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The Polish linguistic test review in the assessment of Central Auditory Processing Disorders

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Abstract

The issue presented here dwells on linguistic tests as universal materials used in detection of hearing deficits and as a possibility of hearing training in all stages of speech perception. The article ranges the tests of which usage is important in case of the Central Auditory processing Disorder. The auditory impairments like CAPD are seldom phenomena from which suffer 10 % of adults and 2-3% of children. Everybody who frequently mishears words, misses instructions, has difficulty rapidly and accurately processing verbal information, has trouble with the prosodic or musical aspects of speech, or has noticeable difficulty hearing in background noise, should be suspected of having an auditory processing deficit and should receive a thorough evaluation. In other words, problem with interpreting and analyzing the sensory information received via auditory pathway is called Central Auditory Processing Disorder and needs a proper battery of audiologic tests. Criteria, which should be applied while preparing central auditory tests, have recently undergone practical practical and theoretical verification. Difficulty in formulating a representative , reliable and precise test is caused by many variables which appear by necessity of taking the phonetic and acoustic structure into consideration. Tests used in medical examination in order to diagnose Central Auditory Processing Disorders are classified into two major categories: Psychoacoustic tests and Electrophysiologic tests.

1 Introduction.

The case of the Central Auditory Processing Disorders flourished at the end of the 50s. in the XX century. At that time E. Bocca and C. Calearo elaborated the basis of diagnosing this brain impairment. Their research results were presented in their collective publication titled *Central Auditory Processing Disorders*. The issue of diagnosing CAPD thrived once again in the 90s. and it is still being explored.

1.1 What the CAPD is?

Central Auditory Processing Disorder is defined in various ways.
Every human being experiences various auditory sensations evoked by: Speech, Music, Noise, etc. However, some people's ability to comprehend such auditory information is lesser than their audiometric hearing threshold. Problems with interpreting and analyzing the sensory information received via auditory pathway are called Central Auditory Processing Disorders.

In general, the main cause of CAPD is the deficiency in processing auditory information. As a consequence, people who suffer from CAPD hardly can understand what others say in an adverse acoustic environment, though they have normal hearing. Therefore, such disorders may concern phonological abilities, capacity and sequence of memory, time discrimination, and speech comprehension in noisy surroundings[1]. Such hearing disorders may also occur as result of brain stem lesions within the upper auditory passage and near the cortical centres[2]. F. E. Musiek defines Auditory Processing Disorders as disorders accompanying peripheral normal hearing. To these disorders are included :

- noise – subjectively located within the central line of head,
- auditory hallucinations and sensations,
- very deep hearing impairment in room with intense reverberation or in a noisy crowd,
- difficulties in assessing complex acoustic stimuli,
- lack of auditory concentration,

difficulties in sound localization,

- lesser ability to assess music[3].

Similar view to central auditory processing disorders present American association ASHA (1995), which makes the existence of Auditory Processing Disorder (APD) conditional from one or more of the following auditory behaviors:

- sound localization and lateralization,
- auditory discrimination,
- auditory pattern recognition,
- temporal aspects of audition,
- auditory performance decrements with competing acoustic signals,
- and auditory performance decrements with degraded acoustic signals [4].

2 What kind of device is used in order to diagnose and rehabilitate CAPD?

In order to recognise and rehabilitate central Auditory Processing Disorders there are applied diverse types of tests. These tests are classified into two basic categories:

- psychoacoustic tests of higher auditory functions,
- electrophisiologic tests[5].

To the first group are included:

- immittance audiometry,
- - testing of hearing in noise – Langbecka technique,
- - SISI test,
- - monaural and binaural trial of equalizing loudness,
- - Fowler test[6],
- Speech Audiometry,
- Conventional Audiometry
- Bekesy Audiometry (Conditioned play audiometry, Behavioural Audiometry, VRA (Visual Reinforcement Audiometry),
- Impedance Audiometry (also called Tympanometry)

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[1] Extract from *Audiologia kliniczna,* Mariola Śliwińska-Kowalska, Marek Bochnia, Andrzej Orębowski, Łódź 2005

[2] Extract from A. Pruszewicza *Audiologia kliniczna*. *Zarys* 2003

[3]Extract from *Audiologia kliniczna* Mariola Śliwińska-Kowalska, Marek Bochnia, Andrzej Orębowski, Łódź 2005

[4] **dokumenty.ifps.org.pl/senderski2.pdf**

[5] sound.eti.pg.gda.pl/student/pp/pomiary – 5%B3uchu.pdf.

[6] sound.eti.pg.gda.pl/student/pp/pomiary – 5%B3uchu.pdf.

- Otoacoustic Emission Testing [7].

With the category of **psychacoustic test** of higher auditory functions are classed:

- Dichotic Digits Test,
- Duration Patterns Tests
- Frequency Pattern Sequence Tests (Difference Limen for Frequency) Test,
- distorted speech test,
- Speech In Noise Test,
- Understanding of Competing Speech test in contralateral ear[8].

The category of electrophysiologic tests contains:

- Auditory Brainstem Response (ABR),
- Middle Latency Auditory Potential (MLAP),
- and Cognitive P300 potential[9].

