The Investigation of the Disintegration of Phonemic Discrimination on a Perception and Production Level in Adults with Aphasia*

J. LEVINSOHN, B.A. Log. (Rand)

It has been established for some considerable time that the role of audition in learning to speak is extremely important. The perception of auditory stimuli determines the child's ability to understand as well as to produce speech. Cherry[14] suggests that speech perception (i.e. understanding) and speech production, are the same phenomenon in the normal individual. Schuell, Jenkins and Jiménez Pabón[15] go one step further and show how the auditory mechanism is also responsible for monitoring speech. The authors conceive of the language system as being dependent on the auditory system for processed information and regulation and control, mediated through feedback loops.

The perception and production of speech sounds are based on the discrimination between the essential (phonemic) signals and the non-essential signals which are determined by the linguistic signals to which the child is exposed — this process is carried out by the auditory mechanism. (Bauman[1]).

Luria[12] explains that the *auditory-articulatory* system is responsible for learning of discrimination between speech sounds, which enables the individual to understand and produce speech. The link between perception and production in the normal person's language ability is stressed by Luria:

> The pronunciation, i.e. the articulatory structure of words, takes place on a basis of phonemic hearing: however, the articulation of sound itself plays an active role in the formation of phonemic hearing.

Modern investigators, basing their evidence mainly on clinical observation, show that it is this auditory mechanism that breaks down in the aphasic (Ebbin[2]). Schuell[15] considers an auditory impairment to be basic to the aphasic's difficulty and concludes from a study on fifty-six aphasics that there is always some impairment of auditory processes in aphasia. She clarifies the nature of the auditory breakdown by explaining that the aphasic patient is unable to retain an auditory configuration or to summon it when required, i.e. there is a breakdown in the process of reauditorization.

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Guttman,[4] Street,[18] Miller[13] and Karlin et al[8] show, through experimentation, that some auditory impairment existed in the aphasic subjects tested.

Eisenson[3] uses Luria's explanation of the auditory analyser (situated in the secondary division of the auditory cortex of the left cerebral hemisphere) to explain that the process of auditory perception is not merely a passive receiving of stimuli but includes the analysis and integration of these stimuli. Thus it has efferent as well as afferent functions. The auditory analyser is *closely associated with the cortical apparatuses of the kinesthetic (articulatory) analysis.*

It has so far been established that:

(a) audition is vital in the normal individual's understanding and production of speech;

(b) many investigators feel an auditory disorder to be basic to the aphasic's language breakdown;

(c) neurological findings confirm the link between perception and production both structurally and functionally.

It seems feasible to postulate that dividing the aphasic's symptoms into those of understanding speech and those of producing speech is artificial, thus the receptive-expressive classification of aphasia is questioned. It seems possible that both receptive and expressive symptoms exhibited by the aphasic involve an auditory dysfunction. It has been felt for a number of years that some aspect of hearing accounted for receptive problems. Wernicke's sensory aphasia was based on a loss of normal auditory control and Kleist's word-sound-deafness occurred when the patient failed to appreciate speech sounds. It is only recently, that an imperfect auditory process has been used to explain the aphasic's *expressive* problems. Keenan[9] shows that where the auditory stimuli of language cannot be retained, both understanding and expression of language become impaired. Thus *receptive* and *expressive* language impairments are not different forms of aphasia, but rather different manifestations of one underlying impairment.

If audition is basic to the aphasic's problem of expression, and if the auditory perception centre and the articulatory centre are closely related, the articulatory errors made by an aphasic subject should be similar to his errors in the perception of phonemes, i.e. the phonemic disintegration shown by an aphasic subject should be the same on a perceptual (intake) and production (output) level. On this hypothesis the following experiment was carried out.

Procedure

Subjects. Seven aphasic subjects were used in the experiment. They formed a fairly representative sample as the major variables of sex, age, educational level and economic standing were represented. As one test required standardization on a normal population, six 'normal' subjects were also used and were chosen so as to represent the variables mentioned above.

Aphasic Subjects.

S	A	B	C	D	E	F	G
Sex	F	M	M	M	M	M	F
Age	28	52	38	30	60	67	20
Education	St. 8	Univ	Univ	Univ	Matr	Matr	Matr
Economic Level ...	L	U	U	M	LM	M	UM

Normal Subjects.

