IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 14, Issue 7 Ver. I (July. 2015), PP 37-43
www.iosrjournals.org

Speech Comprehension (Neurophysiology, Components & Types of sound)

Saurabh chaturvedi[1], Narendra Kumar Gupta[2], Ashok Kumar Verma[3], Amrit Tandan[4]

[1]*PhD Student, Department of Prosthodontics, College of dental sciences Babu Banarasi Das university, lucknow,uttar pradesh, India.*
[2]*Professor, PhD Guide, Department of Prosthodontics, College of dental sciences Babu Banarasi Das university, lucknow,uttar pradesh,India*
[3]*Professor and Head, Department of Prosthodontics, Career Post Graduate institute of dental sciences, lucknow, uttar pradesh, India*
[4]*Professor and Head, Department of Prosthodontics, College of dental sciences Babu Banarasi Das university, lucknow,uttar pradesh, India*

Abstract: *Today, man is judged not only by what he says, but equally by the way he says it. Proper speech is a reflection of education, careless speech is an imputation of slovenliness, and faulty speech is a handicap directly proportionate to the degree of speech incapability. Proper speech comprehension is possible only after correct understanding of its neurophysiology, components & types. These aspects of speech is discussed in detail in this article which will help the feternity in treating the speech problems and providing better treatment.*
Keywords: *Speech, Sound, Vocal cords, Broca's area, Wernickes area.*

I. Introduction

"Speech is the use of systematized vocalization to express verbal symbols or words."
(Sheridan: 1964)

These words of Sheridan explains speech as a sophisticated, autonomous, and unconscious activity. Speech in a human being is a learned habitual neuromuscular pattern which makes use of anatomical structures designed primarily for respiration and deglutition. The development of the vocal sound into significant speech was one of the key accomplishments which enabled man to reach the pinnacle of the animal kingdom, and speech as the basic and fundamental means of communication became the cornerstone for the establishment and organization of society. In the highly complex international society of today, with the sophisticated systems for transmitting the voice, the spoken word becomes increasingly important in establishing and maintaining a niche in the social structure. Its production involves neural, muscular, mechanical, aerodynamic, acoustic, and auditory factors. As orodental morphological features influence speech, the dentist should therefore recognize the role of prosthetic treatment on speech activity.[1-8]

II. Discussion

As a guardian of oral health, the dentists, most of the time are involved in altering the areas needed for proper articulation of the speech , so it is the responsibility of the operator to have well thorough knowledge of the speech its mechanism of production of sound, types of speech sounds, and its prosthodontics considerations. This is so because even loss of single teeth may alter the speech and this is more pronounced in complete edentulous patents.[7-12]

Mechanism of sound production

Sound production is highly coordinated which involves neural, muscular, mechanical, aerodynamic, acoustic, and auditory factors.

For speech production two areas are very important in the cerebral cortex,

i. Broca's area (after paul broca) or area 44,
ii. Wernickes area (auditory psychic area)

The broca's area is situated in the frontal lobe, inferior to the area 4 and the wernicke's area in the posterior most part of the superior temporal gyri. In right-handed persons, broca's area is found in left frontal (or the dominant hemisphere) lobe. [2-5]

Specific language disability :

Some children display difficulty in understanding and using language even though testing reveals no hearing loss, motor defects, intellectual impairment or emotional disturbance. Such difficulty is handling the symbol system is termed as specific language disability / developmental aphasia / congenital aphasia. This is due to the bilateral cerebral lesions or defective endowment with or development of crucial neural substrate for language.[4]

Applied physiology

The term aphasia/dysphasia means defective speech due to damage of the broca's area, wernicke's area. This is due to thrombosis of the feeding artery of the region affected.

Aphasias can be classified as-

(i)sensory,
(ii)motor, and
(iii)global

In sensory aphasia, wernicke's area is destroyed. The patient hears all right but cannot understand what he is hearing. When he speaks, he cannot understand his own words and the feedback from the ear is lost so there develops some incoherence in the spoken words too. Similarly, there may be failure to understand the meaning of the written words (word blindness).

In motor /expressive aphasia, the broca's area is lost. The patient can here and follow spoken words, his internal speech is all right; but when he attempts to express his own thought processes, he fails.