Checking sense of hearing methods are divided into two groups: **objective** ones and **subjective** ones. The **subjective methods of** diagnosing hearing impairments consist of:

- pure tone audiometry of which tasks are:
- to mark air conduction,
- to mark bone conduction.
- **suprathreshold audiometry**,
- speech audiometry,
- behavioural audiometry.

Whereas to the objective methods of diagnosing hearing impairment are included:

- electrophysiologic audiometry, which can be divided into:
- biopotentials collected from tympanic membrane,
- metod of electrocochleography ECoG,
- biopotencials collected from the head surface:
- potentials of ABR (Auditory Brainstem Response) (early potentials) – ABR[10],
- Middle latency response – MLR
- cortical evoked response **audiometry** – CERA
- **late** hearing **potentials** (contigent negative variations; **CNV** – CNV
- Mismatch Negativity Response (MMN)
- Impedance Audiometry (also called Tympanometry)
- Otoacoustic Emission Testing[11].

To sum up here is presented a table[12], which contains all CAPD measures:

Auditory Domain	ASHA(1996,2005) Defined Area	Specific Test Instrument
Temporal (Auditory	Auditory Temporal	MAPA Pitch Pattern

[7] sound.eti.pg.gda.pl/student/pp/pomiary – 5%B3uchu.pdf.
[8] dokumenty.ifps.org.pl/senderski2.pdf.
[9] dokumenty.ifps.org.pl/senderski2.pdf.
[10] sound.eti.pg.gda.pl/student/pp/pomiary – 5%B3uchu.pdf.
[11] sound.eti.pg.gda.pl/student/pp/pomiary – 5%B3uchu.pdf.
[12] Table from Musiek Frank E., Chermak Gail D.: *Handbook of (Central) Auditory Processing Disorder, volume 1, Auditory Neuroscience and Diagnosis*. wydaw. Plural Publishing, San Diego, Oxford, Brisbane 2007,

Pattern Temporal Ordering [APTO})	Processing and Pattering	Test (temporal order) MAPA TAP test MAPA Duration Patterns Tests Auditory Fusion Test-Revised Dutch Duration Patterns
Monaural (Monaural Separation Closure[MSC])	Monaural Low Redundancy Speech Tests	MAPA M-SAAT, MAPA SINCA (Speech in Noise for children and Adults) SCAN Filtered Words SCAN Auditory Figure Ground Dutch Filtered Words and Auditory Figure Ground Quick SIN Test Time-altered/ compressed speech Performance-Intensity functions (PI-PB) Speech In Noise (SPIN) Synthetic Sentence Identification SSI-ICM
Binaural (Binaural integration, Binaural separation [BIBS])	Dichotic Speech Tests	MAPA Dichotic Digits SCAN Competing Words MAPA Competing Sentences Staggered spondaic Words (SSW) Dutch dichotic Digits
	Binaural Interaction	Masking Level Difference Interaural Intensity Difference (IID) (binaural interaction) Sound Lateralization and Localization
	Auditory Discrimination Tests	Difference Limen for Frequency Difference Limen for Intensity Phonem Discrimination
	Electroacoustic Measures	Otoacoustic Emission (colchear level screen) Acoustic Reflex Threshold

		Acoustic reflex Decay
	Physiologic Measures	Acoustic reflex Decay (lower brainstem level screen) Auditory Brainstem Response Middle Latency Response N 1 P 2 P 300

3 Sample of elaborated CAPD tests battery used in the English language.

Observed disorders concern at this point not only impairment of pure tones reception, but also many other hearing phenomena. Therefore, the research of such phenomena cannot base only on single tests, but whole sets of examination should be applied as so to facilitate the evaluation of complex operations.[13].

Basic tests battery used in CAPD detection for each language consists of :

Binaural Integration Tests

Binaural integration tests are also referred to as binaural interaction tests. This group of tests requires the integration of auditory information from both ears. These tests are sensitive to brainstem lesions; however, they can be affected by higher auditory centers.

Masking Level Difference

The Masking Level Difference (MLD) is a widely used test of temporal processing and binaural interaction. The MLD compares the threshold of two binaural signals: either a low-frequency tone (500 Hz) or speech embedded in noise. The thresholds for the signals are measured in noise. The MLD has been shown to be abnormal in patients with brainstem lesions whereas cortical lesions have shown no effect on the MLD (Cullen & Thompson; 1974). There are limited data reporting MLDs in children. In addition, the MLD is reduced in children with auditory perceptual difficulties did not report a reduced MLD in learning disabled children but attributed this finding to the wide heterogeneity of learning disabled children.

Rapidly Alternating Speech Perception

Willeford (1976) first introduced the Rapidly Alternating Speech Perception (RASP) test. This test requires the integration of segments of speech. Unintelligible sequential bursts of information are delivered to the right and left ears at periodic intervals. The most common clinical stimuli have been sentences although monosyllabic words have been used and may be preferred by reducing redundancy. The rapidly alternating message is easily understood in normal listeners. Studies have shown that the RASP tests may not be sensitive to all brainstem lesions. Musiek (1983) and Lynn & Gilroy (1977) report only a small percentage of subjects showed abnormal results on this test.