S	A	B	C	D	E	F
Sex	F	M	F	F	M	M
Age	21	19	45	60	44	58
Education	Univ	Univ	St. 8	Matr	Matr	Univ
Economic Level ...	U	M	LM	U	L	M

Abbreviations:

Univ: University education
U: Upper income group
M: Middle income group
L: Lower income group
UM: Upper-middle income group
LM: Lower-middle income group
F: Female
M: Male.

Tests Used. A battery of tests was given to each aphasic subject:
(a) Hildred Schuell's *Short Examination for Aphasia.*[15] This was used to determine whether the subject was aphasic and, if so, what type.

The following aspects of language were examined:

(i) Auditory: this includes tests of auditory recognition, retention span and comprehension.

(ii) Reading: tests of visual and auditory word recognition and reading comprehension were included.

(iii) Speech and Language per sé: here tests of cranial nerve involvement, sensorimotor involvement and functional speech were included.

(iv) Writing: the subject was tested on revisualization, spelling and functional writing.

The scores obtained by the subjects determined to which of the five groups they belonged. Schuell states: *Probably 90% of aphasic patients fall into one of the five main groups, when classified according to pattern of impairment.*

Schuell offers the following explanation for each of the five groups:

Group (i): this is characterized by an almost total loss of all language functions.

Group (ii): only auditory processes are impaired, but the impairment is reflected in defective speech, reading and writing.

Group (iii): shows the same pattern as Group (ii) but is complicated by specific visual impairments.

Group (iv): there is an involvement of auditory and sensorimotor processes.

Group (v): scattered auditory, visual and motor (usually cranial nerve) impairment compatible with generalized brain damage is found. Some language is usually retained.

(b) Pure-tone audiometry. According to the specific hypothesis of this study, tests were needed which would determine the subject's hearing acuity, thus enabling the experimenter to establish whether phonemic errors, if present, were caused by a hearing loss or a perceptual problem. Thus an audiometer was used to establish the subject's threshold of detection for pure-tones. This was also necessary as a control measure. Knowledge of the subject's pure-tone threshold would enable the experimenter to compare this with the speech reception threshold and the speech discrimination results, and establish whether there was any similarity.

(c) Audiometric Speech Reception Thresholds: This test establishes the threshold at which a subject is just able to hear speech. This is essential as it must be known whether the words in a phonemic discrimination test were inaccurately perceived or merely not heard.

(d) Phonemic discrimination perception test. The Hutton, Curry and Armstrong Semi-Diagnostic Test[6] was used. This particular test was chosen as it appears to be well standardized, includes discrimination between vowels as well as consonants, and the words used are

fairly common ones. The purpose of a perception speech discrimination test in this study is to establish the aphasic's ability to distinguish between the phonemes presented aurally. The subject was required to mark off on a sheet of words grouped in fours, the stimulus word e.g. bowl, bail, ball, bull formed one group, and *bowl* was the stimulus word.

(e) Phonemic Discrimination Production Test. The Schuell Picture Test for consonants and the picture test for vowels were used.[15] Both tests consist of a series of pictures. Each card contains two pictures and the names of the pictures differ from each other by one phoneme only; i.e. the names are minimal pairs, e.g. *pea* and *bee*. These form one series of the consonant test and *shed* and *shared* form one series of the vowel test. From these tests, the aphasic's ability to distinguish between phonemes aurally was assessed.

(f) It was considered interesting to note whether the hypothesis could be extended to include discriminations produced in spontaneous speech. Thus, a sample of each subject's speech was recorded and errors transcribed.

An attempt was made to keep the testing procedure standard for all subjects. The physical environment, instructions and rest periods were similar for each subject. Each subject was tested over two sessions to avoid fatigue, and the order of test presentation was constant. A two-room set-up was used for the phonemic-perception discrimination test.

Results

(a) The results of *normals* on the vowel discrimination test: all subjects were able to discriminate adequately between the phonemes presented by the pictures.

(b) Results of the shorter Schuell Test: all seven subjects showed aphasic symptoms, and could be classified into one of the five Schuell groups. As can be seen all groups, except Group one, were represented.