In global aphasia there is loss of both wernicke's and broca's areas dysarthria there is a defect in the motor cortex/cerebellum/or basal ganglia, so that vocalisation is imperfect. The term dsyphonia applied to all types of impairment in phonation. An articulatory problem without apparent neurological basis is called dyslalia. [3,4]

Speech production: - structural and functional demands:

All speech sounds are produced by controlling the airstreams that is initiated in the lungs and passes through the larynx and vocal cords. Speech sound requires more air than does quiet exhalation; consequently, subtle adjustments in air flow contribute to variations of pitch and intensity of the voice. The structural controls for speech sounds are the various articulations or valves made in the pharynx and the oral and nasal cavities. Each sound is affected by the length, diameter and elasticity of vocal tract and by the locations of constrictions along its length. There is no organ for speech per se. Speech is a learning process and develops over an extended period. Most girls master the normal articulation of speech by 6.5 years of age, whereas boys require an additional year of maturations.[13,14]

Components of speech [15-20]

Kantner and west divided speech into 5 components:-

Respiration, phonation, resonations, and articulations and neurologic integrations, chierici and lawson added audition, or the ability to hear sounds, to this list. The successful performance of these functions is necessary for the production of acceptable speech.

Respiration:

Normally during respiration, the inhalations and expirations are of equal interval. But while speech, the inhalation phase is shortened and expiration phase is prolonged. In normal function upward movement of the diaphragm with contraction of the costal cartilage and contiguous musculature creates an intrapulmonary pressure with is greater than atmospheric pressure, the permitting air to be expelled from the lungs.

Prolongation of exhalation is achieved by the valve mechanism along the laryngeal, pharyngeal, oral and nasal components of the respiratory tract these valves impede the expired air and help to create speech signals. Subglottic pressure is maintained by the balanced elasticity between the inspiratory intercostals musculature and the expiratory abdominal musculature.

The speech process is initiated by the energy inherent in air. In normal speech, the respiratory apparatus provides during exhalation, a continuous stream of air with sufficient volume and pressure under voluntary control for phonation. The stream of air is modified in its course from lungs by maxillo-facial structures and gives rise to the symbols which are recognized as speech.

Phonation:

When air leaves the lungs, it passes through the larynx whose true vocal folds or vocal cords modify the stream. The larynx provide the first level of constriction for the production of speech. The true vocal folds opposing each other with different degrees of tension and space create a slit like aperture of varying size and contour. The folds by creating resistance to stream of air, set up a sequence of laryngeal sound waves with characteristic pitch and intensity. These laryngeal sounds provide the basis for organization of speech.

Determine the pitch of the phonated sound. In the production of low pitched sounds, the vocal folds are relatively thick and flaccid. In high-pitched sounds, the margins of the approximated folds are thin and tense. If the larynx is resected, the patient must learn to use the esophagus, or a substitute mechanical device (electro larynx), as an alternative phonating system. Neurological disorders and vocal cord pathosis, such as papillomas or contact ulcers, can also produce phonatory defects in varying degrees.

Resonation:

The sound waves produced by the vocal folds are still far from being the finished product that we hear in speech. It is the resonators that give the characteristic quality to voice. The resonating structures are the air sinuses, organ surfaces and cavities such as the pharynx, oral cavity, nasal cavity and chest wall. The resonating structures do not contribute any energy to the stream of air. They act to conserve and concentrate the energy already present in the laryngeal tone rather than to let it dissipate into tissues. However, the resonating laryngeal tone is still not speech. The sounds produced at the level of vocal folds, is not the final acoustic signal with is perceived as speech. The velopharngeal mechanism proportions the sound and / or air stream between the oral and nasal cavities and influences voice quality (or the basic sound) that is perceived by the listener. If velopharangeal closure is compromised, or if the structural integrity or relative size of the oral, pharyngeal or nasal cavities has been altered, voice quality can be compromised.

Articulation:

It is the function of articulatory mechanism to break up, to modify the laryngeal tones and to create new sounds itself with in the oral cavity. The articulatory mechanism involves the lips, teeth, palate and tongue. The final action of articulatory apparatus is to articulate in a fluid sequence all the sounds which have been synthesized into symbols. Without this articulating capacity the sounds produced would be only of variable pitch, volume and quantity. Amplified, resonated sound is formulated into meaningful speech by the articulators, namely, the lips, tongue, cheek, teeth and palate, by changing the relative spatial relationship of these structures. The tongue is considered to be the single most important articulator of speech because of its ability to affect rapid changes in movement and shape.