Binaural Fusion

[13] Extract from A. Pruszewicza *Audiologia kliniczna*. 2003

These tests employ stimuli that have been filtered into two separate segments that are then presented simultaneously to the two ears of the subject. Generally, the filtering of the stimuli causes the stimuli to be unintelligible in one ear alone, but with the combined, filtered information from the other ear and assuming the auditory system is functioning correctly, the information is spectrally fused and recognition occurs. Stimuli most often used are monosyllabic words or spondees.

Monaural Low-Redundancy Speech Tests

Monaural low-redundancy tests have been used extensively in the evaluation of APD. These tests use stimuli that have been degraded, modified, or distorted in the frequency, temporal, or spectral domain to reduce redundancy. Because speech is so redundant, the normal listener can recognize speech even when parts are missing. However, subjects with central auditory dysfunction cannot easily recognize this modified speech.

Low-Pass Filtered Speech

Filtered speech reduces the redundancy of the signal. Several investigations have reported the use of low-pass filtered speech in assessing the auditory processing of subjects with intracranial lesions. Using various stimuli, (for instance: monosyllabic words, spondees, digits) and varying the frequency characteristics of the stimuli, as well as presentation levels, investigators have reported contralateral deficits in patients with temporal lobe lesions (Baran & Musiek, 1991; Bocca et al., 1954,1955; Hodgson, 1967; Jerger, 1960; Lynn & Gilroy, 1977; Musiek, Baran & Pinheiro, 1994). Subjects with interhemispheric pathway involvement have performed normally on filtered speech tests (Baran, Musiek, & Reeves, 1986; Lynn & Gilroy, 1977; Musiek & Chermak, 1994; Musiek, Pinheiro, & Musiek, 1985).

Time Compressed Speech

Compressed speech alters the temporal and frequency characteristics of the signal. Historically, the first compressed speech tests were accomplished by having the speaker read the passage faster or by increasing the playback speed of the tape recorder. Soon after, electromechanical alterations and later digital computer editing of natural speech were used to distort the temporal and frequency components of speech.

Speech-in-Noise

One of the most common characteristics of individuals with CAPD is the adverse effect of background noise on communication. There are many clinically acceptable ways to assess speech in noise, including different types of stimuli (monosyllabic words or sentences), different types of noise (white, speech, cafeteria, or babble), and different signal-to-noise ratios. Research indicates that linguistic materials (multi-talker speech babble background noise) are more effective maskers than speech spectrum noise, even though the frequency spectrum and amplitude may be similar .

Dichotic Speech Tests

Dichotic Speech Tests were first introduced in 1961 by Kimura. Different stimuli are presented simultaneously to the two ears. Kimura developed a model to describe how the central auditory nervous system processes dichotic stimuli. The contralateral pathways are more numerous; therefore, the contralateral pathway will be dominant. Dichotic speech tasks have employed a number of stimuli including digits, nonsense syllables, spondees, monosyllabic words, and sentences. These tests, as a group, are

reported to be sensitive to cerebral and interhemispheric compromise (Musiek, Kibbe, & Baran, 1984) and brainstem involvement (Katz, 1962; Jerger & Jerger, 1974; Keith, 1977; Musiek, 1983).

Competing Sentences

The Competing Sentences Test was developed by Willeford (1977). Individuals must attend to stimuli in one ear and ignore the competing message. Approximately fifty percent of subjects with central auditory nervous system (CANS) lesions had abnormal performance in the ear ipsilateral to the lesion whereas subjects with temporal lobe lesions showed contralateral deficits.

Staggered Spondaic Words (SSW)

Katz (1962) first described the Staggered Spondaic Word (SSW) test. This test consists of spondaic words that are presented dichotically in a staggered manner so that the second syllable of the first spondee is overlapped with the first syllable of the second spondee. This test has been shown to be sensitive to brainstem and cortical lesions. It has also been widely used with children.

Dichotic Digits

The Dichotic Digits Test (Musiek, 1983) is a dichotic test in which digits are presented simultaneously to both ears. Results of investigations using the dichotic digits indicate contralateral deficits in subjects with right temporal lobe lesions and bilateral or contralateral deficits in subjects with left hemisphere lesions. Left ear deficits have been reported in subjects with interhemispheric compromise and are more frequently reported than right ear deficits. This test is not highly linguistically loaded and is easy and quick to administer. One criticism of this test is that it offers no normative data, only cut-off ranges for normal and abnormal scores.

Dichotic CVs

Berlin & Lowe (1972) introduced Dichotic Consonant Vowel Test for central auditory nervous system assessment. Although this test is lightly linguistically loaded, it's difficult because of the similarity in the CVs (pa, ba, ta, da, ka, and ga).

Monotonic Tone Tests or Temporal Patterning Tests

Although temporal processes are critical in a number of auditory behaviors, there are limited clinical tests used to assess temporal processing abilities. These tests are based on the assumption that important acoustic signals such as speech vary over time. If a person is to extract meaning from these acoustic signals, the listener must be able to detect very small and rapid time variations. The most commonly used tests are the Pitch Pattern Sequence Test, or Frequency Pattern Test and Duration Pattern Test.