Subject	*Schuell Group*	*Summary of Symptoms for each group*
A	2	Only auditory processes impaired
B	4	Involvement of auditory and sensorimotor processes
C	5	Scattered auditory, visual and motor impairment
D	3	Auditory processes impaired plus specific visual involvement
E	3	As D above
F	2	Only auditory processes impaired
G	2	As F above

(c) Results of Hearing Tests:

SUMMARY TABLE OF EACH SUBJECT'S AUDIOGRAM, AVERAGE LEVEL OF SPEECH RANGE AND SPEECH RECEPTION THRESHOLD.

S	*Age*	*Pure-tone hearing*	*Average intensity for speech range*		*Speech reception threshold*	
A	28	Right ear: Normal	Right ear:	8 dB	Right ear:	5 dB
		Left ear: Normal	Left ear:	8 dB	Left ear:	0 dB
B	52	Right ear: 8000 cps at 25 dB	Right ear:	0 dB	Right ear:	0 dB
		Left ear: Normal	Left ear	2 dB	Left ear:	0 dB
C	38	Right ear: 8000 cps at 50 dB	Right ear:	3 dB	Right ear:	0 dB
		Left ear: 8000 cps at 40 dB	Left ear:	13 dB	Left ear:	10 dB
D	20	Right ear: Normal	Right ear:	7 dB	Right ear:	0 dB
		Left ear: Normal	Left ear:	3 dB	Left ear:	0 dB
E	60	Right ear: 4000 cps at 40 dB 8000 cps at 50 dB	Right ear:	7 dB	Right ear:	0 dB
		Left ear: 4000 cps at 45 dB 8000 cps at 70 dB	Left ear:	8 dB	Left ear:	10 dB
F	67	Right ear: 4000 cps at 50 dB 8000 cps at 55 dB	Right ear:	13 dB	Right ear:	35 dB
		Left ear: 4000 cps at 55 dB 8000 cps at 65 dB	Left ear:	32 dB	Left ear:	40 dB
G	21	Right ear: Normal	Right ear:	1 dB	Right ear:	10 dB
		Left ear: 4000 cps at 25 dB 8000 cps at 50 dB	Left ear:	26 dB	Left ear:	25 dB

Five out of seven subjects showed normal bilateral hearing. The remaining two showed a unilateral loss in the left ear with a conductive-type loss for the speech frequencies. One could, therefore, expect almost a 100% speech discrimination score for all the subjects.

Four out of seven subjects showed a sensori-neural type of loss in the high frequency range. It seems unlikely that this is caused by presbycusis as the mean age of the subjects showing this was forty-six years. Also, as the case histories of the subjects do not reveal any possibility of a noise-induced loss, it was hypothesized that the loss was the result of the aphasic condition rather than any specific auditory disorder.

The subjects showed a lower hearing threshold for pure-tones than for speech. This points to cortical pathology (which is known in these subjects) and also the possibility of speech discrimination difficulties.

(d) Similarity between phonemic discrimination on a perception and a production level was shown.

SUMMARY OF THE SIMILARITY BETWEEN PHONEMIC DISCRIMINATION ON A PERCEPTUAL AND PRODUCTION LEVEL.

Subjects	*Error Patterns observed in Perception Test Results*	*Error Patterns observed in Production Test Results*	*Errors and Error Patterns observed in Perception and Production Test Results*
A. Consonants	1. Lack of discrimination between homologous pairs. 2. Breakdown in front-back contrast. 3. Breakdown in tip-alveolar and tip-dental contrast.	1. Lack of discrimination between homologous pairs. 2. Breakdown in front-back contrast. 3. Misarticulation of blends.	1. Inability to perceive and produce /t/; /n/. 2. Lack of discrimination between homologous pairs. 3. Breakdown in front-back contrast.
Vowels	1. Breakdown in ,/3/ : /a/ distinction. 2. Breakdown in /e/ : /3/ distinction.	1. Breakdown in long-short contrast.	1. Lack of discrimination between /u/ and /uh/. 2. Inability to perceive and produce /u/.
B. Consonants	1. Lack of discrimination between nasals. 2. Lack of discrimination between homologous pairs. 3. Lack of discrimination between tip-alveolar and bilabial consonants. 4. Breakdown in front-back contrast.	1. Lack of discrimination between homologous pairs. 2. Inaccurate production of nasals. 3. Breakdown in voiced-voiceless contrast. 4. Breakdown in front-back contrast 5. Misarticulation of blends.	1. Inability to discriminate between /l/ and /n/ and also between /m/ and /n/. 2. Inaccurate discrimination of /ɔ/. 3. Inability to perceive and produce /b/. 4. Inaccurate perception and production of nasals. 5. Lack of discrimination between homologous pairs. 6. Breakdown in front-back contrast. 7. Confusions between phonemes of the same class.