Neural integration:

Speech is integrated by the central nervous system both at the peripheral and central level. The sequential and simultaneous movements required throughout the speech complex demand precise co-ordination. Mac neilage and de clerk stated that at least 17000 different motor patterns are required during speech. Neurologic impairments may compromise; a specific component of the speech mech. Such as the vocal folds, soft palate or tongue, or it may indirectly affect the entire speech system.

A cerebrovascular accident may compromise the ability of the patient to comprehend and / or formulate meaningful speech, even though all structures used to produce speech are anatomically within normal limits. In addition, a neurologic impairment may produce a specific type of speech deformity. Example: the loss of motor innervations to the soft palate may compromise elevation and velopharangeal closure.

The factors for speech production are highly coordinated, some sequentially and some simultaneously by the central nervous system. Speech is a learned function and requires adequate hearing, vision, and normal nervous system for its full development. Associated with speech is the whole phenomena of intelligence. When speech functions come into contact with the other vital functions of maxillo-facial structures, it is speech that suffers. This is particularly true when the conflict is with the important reflex actions, for example coughing, sneezing, hiccups, and regurgitation.

Audition:

Audition, or the ability to receive acoustic signals, is vital for normal speech. Hearing permits receptions and interpretation of acoustic signals and allows the speaker to monitor and control speech output. Compromised can preclude accurate feedback and hence, affect speech. Speech development and subsequent speech therapy is hampered in-patient with hearing impairments.

Types of sounds : [1,2,5,16,20]

Morphemes are the smallest meaningful units of the language. These all together for a language are called as phonemes. A set of phonetically similar, but slightly differing stand in a language that are heard as a same sound by native speakers and are represented in phonemic transcription by the same symbol are known as phonemes.

Eg : phoneme |p| includes phonetically differentiated sounds represented by p in pin, spin, tip.
Phonemes of english can be divided into four groups-

- Vowels
- Diphthongs
- Consonants
- Combinations

Vowels – these are voiced sounds. They are produced by vibration of some portions of vocal folds to establish the original sound wave, which is augmented by cavity resonations. The vowels require minimum articulation. Eg. A, e, i, o, u. Diphthongs – these are blends of two vowels or vowel like sounds, spoken with in a single syllable without interruption of phonation.
Consonants – consonants are articulated speech sounds, and all require articulation to impede, constrict, divert, or stop the air stream at the proper place and time to produce the desired sound.
Combination – is a blend of a consonant and a vowel articulated is such quick succession that they are identified as a single phonemes.

Classification of consonants :[1,2,8,21-25]

During prosthodontic rehabilitation the consonants are of utmost importance because these are created by differential impedance of the breath stream including impedance introduced by the teeth.

Classification by manner of production :
Nasal – these sounds are produced with the combined effect of larynx and nasal cavity where the later acts as resonator. During nasal congestion the the hyponasal sounds are produced. Eg. U, m, ng .

Plosives / stop-plosive – these are characterized by stoppage and sudden release of air stream and require complete occlusion of the articulators involved; the plosives p and b are produced by closure of the lips to permit momentary build up of the air stream, followed by a sudden explosive release, and t and d are produced by tongue contacting the hard palate to stop the air stream before suddenly releasing it. Eg. P, b, t, d, k.

Fricative – these are produced by the air stream being forced through loosely closed articulators or a narrow passageway. The term "sibilant" is used to describe the 's' like sound. The sibilants s, z, zh, sh are produced by tongue blade articulating with the lateral aspects of the hard palate, permitting the air stream to be forced through the groove created in the tongue apex.
For the labiodentals f and v, the lower lip articulates with the maxillary anterior teeth to constrict the air stream. Eg. F, v, s, z, h

Affricatives – j and ch are produced by a combination of stop and friction, accomplished by articulation of the tongue and anterior hard palate.
Liquid consonants(semi vowels) - these involves least impedance of the breath stream , as the name implies , produced without friction. Ex: r (rose),l(lily)

Glides- these involves relatively very little impedance of the air stream. That is sounds characterized by a gradually changing articulator shape ex: w (witch), y (you)

According to laryngeal action
Surds, Sonants, Consonants

The surd is any voiceless sound and is produced by separation of the vocal folds (glottis open) with no marginal vibration. The sound is made by frictions of the air stream as it passes through the appropriate cavities; the initial 'h' sound as in huh and the voiceless sibilants, z, sh and zh pronounced initially are examples.