Pitch Pattern Sequence Test (PPST)

Pinheiro (1977) first reported the use of the Pitch Pattern Sequence Test to assess pattern perception and temporal sequencing skills. The tones consist of a low frequency tone and a high frequency tone. This test is "not designed to assess fine temporal acuity per set but rather to assess the listener's ability to perceive a pattern of auditory events occurring over time. Listeners are able to respond in three modes: humming, verbal or pointing to the correct sequence of "low-high" or "high-low" tones. Later learning-disabled individuals were reported as able to hum the correct response but did not do well in the verbal or pointing modes. Pinheiro found a

significant deficit in the ability of dyslexic children and a control group of normal children.

Duration Pattern Test
The Duration Pattern Test (Pinheiro & Musiek, 1985) is very similar to the Pitch Pattern Test. The frequency of the stimulus tones are the same, however, the duration of one of the tones is different from the other two. The listener must respond verbally, humming, or pointing to the correct sequence of "long" and "short" tones.

Gap Detection/ Auditory Fusion Test
Temporal resolution may also be investigated using gap detection thresholds. Gap detection reflects the ability of the auditory system to detect a brief silent interval in white noise. This test requires temporal fusion of the auditory system. Gap detection thresholds may be obtained by using the Random Gap Detection Test, Auditory Fusion Test-Revised. Investigators have found larger auditory fusion thresholds in children with language, learning, and reading disorders . Gap detection thresholds systematically decrease with increasing age from three to nine years (McCroskey & Keith, 1996). Gap detection thresholds remain stable throughout adulthood until the fifth decade of life, and then increase with age.[14]

4 Description of the Polish CAPD test battery NLA-93.

In Poland, there have been elaborated new ariticulation lists so far. They are called NLA-93. Into them can be classified following tests which assess Central Auditory Processing Disorders:
Auditory Pattern Temporal Ordering tests.
Monaural Low Redundancy Speech Tests assessing hearing sense, its disorders as well as temporal sequences in a process of hearing.

- filtered speech,
- hearing in noise,
- compressed speech.

Binaural tests (Binaural integration, Binaural separation [BIBS]) in order to assess the dominance of hemisphere.
Electrophysiologic tests (measurements), which evaluate operations within organ of hearing central part (P 300, Mismatch Negativity, BERA)[15].
Monaural Low Redundancy Speech Tests enable to make out a word and phrase with information, which exceeds the minimum needed to recognize them.
The phenomenon of redundancy characterize all natural languages, which is presented in following sample for the Polish language:

> Najcz_ściej je_nak n_ucz_ciele wysz_kują ju_ istniej_ce, sto_wne materia_y.

The fact that this sentence can be deciphered, though the lack of many letters, results in redundancy.

The examination by the usage of competing speech and tests with insufficient information is irreplaceable in cases of unchanged hearing of pure tones and seemingly unchanged speech intelligibility. It is particularly necessary in early diagnosis of some alterations within Central Nervous System[16].

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[14] Extract from etd.lsu.edu/docs/available/etd-04062004.../Hurley_dis.pdf

[15] Extract from *Otolaryngologii Polskiej* 2006 (3) article *Testy utrudnione w audiometrii mowy dla języka polskiego. Część I :przygotowanie materiału testowego.*

[16] Extract from *Otolaryngologii Polskiej* 2006 (3) article *Testy utrudnione w audiometrii mowy dla języka polskiego. Część I :przygotowanie materiału testowego*

Binaural (Binaural integration, Binaural separation [BIBS]) to which are included Dichotic Speech Tests demand a good short-term memory.
Dichotic Speech Tests facilitate assessing the lateralization and the efficiency of cognitive processes. Signal applied to the test characterizes of the same duration time. In the Polish Numeral Dichotic Tests was used a list containing 10 pairs of digits. Each digit from the same pair consisted of the same number of syllables. Mostly they were words of four and five syllables (disyllable pairs – 102 103, three syllable pairs – 14 15, six syllable pairs 79 99).
Two the most import ant rules, which were adhered to:

1) No digit appeared more the once in the given set,
2) Each of the given 10 pairs was presented in the same way, (exactly at the same place in the test and always to the same ear)[17].

In the Verbal Dichotic Tests the minimal pairs were used. (Minimal pair is a pair of word or phrase, for each language, which differs in one phoneme and have different meaning). So minimal pairs are pairs of words differ in eg. one sound – paczka , taczka – which keep their phonetic structure in other parts of word). For the Polish Verbal Dichotic Test the articulatory lists elaborated by A. Pruszewicz et al have been applied. In this test phonetically distinctive features differentiating Polish sounds have been considered such as:
a) variation of the tongue position in the oral cavity during the articulation, for instance:

i, y, e in pairs
– syn – sen
– ważny – ważni
e, a
– teczka – taczka
o, u
– Ola – Ula

b) variation of e, o vowels with their nasal equivalents ę, ą as well as considering differences only between nasal vowels ę, ą

– myję – myje
– kosa – kąsa
– widzę – widzą

c) variation between voiced consonants l, r likewise between them and nasal consonants m, n

– loczek – roczek
– maska – laska
– guma – góra

d) variation between particular voiceless plosives such as p, t, k and voiced ones b, d, g

– półka – bułka
– torba – korba
– duma – guma

e) variation between particular fricative voiceless sounds i f, s, sz, ś, h and voiced w, z, ż, ź

– łaska – ławka
– kosa – koza

[17] Extract from *Otolaryngologii Polskiej* 2006 (3) article *Testy utrudnione w audiometrii mowy dla języka polskiego. Część I :przygotowanie materiału testowego*

– szereg – serek

f) variation within the framework of affricates; between voiceless c, cz, ć and voiced dz, dż, dź as well as considering differences between affricates and fricatives such as s, sz, ś, ż, ź

– czubek – dzióbek
– bucik – budzik
– biegacz – biegać
– czapka – żabka
– praca – prasa
– zrobić – zrobisz

g) research on a perception of words which consist of consonants clusters

– rowy – krowy.

