation coefficient.

Table 4 The cutoff scores of the various test items

Test item	Sensitivity %	Specificity %	Cutoff (Arabic)	Cutoff (English)
Diadochokinetic rate	75%	97%	23	26
Increased word length (part A)	73.4%	100%	2	1
Increased word length (part B)	81.1%	100%	2	1
Limb apraxia	71%	89%	45	44
Oral apraxia	82.9%	97%	45	44
Utterance time for polysyllabic words	96%	100%	15	15
Repeated trials	92.5%	100%	27	28
Inventory of articulation characteristics of apraxia patients	70%	100%	5	5

of age the sample was divided into two groups: from 18 to 45 years and above 46 years. More than half of the apraxic patient group was above 45 years as AOS with associated disorders (aphasia and dysarthria) tends to occur at older age, which was also revealed in the study by Engelter *et al.* [24]. As regards sex distribution, nearly 57% of apraxic patients were male. This was because stroke is more common among men than among women and also because of the higher referral of men for language and speech therapy (for social and professional reasons). With regard to educational level, the high percentage of middle education and illiterate patients was because Alexandria Main University Hospital provides health services to the people of Alexandria and surrounding rural areas where citizens tend to be of low educational level. Patient diagnosis varied between expressive aphasia, spastic dysarthria, and UMN dysarthria in association with AOS. It was found that AOS occurred most commonly in association with expressive aphasia as these two disorders share the same lesion site (Broca's area). Nonhemorrhagic brain infarction was the most common cause of neurological insult leading to AOS. Other causes included brain trauma and infection. This was found in the study by Duffy [23] as well, who stated that brain infarction is the most frequent cause leading to AOS. The site of the lesion that could lead to AOS varied among different areas of the brain. Left inferior frontal gyrus (Broca's area) was the most common site, as seen in 42.9% of apraxic patients. This can explain the frequent association between AOS and expressive aphasia. The other sites affected in apraxic patients were left temporoparietal region (19%), left parietal lobe (14%), and left frontoparietal (insula) with left temporoparietal (14%) region. This finding was agreed upon by Hillis *et al.* [8] and Ogar *et al.* [9]. All the patients were evaluated by various psychometric tests (Stanford Binet and TONI) to determine their cognitive abilities. On assessment using TONI, 76.1% of apraxic patients exhibited nonverbal performance ranging between average to slow learner. These patients had poor verbal IQ, which reflects the impact of the existing speech disorder. As regards the results of the Taylor test of anxiety, it was found that 11 (52.4%) apraxic patients had no anxiety, whereas 10 (47.6%) showed variable degrees of anxiety (50%) of whom had severe anxiety. It could not be determined whether anxiety was caused by AOS alone or by other associated disorders such as dysarthria and aphasia. Regarding the results of MDVP, nasometer, aerodynamics, and laryngoscopic findings, it was found that there was a significant difference between the apraxic and control groups in jitter percentage, shimmer percentage, and mean flow rate. This may be due to the associated dysarthria, which can affect all speech components. This is supported by a study conducted by Odell *et al.* [25], which stated that AOS showed no effect on voice and resonance. Patients with isolated AOS are needed to further study the effect of AOS on various speech components. As to spectral analysis, there was a significant difference between apraxic patients and controls in prolongation of vowel duration, syllable duration, and sentence duration. This is in line with the results of the majority of apraxia studies, such as those by Varley *et al.* [26] and Ballard *et al.* [27]. Test reliability was assessed using internal consistency by using reliability coefficient α (Cronbach's α), which increases as the intercorrelations among test items increase. The high values of α in all subtest items, which ranged from 0.746 to 0.937, denote significant intercorrelation between test items. These results were similar to the results of the original ABA II, in which coefficient of α ranged from 0.83 to 0.97. Test–retest reliability was not examined in this study, nor in the original test. ABA is a measure of apraxia and is designed for individuals who experience CVS, traumatic brain injuries, and other neurological insults. Thus, persons receiving treatment for these conditions would show varying amounts of improvement over time and would produce low test–retest correlation coefficients.

Validity of the test was proven. Content validity is the adequacy with which the test items adequately and representatively sample the content area to be measured. Expert judgment is the primary method used to determine whether a test has content validity. Experts (five phoniatricians) examined the content validity relying on the concept tested by each subtest and its aim. They checked that the test included all relevant and important items and excluded irrelevant ones. The test was considered valid when judges indicated high satisfaction as regards test questions and pictures. *Concurrent validity*: Correlation matrix between different items of the test was performed and there was strong correlation between the test items. Group differentiation is the most general type of evidence and involves the ability of the test results to discriminate between groups that are known to be different in a theoretically appropriate manner. Comparison of the mean and SD of the control, aphasic, dysarthric, and apraxic groups showed that apraxic scores significantly differ from the scores of the normal, aphasic, and dysarthric groups on all test items, and thus ABA can discriminate between these groups. Comparison between original test scores and Egyptian sample scores revealed

statistically nonsignificant differences in all test items. This may add to test validity as it indicates consistency of the test after translation and adaptation. As regards the sensitivity and specificity of the test; the modified ABA was highly sensitive and specific. Sensitivity and specificity of the test ranged from 70.4 to 100% for cutoff scores of all test items. The cutoff values for diagnosis was applied only for statistically significant AUCs where the value that maximized both the sensitivity and specificity of the scale was chosen. Values above or equal to the identified cutoff values denote a positive diagnosis. AUC proved to be large for all test items, denoting high sensitivity and specificity. The comparison of the cutoff values between the original test and the Egyptian sample revealed the same values for subtests 4 and 6 (utterance time for polysyllabic words and inventory of articulation characteristics of apraxia). The rest of the cutoff values were more or less very similar to those of the original test.