The sonants are voiced sounds and include all vowels and vowel like sounds. They are produced by vibration of some portions of vocal folds to establish the original sound wave, which is augmented by cavity resonations. The vowels require minimum articulation

Consonants are articulated speech sounds, and all require articulation to impede, constrict, divert, or stop the air stream at the proper place and time to produce the desired sound.

	Plosives	Fricatives	Affricatives
Voice less	P t k	S f θ	|ts|
Voiced	B d g	Z v δ	|dz|

On the basis of pressure classification by pressure uniqueness
Consonants vary in the amount of intraoral breath pressure required for their correct production. The consonants requiring the most pressure are the affricatives, fricatives and plosives. Therefore they are known as "pressure consonants". Voiceless consonants require more pressure than their voiced cognates.

On the basis of structures involved in production
This is the most important method of classification from prost hodontist aspect as it demarcates the areas which areas involved in production of particular consonants.
Bilabial (ex: p, b, m, n,w)
Linguoalveolar (ex: t, d, s, z, n)
Labiodentals (ex: f, v)
Linguovelar (ex: k, g, h, ng)
Linguodentals (ex: th)
Linguopalatal (ex: sh, ch, j, r, y)

Bilabial sounds - the sounds b, p, m are made by contact of the lips. In case of b, p – the palatopharyngeal valve is closed and the impounded air is suddenly exploded orally. For production of m – palatopharyngeal valve is open and voiced air stream is resonated nasally.
Formed mainly by the lips. For the correct articulation of these consonants the lips are brought into active contact and then opened suddenly, this sudden opening of the lips produces an explosive sound. [eg: b,p (plosives) ,m (nasals) and w (glides)] in b and p, air pressure is built up behind the lips and released with or without a voice sound.

Clinical significance: to determine the anteroposterior positioning of the anterior teeth and thickness of the denture. To determine the vertical dimension of occlusion

Lingualveolar sounds- 10 linguoalveolar are divided into 5 groups, each has distinct place and manner of production. Alveolar sounds (t, d, s, z, v, c) are made with the valve formed by contact of the tip of the tongue with the most anterior part of the palate or the lingual side of the anterior teeth. The upper and lower incisors should approach end to end but not touch.

Clinical significance: to determine the horizontal and vertical relations of the anterior teeth. To determine the labiolingual position of anterior teeth. To determine the thickness of denture base. To determine the vertical dimension of the occlusion.

Labiodental sounds – fricatives f & v. Forcing breath stream through contact made by upper incisors with lower lip, during this the palatopharyngeal valve is closes.

Clinical significance: to determine the superoinferior position of anterior maxillary teeth. To determine the correct occlusal plane. To determine the antero posterior position of incisors.

Linguovelar sounds – these are also called as back consonants or gutturals 'k', 'g' , basically sounds are produced by contact of the middle of the tongue with the soft palate. The palatopharyngeal valve is close ; pressure is build up behind the linguovelar contact, then released.

Clinical significance: to determine the thickness and posterior extension of denture :

Linguodental sounds – theta & eta. These are formed by the tongue and the teeth. During the production of these sound the toungue extends slightly between the upper and lower teeth.hence they are also called interdental sounds. The palatopharyngeal valve is close. Ex: th (fricative)

Clinical significance: to determine the labiolingual position of the anterior teeth:
Linguopalatal sounds – 2 consonants r & j are produced by lingual approximation to some portion of palate posterior to the alveolar ridge. 'r' – during production of this sound the tip of the tongue is often pointed to an immediately anterior maxillary postdental area and palatopharyngeal valve is closed. 'j' – during production of this sound the tongue is raised in the front of the hard palate, but during the production of sound the tongue moves to a position approximate for articulation of the following phoneme. The palatopharyngeal value is closed and teeth are closely approximated.

Clinical significance: to determine the thickness of denture. To determine the anteroposterior position of the maxillary incisors.
Methods for speech analysis[26-29]

A number of methods are available for speech analysis. There are basically 2 procedure :
- Acoustic /perceptual analysis.
- Kinematic methods for movement analysis.