In the tests sound changes are considered at onset, nucleus and coda. While selecting minimal pairs for tests the attention is paid to the frequency of appearing words in the Polish Language .[18]Prepositions and conjunction were not considered in the test.

Basing on the Normal Calearo Test for the Polish language five sample words were suggested. Five sample word are given:

1. Teraz wiesz.
2. To nic nie znaczy.
3. To nic nie znaczy?
4. Jakie masz pragnienie?
5. To nie pragnienie, tylko konieczność.

(This test embraces rapidly alternating speech perception.) Proposed sentences were divided into open syllables ended with a vowel and closed syllables ended with a consonant. The shortest sentences consisted of three syllables, and the last one of ten syllable Sentences contain everyday speech.

5 Speech audiometry and its involvement in the CAPD investigations.

While diagnosing and rehabilitating CAPD a special attention should be paid to speech audiometry. At present speech audiometry is an integral world part of the audiologic tests necessary in assessing speech intelligibility. The main task of speech audiometry is to determine a level and character of hearing disorders[19].

Speech audiometry is used in recognising disorders of conductivity type, mainly as an additional tool completing other methods. However, it has more importance while diagnosing disorders of acceptance type especially in neuritic and central localization. Linguistic tests play an exteremly important part in an auditive rehabilitation, which includes:

1. adjusting hearing aid,
2. rehabilitation of patients with cochlear implants.

Speech audiometry in contrast to pure tone audiometry provides information about hearing impairments, which cause specified effects in speech recognition and constitute grounds of rehabilitation[20].

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[18] Extract from *Otolaryngologii Polskiej* 2006 (3) article *Testy utrudnione w audiometrii mowy dla języka polskiego. Część I :przygotowanie materiału testowego*

[19] Extract from A. Pruszewicza *Audiologia kliniczna. Zarys* 2003

[20] Extract from *Otolaryngologii Polskiej* 1994 (1) article *Nowe listy artykulacyjne do badań audiometrycznych. Część I*

Speech audiometry enables to establish a social efficiency with determining hearing impairment and speech recognition. It is also logic development of previously used acumetric tests, which involved speech in examinations. Its advantage is a possibility of transmitting information together with topodiagnostics as well as processing the information in the Central Auditory Nervous System (CANS).
While taking measurements and creating an articulation curve the following factors should be concerned:

- **Speech Detection Threshold SDT,**
- **Speech Recognition Threshold SRT,**
- **measure of hearing loss,**

width of the articulation curve.
In the 70s. in XX century, the specialist tests were being developed in the World. The tests enabled to precise interpretation of hearing examinations results. One of these elaborated tests was **SPIN-test** (Speech perception in noise) made for the English language. It is a test used to examine the speech understanding in noise in order to diagnose Central Auditory Processing Disorders.
Moreover, for the English and German language a set of **MAC lists** was prepared, which served to test speech perception of patients with cochlear implants. These sets facilitate hearing training which concerns every stage of speech perception development owing to special punctuation, which is applied here. MAC tests examine a speech perception at different levels:

1. At discrimination level, which includes:
   a) acoustic signals perception, which are not a speech,
   b) perception of segmental features (vowels identification in words and in commutation circuits),
   c) suprasegmental level: intonation perception, number of syllables, sentence stress, word stress.
2. At auditory associative level, which tests:
   a) discrimination of simple phrase,
   b) syntactically simple sentences.
3. At acoustic stimulus filtered level, which examines:
   a) speech recognition in background noise[21].

The early diagnosis of some alterations in Central Nervous System is applied in modified speech audiometry. It includes changing, distorted and compressed speech signal. To carry out an examination, the mostly used tests involve a time compressed speech (also called accelerated speech), which is distorted (regarding the pitch and volume), filtered and converted (which involves transmitting text alternately to the one ear and another). These tests are very interesting from the psychoacoustic viewpoint[22].

Within the framework of audiometric examinations and presentation of speech audiometry outcomes for every language there are concerned; individual phonetic and acoustic structure . Therefore, during the elaboration of tests the following factors are included:

- **representativeness**,

[21]Extract from A. Pruszewicza *Audiologia kliniczna. Zarys* 2003
[22]Extract from A. Pruszewicza *Audiologia kliniczna. Zarys* 2003

- **reproductiveness**,
- peculiar naturalness (tests for specific language).

The selection of proper linguistic tests depends on the goal of audiometric examination. Contemporary tests are prepared from the linear speech point of view. However, their shortcoming lies in an unfinished analysis of examination results which bases on a subjective evaluation of comprehending speech-essence by a patient and impedes an objective analyses of hearing disorders.
Nowadays in an audilogical examination are used:

- **threshold tests** (to assess the loss of speech comprehension),
- **discrimination tests** (to assess the loss of discerning phonemes).