SUMMARY OF THE SIMILARITY BETWEEN PHONEMIC DISCRIMINATION ON A PERCEPTUAL AND PRODUCTION LEVEL.

Subjects	*Error Patterns observed in Perception Test Results*	*Error Patterns observed in Production Test Results*	*Errors and Error Patterns observed in Perception and Production Test Results*
Vowels	1. Breakdown in long-short contrast. 2. Breakdown in vowel + length — vowel + glide contrast.	1. Breakdown in long-short contrast. 2. Breakdown in vowel + length — vowel + glide contrast.	1. Breakdown in long-short contrast. 2. Breakdown in vowel + length — vowel + glide contrast.
C. Consonants	1. Inaccurate perception of nasals. 2. Lack of distinction between plosives. 3. Lack of discrimination between phonemes of the same class.	1. Lack of discrimination between phonemes of the same class.	1. Lack of discrimination between phonemes of the same class.
Vowels	No errors made in vowels.	2. No errors made in vowels.	No vowel errors made on Perception and Production Test results.
D. Consonants	1. Breakdown in tip-alveolar bilabial contrast. 2. Lack of discrimination between homologous pairs.	1. Breakdown in tip-alveolar-tip dental contrast. 2. Lack of discrimination between homologous pairs.	1. Breakdown of voice-voiceless dichotomy. 2. Lack of discrimination between homologous pairs. 3. Tip-dental consonants poorly discriminated from other consonants.
Vowels	1. Breakdown in long-short contrast. 2. Poor discrimination between central vowel and others.	1. Breakdown in long-short contrast.	1. e/ɜ occurred on both perception and production test results. 2. Breakdown in long-short contrast.

SUMMARY OF THE SIMILARITY BETWEEN PHONEMIC DISCRIMINATION ON A PERCEPTUAL AND PRODUCTION LEVEL.

Subjects	*Error Patterns observed in Perception Test Results*	*Error Patterns observed in Production Test Results*	*Errors and Error Patterns observed in Perception and Production Test Results*
E.	1. Breakdown in front-back contrast.	1. Breakdown in front-back contrast.	1. p/b occurred on both perception and production test results.
Consonants	2. Breakdown in bilabial-tip-alveolar contrast.	2. Breakdown in voice-voiceless contrast.	2. Inability to perceive and produce /b/; /t/; /v/.
	3. Breakdown in tip-alveolar labiodental contrast.		3. Breakdown in front-back contrast.
Vowels	1. Poor perception of complex nuclei.	1. Breakdown in short-long contrast.	1. Inability to perceive and produce /ɜ/.
	2. Lack of distinction between /æ/ and other vowels.	2. Substitution of high for mid vowels.	2. Poor perception of complex nuclei.
		3. Poor perception of complex nuclei.	
F.	1. Inaccurate perception of nasals.	1. Lack of discrimination between homologous pairs.	1. Inaccurate perception and production of /d/; /ɔ/; /p/.
Consonants	2. Lack of distinction between sibilants and other consonants.		
	3. Substitution of /t/ for plosives.		
Vowels	1. Inaccurate perception of simple vowels + length.	1. Inaccurate articulation of /e/.	
	2. Poor perception of /æ/.		None.

SUMMARY OF THE SIMILARITY BETWEEN PHONEMIC DISCRIMINATION ON A PERCEPTUAL AND PRODUCTION LEVEL.