Any speech problem will lead to social and psychological embarrassment to the patient. Proper speech analysis is very important specially while rehabilitating edentulous patient . This should be done before the start of the treatment as it will provide the basis for further comparison and modification done by the treatment.
An acoustic analysis is based on a broadband spectrogram recorded by a sonograph during the uttering of different phrases containing key phrases. By doing this, an objective opinion of the performance of certain sounds may be achieved.
Kinemetic analytical methods are ultrasonics, x-ray mapping, cineradiography, optoelectronic articulatory movement tracking, electropalatography (epg). These methods play an essential part in both experimental and routine clinical evaluation of speech defects and treatment effects.

Electropalatography : this is a highly precise method of recording the tongue and palate contact . Epg is performed by adapting the 70-80 contact electrodes into an individually made acrylic palate, covering the area from the front teeth back to the soft palate. This plate and electrodes are connected to a computer. The electrodes react when the tongue is in contact with the palate. In this way, untouched and touched electrodes can be recorded at a high frequency and a mapping achieved of the tongue contact pattern. This method enables the exact determination of the contact area and help in the diagnosis of some speech disturbances .
Other method for obtaining the palatogram which requires less equipments then epg envolves use of a uniformly thin artificial plate of methyl methacrylate resin, non-scanted talcum powder or mouth temperature waxes.

Speech tests :

At the time of try-in the role of the dentist, patient and relatives are very important . At this stage the phonetics should be assessed cautiously along with other aspects of the denture such as esthetics and function. At the time of the waxed try-in, it is possible to alter palatal contour to accommodate speech articulation.
The speech test should be made after satisfactory esthetics, correct centric relation, proper vertical dimension and balanced occlusion have been attained and after waxing for esthetics has been completed.

1st test : 1st test is of random speech and is best accomplished by engaging the patient in conversation and obtaining a subjective speech analysis by asking the patient how the denture feel, how his speech sounds to him and which words seem most difficult to pronounce.

2nd test : the 2nd test is of specific speech sounds. This is best accomplished by having the patient pronounce 6-8 words containing the sound and then combining these words into a sentence. The following is a list of the sounds to be tested.

S.sh	Six, sixty, ships, sailed mississippi, sure, sign, sun, shine	Sixty six ships sailed the mississippi. Sure sign of sunshine.
T, d, n, l	Locator, located, tornado, near, toledo	The locator located the tornado near toledo
Ch, j	Joe, joyce, joined, george, charles, church	Joe and joyce joined george and charles at the church.
K	Committee, convented, political, convention, connecticut	The committee convented at the political convention in connecticut.
F,v	Vivacious, vivian, lived, five, fifty five, fifth,	Vivacious vivan lived at five fifty-five fifth avenue.

	avenue	

3rd test : in the 3rd test, the patient is asked to read a short paragraph containing an abundance of 's', 'sh' and 'ch' sounds. If the patient can complete the speech test distinctly with no difficulty and if his random speech satisfies him and the operator, it would be unwise to contour the palate to solve the speech problem that does not exist.

III. Conclusion

Most dominating aspect of human being is speech. This quality of human makes him superior to other members of living kingdom. Proper and through understanding of the speech sounds its area and method of production provide opportunity to the dentist to rehabilitate the afflicted to his normal form. Various speech test are described in this article which helps in judging the effectiveness of the treatment rendered to the individuals.