In order to recognise speech the articulation test are involved also called threshold tests. Other tests called spondee tests contain simple sentences, numerals and multisyllable words (though with limited usefulness concerning possibilities of recognizing them by rhythmical and vocalic structure). They consist of evenly stessed words. The threshold tests have more practical application in rehabilitation for the organ of hearing. More useful in an audilogical evaluation become modified tests, also called auditory discrimination tests, which consist of monosyllable words with semantic, structural, and grammar balancing.
When diagnosing Central Auditory Processing Disorders very efficient become sentence tests, which contain diverse information material. The standardization of test material is impeded by various level of verbal signal complexity and language redundancy (which is determined on context ground, phonological, lexical and semantic knowledge). These tests consist of several syllable words, which are perceptually easy. The auditory discrimination tests contain the linguistic material which is composed of rarely used words, logatomes and monosyllables with intricate phonetic structure (eg. containing plosives) and words from professional jargon.

Considering the determination of sets; two types of tests are identified: closed and open ones. In open sets, likewise to natural verbal communication, unlimited statement can be coined, such a type of set is used to assess the speech intelligibility. When it comes to tests from closed sets, patient is informed, which words and phrases can be included in test composition. The closed set make analysis of wrongly recognised phonemes, their discrimination and randomization possible; which assures of painstaking examination. In open tests are usually applied sets of 10 -15 lists consisting of 20 -30 monosyllable and disyllable words. In closed, there are sets different in longitude lists applied. But audiomietric examination should not be long because of ear strain. As so to eliminate accidental errors a number of proper word units are applied, but set of linguistic elements once used cannot be applied once again in other intensity because of memory factor. Applied word lists must balance one another, it means that the same result of intelligibility should appear at the same determined intensity[23].

Carrying out the audiometic examination and its results depend on the manner of the acoustic test realization. Features coming out from the recorded voice and the technique of recording directly influence on the comprehension of passing word signals. Applying the synthetic speech in audiological examinations would be convenient for controling acoustic signal features. In this field, taking the Polish language into account, first experiment was conducted by Zakład Fonetyki Akustycznej Instytutu Podstawowych Problemów Techniki PAN and Kliniki Foniatrii i Audiologii w Poznaniu. Carried out research proved insufficient quality of synthetic speech. Moreover, it reached 78% intelligibility of isolated monosyllabic words, but it

[23] Extract from A. Pruszewicza *Audiologia kliniczna. Zarys* 2003

is not enough for reliable assessment of Central auditory Processing Disorders. Fluctuations of signal level cannot exceed 1,5dB. 45 dB is considered to be as an enough signal gap from noise. The audiometric examination should concern the choice of methods for:

- test strategy,
- manner of presentation,
- registration of test results.

Tests can be administered according to procedures, which are grouped into fixed – level and adaptative methods. Within the fixed-level method of examination articulation lists are given to listen under determined scheme, but the answer of the listener has no impact on the process of test. Within the adaptative strategy, the manner of examination depends on patient reaction. In classical audiometric examination mostly fixed-level strategy is applied[24]. Earlier established linguistic and acoustic specification of the test and the technique of carrying out examinations influence on credibility of audiometric examination results. To each test construction its evaluation unit is matched, for instance in classical audiometry there is determined a number of correctly recognised words and sentences.

In specialist tests, it is possible to evaluate: phonemes, syllables and key words. To make the audiometric examination comfortable the established forms of registering results are considered. Recognised units can be repeated, written down or shown. Subjective way of evaluating test, which reveals the rate of linguistic material intelligibility by listener, possesses following features:

a) assures a fast evaluation of speech comprehension – to initial assessment 3 s are enough; whereas the objective one needs several minutes,
b) facilitates testing of linear speech; whereas objective one is usually composed of isolated words,
c) considers speech comprehension – estimates perception of speech extracts, which are understandable; whereas objective method demands rehearsals of word without their understanding.

The objective method of assessing results, mostly used in speech audiometry, has following features:

a) precision of the examination,
b) analyses accuracy of wrong recognitions,
c) objectivity of results interpretation[25].

6 Sample tests for the Polish language (based on materials given in the references).

In the end, perception tests are still being elaborated in Poland as well as in the World, thus in conclusion some sample test for the Polish language are suggested (based on lisa. Mendel and Jeffrey L. Danhauer publication titled *Audiologic evaluation and management and speech perception assessment*):

Stressed and Unstressed Word Test (Monosyllable –Trochee –Spondee)
Note: test bases on an American version of MTS. The lack of specified carrier phrase. Test for children, who are aware of their language, even though words

[24] Extract from A. Pruszewicza *Audiologia kliniczna. Zarys* 2003
[25] Extract from A. Pruszewicza *Audiologia kliniczna* 2003

should be short and appropriate to their age it is a visual test, thus words should be simple and easy in denoting the reality eg. word „krzesło" (chair).
Purpose: to assess closet-set word identification in children with hearing impairments using words.
Stimuli: 12 words each set; four each Tyree stress categories, each four differ in vowel information presented twice in random order. For the polish language the number of syllable should be enlarged. However, words should be mixed: monosyllabic word disyllable words and three syllable words, the attention in this case should be paid at first.
Format: closed – set 12 items overall.
Target group: children four years -old (some range of vocabulary is demanded).
Sample set:

Tabela 1	Tabela 2	Tabela 3	Tabela 4
piłka półka gałka wąs	serce palec lok głowa	głowa brzuch krzesło ręka	bilet miód smok latawiec
lalka bułka ser potok	mucha koc lilia myszka	drzewo lista jabłko stół	barka kolej samolot dar
lot pralka beczka kupon	sok zima lato marzec	bułka tory śnieg zęby	miś koło zima deska

Synthetic Sentence Identification

Note: test bases on the American version of SSI. The carrier phrase is not specified. The sample test is made for children, thus the cohesion and coherence of question should be considered. The difficulty of the test appears in its preparation, because of illogical sentence structure, which has no reflection in reality. The artificial sentence test despite of its illogic should preserved forms of sentence (the position of subject, verb, object).
Purpose: to determine correct identification of sentences rather than repetition.
Stimuli: 24 10-sentence massage sets; artificial sentences created by selecting each successive words on the basis of conditional probabilities on preceding word(s); first, second and third order approximation used; sentences are five to nine words in length; three separate forms for each sentence length were constructed.
Format: closed message set with ten alternatives.
Sample set:

SET No 1

1) Duży ślimak z rowerem jadł.
2) Zbudowali zamek bez zegarka prawie.
3) Dalej pójdziesz z kwiatem sam na spacer.
4) Zajączkowi Janek górę jutro kupił.
5) Prawie Staś nad morzem dzisiaj padł.
6) Wiał z domem deszcz cały i zdrowy zając.
7) Kot gonił tenis w parku szybko Jaś.
8) Uciekł nad domem wiatr w nosie.
9) Pod prąd Mama siano wisi.
10) Z Adasiem klops pojutrze tak groźnie trwa.

SET No 2

1) Chomikowi wczoraj wolno Dominik siadł.
2) Okno nad górą dał Krzyś.
3) Widział kwiatek Jasiowi w górach Adaś śpiewał.
4) Lew skromnie ze słoniną całkowicie chleb brał.
5) Za targiem położyła jutro sosnę prawie Kasia.
6) Dla Ani deszcz pod mostem grał.
7) Kradł za 2 złote żubr zupełnie stary.
8) Bulwarem słonik morski motor sterował.
9) Za lasem pił wczoraj czerwony smok ogień.
10) Jak małpa się w nos opluł przedwczoraj poseł.

References:

Bystrzanowska T.: *Audiologia kliniczna*. Wyd. III, PZWL, Warszawa, 1978

Demenko G.: *Analiza cech suprasegmentalnych języka polskiego dla potrzeb technologii mowy. Rozprawa habilitacyjna*. Wydawnictwo UAM, Poznań 1999

Grabias S.: *Zaburzenia mowy*. Lublin 2001/02 wydaw. UMSC Zakład Logopedii i Językoznawstwa Stosowanego,

Greenberg S.: *Speech processing in the auditory system*. New York 2004 wydaw. Springer,

Imiołczyk J.: *Prawdopodobieństwo subiektywne wyrazów. Podstawowy słownik frekwencyjny języka polskiego*. Polska Akademia Nauk, Instytut Podstawowych Problemów Techniki PWN, Warszawa, 1987

Iwankiewicz S.: *Audiometria mowy*. Otolaryngologia Polska 1961; 15

Jassem W.: *Mowa a nauka o łączności*. Warszawa: PWN 1974

Jassem W.: *Polskie listy wyrazowe ze zrównoważeniem fonetycznym i częstościowym*. Technologia Mowy i Języka, Polskie Towarzystwo Fonetyczne, Poznań, 1971

Kathleen Campel: *Essential auditory for physician*. wydaw. Singular San Diego London, 1998,

Knychalska-Karwan Z.: *Język: fizjologia i patologia*. Kraków 2000 wydaw. Uniwersytet Jagielloński,

Kollmeier B.: *Moderne Verfahren der Sprachaudiometrie*. wydaw. median-verlag von Kilisch-Horn GmbH 1992.

Kowalikowa J., Żydek-Bednarek U.: *Współczesna polszczyzna*. wyd. 1996

Kubiak S.: *Zarys higieny narządu głosu*. wydaw. Wyższa Szkoła Humanistyczno-Ekonomiczna, Wocławek 2006,

Kurcz I., Lewicki A., Sambor J., Szafran K., Woronczak: *Słownik frekwencyjny polszczyzny współczesnej*. Polska Akademia Umiejętności, Instytut Języka Polskiego, Kraków 1990

Latkowski J. Bożydar: *Poradnik dla protetyków słuchu*. wyd. Mamos Sp. z o.o. Łódź 2002,

Łobacz P.: *Polska fonologia dziecięca; studia fonetyczno-akustyczne*. Warszawa 1996 wydaw. Energia,

Łobacz P.: *Psychometric Classification of Phones – Some Metodological Considerations*. Lingua Posnaniesis, 1991

Łobacz P.: *O percepcji klasyfikacji raz jeszcze. Eufonia i Logos*. Wydawnictwa Uniwersytetu Adama Mickiewicza, Poznań, 1995