Subjects	*Error Patterns observed in Perception Test Results*	*Error Patterns observed in Production Test Results*	*Errors and Error Patterns observed in Perception and Production Test Results*
G.	1. Breakdown in tip-alveolar-bilabial contrast.	1. Breakdown in front-back contrast.	1. The following substitutions occurred in both test results: b/d; r/v; p/t.
Consonants	2. Lack of discrimination between homologous pairs.	2. Breakdown in tip-alveolar : labio-dental contrast.	2. Lack of discrimination between /l/ and /r/.
	3. Breakdown in tip-alveolar : labio-dental contrast.	3. Breakdown in tip-alveolar : bilabial contrast.	3. Breakdown in tip-alveolar : labio-dental contrast.
	4. Breakdown in front-back contrast.	4. Lack of discrimination between homologous pairs.	4. Breakdown in tip-alveolar : bilabial contrast.
			5. Lack of discrimination between homologous pairs.
			6. Breakdown in front-back contrast.
Vowels	1. Poor perception of /3/ and complex nuclei containing /3/.	1. Inaccurate production of complex nuclei /ih/.	1. The following substitutions occurred in both test results: ih/e; 3w/uh; oh/3w.

Discussion

(a) Intra-subject responses on perception and production levels tended to be related. This was seen either as the same substitution of one phoneme for another on the perception and production tests or as a trend or error pattern observed in both tests (e.g. a breakdown in front:back contrast of consonants).

The degree of similarity differed for each subject and although all showed some phonemic breakdown which existed on both the input and the output levels, all subjects but one also showed phonemic breakdown on one level and not on the other. However, owing to the limitations of the tests used (to be discussed more fully later) although the results do not support the hypothesis fully, neither do they negate it.

(b) Little similarity existed between phonemic errors in isolation and in spontaneous speech.

(c) A number of relevant factors, not specifically related to the hypothesis, were noted:

(i) The subjects' phonemic errors were not random and inconsistent but followed a phonemic trend or pattern. This is in accordance with Schuell's results.[15]

(ii) There was a strong similarity between auditory-type aphasic symptoms and phonemic discriminatory ability.

(iii) The severity of the aphasia seemed closely linked to the degree of phonemic breakdown.

Diagnostic and Therapeutic Implications

(a) A full audiometric assessment should be one of the tests used for testing aphasics.

(b) If some form of auditory breakdown is evident in all aphasic patients it is likely that other cases of cerebral dysfunctioning also have neural auditory impairments.

(c) If auditory perception and speech production are linked, auditory training with patients should be done. Accurate listening and phonemic discrimination should aid speech production and influence the use of language.

Limitations and Evaluation of Study

(a) Only seven aphasic subjects were used in the experiment. It is impossible to draw conclusions and generalize test findings based on so small a sample.

(b) The scope of the study did not allow the author to draw up identical tests of phonemic discrimination for perception and production. Factors such as the phonetic environment of the phoneme being tested and the fact that blends were included in the perception test but not in the production test, reduce the reliability of the tests used.

(c) As aphasics are known to show perseveration difficulties it is possible that a repeated response was noted as a phonemic error.

(d) As the phonemic discrimination tests demanded a word-naming ability, it was difficult to discriminate, with some subjects, whether the difficulty was one of word-naming or of phonemic breakdown.

(e) One cannot state definitely that the disintegration of phonemic discrimination was the result of a cortical or a retrocochlear disorder.

(f) The fact that little similarity was shown between perception and production test results and spontaneous speech can be attributed to the fact that the samples of speech elicited were inadequate as they were too short.

Implications for Research

(a) The results of this study as well as experimental evidence and clinical observation seem to indicate that auditory impairment may be the core of most aphasics' difficulties. However, the exact nature of how audition affects or causes other aphasic symptoms is not understood. In terms of the particular symptom analyzed in this study, further experimentation is needed to determine the relationship between auditory perception and a breakdown in phonemic discrimination on an articulatory level.

(b) It is extremely important to establish at what level of auditory perception the aphasic breakdown occurs. Hirsch,[5] offers four levels of perception:

(i) Detection. This is the threshold at which sound is just heard.

(ii) Discrimination. The listener compares one speech sound with another.

(iii) Recognition or identification. The listener compares incoming sound stimuli with his memory of sounds and words.