Conclusion

The results were highly significant and were capable of discriminating between normal subjects and apraxic patients.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1 Heilman KM, Rothi LJ. Apraxia. In: Heilman KM, Valenstein E. Clinical neuropsychology. 3rd ed. New York: Oxford University Press; 1993. 141–163.

2 Duffy JR. Motor speech disorders. St Louis: Mosby; 1995. 259–277.

3 Morgan AT, Vogel AP. A review of treatment for childhood apraxia of speech. Eur J Phys Rehabil Med 2009; 45:103–110.

4 Vargha-Khadem F, Gadian DG, Copp A, Mishkin M. FOXP2 and the neuroanatomy of speech and language. Nat Rev Neurosci 2005; 6:131–138.

5 Maassen B. Issues contrasting adult acquired versus developmental apraxia of speech. Semin Speech Lang 2002; 23:257–266.

6 Josephs KA, Duffy JR, Strand EA, Whitwell JL, Layton KF, Parisi JE. Clinicopathological and imaging correlates of progressive aphasia and apraxia of speech. Brain 2006; 129:1385–1398.

7 Ricci M, Magarelli M, Todino V, Bianchini A, Calandriello E, Tramutoli R. Progressive apraxia of speech presenting as isolated disorder of speech articulation and prosody: a case report. Neurocase 2008; 14:162–168.

8 Hillis AE, Work M, Barker PB, Jacobs MA, Breese EL, Maurer K. Re-examining the brain regions crucial for orchestrating speech articulation. Brain 2004; 127:1479–1487.

9 Ogar J, Willock S, Baldo J, Wilkins D, Ludy C, Dronkers N. Clinical and anatomical correlates of apraxia of speech. Brain Lang 2006; 97: 343–350.

10 Square PA, Roy AE, Martin RE. Apraxia of speech: another form of praxis disruption. In: Rothi LJ, Heilman KM. Apraxia: the neuropsychology of action. East Sussex: Psychology Press; 1997. 173–206.

11 Wertz RT, LaPointe LL, Rosenbek JC. Apraxia of speech: the disorders and its management. New York: Grune and Stratton 1984.

12 McNeil MR, Pratt SR, Fossett TR. The differential diagnosis of apraxia of speech. In Maassen B. Speech motor control in normal and disordered speech. New York: Oxford University Press 2004. 11 223–230.

13 Robin DA, Solomon NP, Moon JB, Folkins JW. Nonspeech assessment of the speech production mechanism. In McNeil MR. Clinical management of sensorimotor speech disorders. New York: Thieme 1997. 49–62

14 Hartelius L, Svensson P, Bubach A. Clinical assessment of dysarthria: performance on a dysarthria test by normal adult subjects and by individuals with Parkinson's disease or with multiple sclerosis. Scand J Logop Phoniatr 1993; 18:131–141.

15 Kotby MN, Mostafa ME, Bonowby MH, Baraka MA. Modified scoring system for testing language disability in dysphasic patients. HNO Praxis Leipezing 1981; 6:194–198.

16 Dabul B. Apraxia Battery for Adults. 2nd ed. Austin: Pro-Ed; 2000.

17 Haley KL, Ohde RN, Wertz RT. Vowel quality in aphasia and apraxia of speech: phonetic transcription and formant analyses. Aphasiology 2001; 15:1107–1123.

18 Howard S, Varley RA, Rosemary A. EPG in therapy, using electropalatography to treat severe acquired apraxia of speech. Int J Lang Commun Disord 1995; 30:246–255.

19 Wambaugh J. A summary of treatments for apraxia of speech and review of replicated approaches. In: McNeil MR. Seminars in speech and language. Apraxia of speech: from concept to clinic. New York: Thieme 2002. 293–308

20 Kotby MN, Bassiouny S, El-Zomor M, Mohsen E. Standard isolation of an articulation test. Proceedings of the 9th Annual Ain Shams Medical Congress; Cairo, Egypt, March 1986.

21 Meleka LK. Stanford Binet scale. 4th edition. 1998.

22 Linda B, Rita J, Shrbenou XX, Johnsen SK. Test of non verbal intelligence. 2nd ed. UK; 1990.

23 Duffy JR. Motor speech disorders: substrates, differential diagnosis and management 2nd ed. St Louis: Mosby; 2005. 260–281.

24 Engelter S, Gostynski M, Papa S. Epidemiology of aphasia attributable to first ischemic stroke.incidence, severity, fluency, etiology, and thrombolysis. Stroke 2006; 37:1379–1384.

25 Odell KH, Shriberg LD. Prosody-voice characteristics of children and adults with apraxia of speech. Clin Linguist Phon 2001; 15:275–307

26 Varley RA, Whiteside SP, Luff H. Apraxia of speech as a disruption of word-level schemata: some durational evidence. J Med Speech Lang Pathol 1999; 7:127–132.

27 Ballard KJ, Granier JP, Robin DA. Toward a new understanding of apraxia of speech: theory, analysis, and treatment. Aphasiology 2000; 14: 969–995.