Acknowledgements

Dr.Mudita Chaturvedi ,MDS-Oral Pathology

References

[1]. Zarb GA, Bolender CL, Eckert SE, Jacob RF, Fenton AH, Mericske-Stern R. Prosthodontic Treatment for Edentulous Patients. 12th ed., Mosby; 2004. p. 379- 87.
[2]. Sharry John J. Complete Denture Prosthodontics. 3rd ed., McGraw-Hill Book Company;1974. p. 130-48.
[3]. Tachimura T, Nohara K, Hara H, Wada T. Effect of placement of a speech appliance
[4]. on levator veli palatini muscle activity during blowing. Cleft Palate Craniofac J 1999; 36:224-32.
[5]. Chaudhuri; concise medical physiology; 3rd edition; 542-543.
[6]. Rothman R. Phonetic considerations in denture prostheses. L. Prosthet. Dent. 1961; 11:214-23
[7]. Petrovic A., Speech sound distortions caused by changes in complete denture morphology. J Oral Rehabil. 1985; 12:69-79.
[8]. Benediktsson E. Variation in tongue and jaw position in "S" sound production in relation to front teeth occlusion. Acta Odont. Scand. 15, 1957
[9]. Allen, L.R.: Improved phonetics in artificial denture construction, Report 59-10, December 1958.
[10]. HRB fenn; clinical dental prosthetics Staples Press. London N.Y 1953; 2nd edition; 302-308. 17
[11]. Petrovic A., Speech sound distortions caused by changes in complete denture morphology. J Oral Rehabil. 1985; 12:69-79.
[12]. Strenger F. La fonetica in Odontoiatria Fasc.20 Trattato di Odontostomatologia, N. LXVI Lawrence Triesen
[13]. McFarland et al. Speech compensation to structural modification of the oral cavity. J Acoust Soc Am. 1996; 100:1093-1104
[14]. Andrews, G., Craig, A., and Fe5'er, A.M., Hoddinott, S., Howie, P. and Nei1on, M (1983) stuttering: a review of research findings and theories circa, -journal of speech and Hearing disorder 8, 226-246.
[15]. Beli Berti F. ai'e1ectromyographic study of velopharyngeal function in speech: J. Speech Hear Res. 1976 Jun; 19(2):225-40
[16]. Black, J.W. The pressure in the oral cavity in the production of consonants, Pensacola, 190, The Ohio State University Research Foundation and U.S. Naval School of Aviation Medicine, The Bureau of Medicine and Surgery, Project NM 001 064 01 Report No.4.
[17]. Kessler, H.E.: Phonetics in denture construction, J.A.D.A. 54:347-351, 1957.
[18]. Larson H, Hertegard S, and Lindestad PA, Hammarberg B.: Vocal fold vibrations: high speed imaging, kymography and acoustic analysis: a preliminary report. Laryngoscope 2000 Dec. 110 (12):21 17-22.
[19]. Martone, A L., and J.W. Block, 1962, the phenomenon of function in complete denture prosthodontics; an approach to prosthodontics through speech science, J. Prosth. Dent. Part 4, 12: 409-419, part 5, 12: 629-636.
[20]. Martone, A.L. AND Edwards, L.F.: The phenomenon of function in complete denture Prosthodontics. Anatomy of the Mouth and Related structures. J. The face; J. Pros. Den. 11:1006-1018, 1961:11.
[21]. Stone M. Lundberg A. Three dimensional tongue surface shapes of English consonant and vowels. J. Acoust Soc. AM 1996 June 99(6):3728-37.
[22]. Mehringer, E.J., 1963: The use of speech patterns as an aid in prosthodontic reconstruction, J. Prosth. Dent. 13:825-836.
[23]. Pound, E., 1951, Aesthetics and Phonetics in full denture construct4un, D.J. Australia, 23: 126-134.
[24]. Prendergast, W.K. 1935, Phonetics and speech defects in prosthetic dentistry, J Canad. Dent. Ass. 1: 295-308.
[25]. Rothman, R., 1961, Phonetics considerations in denture prosthesis, J. Prosth. Dent., 11:214-223.
[26]. Rowe, Arthur T: Some causes of Instability in maxillary and mndibu1ar dentures, D. cosimos 78:58-66, 1936.
[27]. Runte C, 'Tawana D, Dirksen D, Runte B, Lamprecht-Dinnesen A, a Bollmann F, Seifert E, Danesh G. Spectral analysis of/s/sound with changing angulations of the maxillary central incisors. Int. J. Prosthodont. 2002 May-Jun: 1 5(3):254-8.
[28]. Rutter, M and Martin, J. A.M. (1972) the child with Delayed speech. London: William Heinemann Medical Books.
[29]. Schierano G, Mozzati M, Bassi F, Preti G. Influence of the thickness of the resin palatal vault on the closest speaking space with complete dentures. J. Oral Rehabil. 2001 Oct.28 (10)903-8.
[30]. Pytte CL, Suthers PA: Sensitive period for sensorimotor integration during vocal motor learning. J. Neurobiol 2000 Feb. 5:42(2):172-89.