Martin Micheal: *Speech Audiometry*. wydaw. Singular San Diego London, 1997

.Mendel Lisa L, Danhauer Jeffrey L.: *Audiologic evaluation and mangement and speech perception assessment*. wydaw. Sigular San Diego London, 1997

Mihilewicz S.: *Zaburzenia przetwarzania słuchowego u dzieci z porażeniem mózgowym*. Wrocław 2003 wydaw. Uniwersytet Wrocławski,

Musiek Frank E.: *Neuroaudiology case studies*. wydaw. Singular San Diego London, 1994

Musiek Frank E., Chermak Gail D.: *Handbook of (Central) Auditory Processing Disorder, volume 1, Auditory Neuroscience and Diagnosis*. wydaw. Plural Publishing, San Diego, Oxford, Brisbane 2007,

Ozimek E.: *Dźwięk i jego percepcja: aspekty fizyczne i psychoakustyczne*. Wydawnictwo Naukowe PWN ,Warszawa, Poznań 2002,

Piela R., Dukiewicz L.: *Szczegółowe badania wyrazistości i rozróżnialności głosek polskich w różnych warunkach przenoszenia*. 1962

Pruszewicz A.: *Audiologii klinicznej. Zarys*. wydanie 3 poprawione , Poznań, 2003, wydaw. Akademia Medyczna,

Pruszewicz A.: *Foniatria kliniczna*. PZWL, Warszawa, 1992

Pruszewicz A., Obrębowski A..: *Wyrazistość i rozróżnialność głosek testu jednosylabowego dla dzieci*. Otolaryngologia Polska, 1970; 24: 4

Pruszewicz A., Demenko G., Richter L., Wika T.: *Nowe listy artykulacyjne do badań audiometrycznych*. Otolaryngologia Polska

Rhaw, Baltimore: *Neuropsychiatry, neuropsycholgy and clinicalneuroscience: emotion, evolution, cognition, language, memory, brain damage and abnormal behaviour*. wydaw. Wiliams and Wilkins, 1996

Steffen M.: *Częstość występowania głosek polskich*. Biuletyn Polskiego Towarzystwa Językoznawczego 1957

Steffen M. :*Polskie testy do badań nad wyrazistością i zrozumiałością mowy*. Przegląd Telekomunikacyjny 1962

Styczek I.: *Badanie i kształtowanie słuchu fonematycznego*. Wydawnictwo Szkolne i Pedagogiczne, Warszawa,

Suzuki J., Kobayashi T., Kogo K.: *Hearing impairment: an invisible disability*, wydaw. Springer, Tokyo 2004

Szmeja Z., Pruszewicz A., Dukiewicz K.: *Metoda masowego wstępnego badania słuchu dzieci szkolnych audiometrią słowną* Otolaryngologia Polska 1963; 17: 4

Śliwińska -Kowalska M., Bochnia M., Orębowski A.: *Audiologia kliniczna*, wydaw. Mediton, Łódź, 2005

Taniewski J., Kugler R., Wysocki Z.: *Audiometria słowna mową polską*. Otolaryngologia Polska 1961; 15: 131

Tarkowski Z., Jastrzębska G.: *Człowiek wobec ograniczeń; niepełnosprawność, komunikowanie, diagnoza, terapia*. Warszawa 2002 wydaw. Fundacja Orator,

Wyburz G.M.: *Zmysły i odbiór wrażeń przez człowieka*. Warszawa 1970, wydaw. Państwowe Wydawnictwo Naukowe,

Wojnowski W., Obrębowski A., Pruszewicz A., Demenko G., Wiskirska-Woźnica B., Wika T., Komar D.; *Testy utrudnione w audiometrii mowy dla języka polskiego* Otolaryngologia Polska 2006, LX (3):385-390,

Zakrzewski A., Suwalski W., Antkowski F., Suwalski J.: *Próba ustalenia list fonetycznie zrównoważonych dla badania słuchu przy pomocy prób artykulacyjnych*. wyd. 1953,

Zakrzewski A., Pruszewicz A., Kubzdela H.: *Nowe listy artykulacyjne zrównoważone fonetycznie i strukturalnie*. Otolaryngologia Polska, 1971, 25, 3

Zakrzewski A., Jassem W., Pruszewicz A., Obrębowski A.: *Identification and discrimination of speech sounds in monosyllabic meaningful words and nonesense words by children*. Audiology 1975; 14: 21

Zakrzewski A., Jassem W., Pruszewicz A., Obrębowski A.: *Speech audiometry for children and subjective probabilisty of Polish words*. Audiology 1976; 15: 228

1. dokumenty.ifps.org.pl/senderski2.pdf.
2. sound.eti.pg.gda.pl/student/pp/pomiary–5%B3uchu.pdf.
3. annales.amg.gda.pl/attachment/attachment/408/14-an36-Przewozny.pdf.
4. www. wypadek.pl/body/definicje/ucho/ucho.htm-9k
5. www. ichs.pl/2132dhtml?l=B-19k
6. www. emedyk.pl/artykul.php?idartykul-rodzaj=72&idartykul=1355-46k
7. etd.lsu.edu/docs/available/etd-04062004…/Hurley_dis.pdf