(iv) Comprehension, i.e. *Recognition sustained over a long period of time.*

The testing of an aphasic patient on these four levels would also test the functioning of the *auditory analyser* (a term used by Luria[12]) to note whether the auditory defect was one of analyzing, comparing, or synthesizing received auditory stimuli.

(c) All subjects in this study showed some degree of phonemic breakdown. Does this breakdown mirror the child's acquisition of phonemic discrimination? Jakobsen and Halle[7] state: *the linguistic, especially the phonemic, progress of the child and the regression of the aphasic obey the same laws by implication.* If this were indeed so, one could determine the aphasic's level of phonemic disintegration and assign this to the particular developmental level of phonemic competence of the child. Therapy would aim at teaching the aphasic the next and following stages through which the child normally progresses.

Summary

As more stress is being placed on the auditory disability of aphasics, the validity of dividing aphasic symptoms into expressive and receptive disorders is queried. The reflex-arc seems too simple a configuration to explain the complex functioning and breakdown of language. It is postulated that the auditory disorder is basic to aphasic symptoms on the level of understanding as well as that of production of language. Thus, if an aphasic patient shows a breakdown in the perception of phonemes, it seems likely that the auditory imperception will affect the production of the same phonemes. Aphasic subjects were presented with tests of phonemic discrimination on a perceptual and a production level and the similarity of phonemic errors was noted.

The results of the experiment seemed to indicate that a hearing loss did not account for the subject's phonemic disintegration. However, it was not possible to control certain factors thus this result is not conclusive.

The similarity between errors on an input level and those on an output level was poor, according to the result of the perception and production tests used in the study. However, despite the inadequacies of the tests used, all subjects showed some degree of similarity and this tends to support the hypothesis. The errors in phonemic

discrimination indicated by both perception and production tests were not random and inconsistent, but followed a trend.

It was noted that the severity of the aphasic symptoms seemed closely linked with the degree of phonemic breakdown. Also, the subjects tested showed a significant similarity between auditory-type aphasic symptoms and phonemic discriminatory symptoms. Little similarity existed between phonemic errors in isolation and in spontaneous speech.

Opsomming

Aangesien meer klem geplaas word op die ouditiewe onvermoë van afasie gevalle, word die geldigheid van 'n verdeling van afatiese simptome in ekspressiewe en reseptiewe versteurings in twyfel getrek. Die refleksboog blyk 'n té eenvoudige konfigurasie te wees om die komplekse funksionering en afbraak van taal te verklaar. Dit word veronderstel dat die ouditiewe versteuring onderliggend is aan afasie simptome op die vlak van begrip asook op die vlak van taalproduksie. As 'n afatiese pasiënt dus 'n afbraak toon in die persepsie van foneme, blyk dit dan waarskynlik te wees dat die ouditiewe onvermoë die produksie van dieselfde foneme sal aantas. Fonetiese diskriminasie-toetse is op 'n perseptuele sowel as produksie vlak gegee, en die ooreenkoms van fonemiese foute is aangeteken.

Die resultate dui daarop dat 'n gehoor verlies nie die oorsaak is van die geval se fonemiese disintegrasie nie. Sekere faktore kon nie konstant gehou word nie, dus is daar nie afdoende bewys vir hierdie resultaat nie.

Volgens die uitslag van die persepsie en produksietoetse wat gebruik is in die studie kon afgelei word dat die ooreenkoms tussen foute op ontvangsvlak, en dié op vlak van weergawe swak was. Ten spyte van die ontoereikendheid van die toetse wat gebruik is, het alle proef-persone 'n mate van ooreenkoms getoon en dit ondersteun die hipotese. Die foute in fonemiese diskriminasie wat aangetoon is deur beide persepsie- en produksietoetse was nie lukraak en onkonstant nie, maar het 'n definitiewe lyn gevolg.

' Daar is opgemerk dat die erns van die afatiese simptome nou verwant blyk te wees aan die graad van fonemiese afbraak. Die proef-persone wat getoets is het ook 'n beduidende ooreenkoms getoon tussen ouditiewe-tipe afasie simptome en fonemiese diskriminatoriese simptome. Klein ooreenkomste het bestaan tussen fonemiese foute in isolasie en spontane spraak.

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