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Patterns Of Speech Articulation In Subjects With Neurogenic Dysphagia And Dysarthria

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Abstract

The purpose of this descriptive study was to examine place-manner-voicing features and neuromuscular substrates of articulation and swallowing in a group of nursing home residents having concurrent dysarthria and dysphagia. Similar muscle groups function in speech articulation and swallowing, accounting for the high coincidence of dysarthria and dysphagia in neurological impairment. Subjects were forty patients residing in two skilled nursing facilities in Las Vegas, Nevada. The results described place, manner, and voicing characteristics of articulation patterns in neurologically impaired nursing home subjects with and without dysphagia. Place-of-articulation anomalies identified for the dysphagia group were most frequently at the blade-prepalatal site. Manner-of-articulation anomalies among the dysphagia group occurred most often for fricatives. Perceptual changes of soft or weak vocal loudness were most common quality anomalies among the dysphagia group subjects.

Introduction

Both speech and swallowing involve coordinated action of the bulbar and respiratory musculature to perform their distinct systemic functions. Although movement patterns and origins differ, speech and deglutition share certain neurological pathways and anatomical structures. It follows that neurological diseases often result in concurrent speech and swallowing disorders. The purpose of this study was to examine consonant articulation and perceptual quality disorders in a group of subjects having acquired dysarthria with concomitant neurogenic dysphagia.

Physiological Differences between Swallowing and Speech Articulation

The most obvious physiological difference between speech and swallowing is systemic. Speech employs the oral, nasal and pharyngeal cavities as respiratory structures while swallowing employs them as alimentary structures. Neuromuscular differences between speech and swallowing involve their behavioral origins and variations in movement patterns. Behavioral origins of speech and deglutition arise from their diverse physiological foundations. These origins have clinical import because they influence patients' therapeutic compliance and, hence, the success of treatment. Initiation and continuation of speech movement patterns involve the interplay of diverse central affective motivations and neurolinguistic substrates with sensorimotor functions. Once speech is underway, the speaker consciously maintains speech neuromuscular subsystem coordination and modifies ongoing patterns and intensities of contraction through afferent system feedback (Mysak, 1976, Darley, et al., 1975). It is apparent, then, that most speech movements originate voluntarily and continue at least partly through conscious self-monitoring. Swallowing origins are less well understood (Logemann, 1995), but appear to involve an interplay of conscious and unconscious motivations and movements. Voluntary intake and preparation of the food bolus begin a chain of swallowing events. Once underway, deglutition becomes successively more reflexive and ultimately autonomic (Zemlin, 1988, Tanner and Culbertson, 1999).

Speaking and swallowing movement patterns are distinct, as well, in their directionality and rhythm. Speech movements are usually egressive, with air flowing out of the body, while swallowing is always ingressive. Speech movement patterns vary with the language of the speaker, but include movements that vary widely in range, direction and velocity. Swallowing patterns are much more stereotyped and sequential, varying relatively little in action (Kennedy and Kent, 1985). Speaking and swallowing are often concurrent, and momentary interruptions of speech are common while a speaker clears saliva from the mouth. Autonomic phases of deglutition can continue while the mouth is occupied with speaking.

Physiological Similarities between Swallowing and Speech Articulation

Differences aside, both speech and swallowing involve coordinated contraction of similar muscle groups supporting the same anatomical structures in the upper airway. Oropharyngeal muscle groups seal the upper respiratory (alimentary) tract at several sites and change its dimensions during both speech and deglutition (Edwards, 1992; Logemann, 1995). For example, anterior-posterior lingual movements produce palatal or palato-alveolar glides (to back vowel targets) during speech and also push the bolus toward the oropharynx during deglutition. Intrinsic laryngeal muscle groups that adduct the vocal folds during vowel articulation, sonant consonant articulation and glottal consonant articulation also function sequentially to secure airway closure as a bolus passes through the pharynx. The velopharyngeal valving action that couples or uncouples the nasal cavity to the vocal tract and changes vocal tract resonance also prevents penetration of food and liquid into the nasopharynx and allows reduction of relative intraoral air pressure for sucking. Further, individuals contract extrinsic laryngeal muscles to elevate their larynges to varying extents during pitch increases (Zemlin, 1998). These extrinsic laryngeal muscle groups also engage during the pharyngeal swallowing stage.

Neuropathology of Speech and Deglutition

Speech and swallowing disorders may occur simultaneously in several neurological diseases, since muscle groups associated with speech also function in the oral and pharyngeal stages of swallowing (Kennedy, Pring and Fawcus, 1993). It is logical to expect dysarthria and neurogenic dysphagia to occur concurrently. Duffy (1995) found dysarthria to be the most frequently presented acquired neurogenic communication disorder in over three thousand patients. Miller and Langmore (1994) identified neurological disorders as the cause of most dysphagia. Almost all of the subjects of Darley, Aronson and Brown's (1975) subjects presented dysphagia as well as dysarthria, no matter what their neuropathological classifications. Logemann (1983) observed diminished lateral and vertical lingual range of motion, reduced buccal tension, and limited rotary mandibular movement in oral stage neurogenic dysphagia. Dobie (1978) noted reduced, uncoordinated lingual movements and decreased oral sensation that affected bolus formation in the oral preparatory phase. Among a group of individuals with neurogenic dysphagia, Miller (1982) observed reduced lingual elevation, lingual range of motion, disorganized anterior to posterior lingual patterns, and limited mandibular movement in mastication during the oral phase of the swallow.

Swallowing problems in the oral stage may include difficulty with mastication, with managing and initiating bolus transfer, and with poor retention of intraoral material. These swallowing functions depend upon lingual and mandibular mobility, and so does speech articulation. The vertical lingual movement required to maneuver a bolus along the palatal (maxillary) vault is essential to palatal, palato-alveolar or velar consonant production as well as for close (high) vowel articulation. Mandibular elevation is necessary for mastication and also for lingua-palatal and labial juxtaposition. Such juxtaposition is required as well for close vowel formation and for palatal and labial consonant production.

Post oral (pharyngeal stage) swallowing disorders may also occur concomitantly with dysarthria, resulting from the same injury or disease process that disrupts efficient muscular control. The involuntary swallowing reflex includes coordinated velopharyngeal and laryngeal closure combined with rhythmic and sphincteric, pharyngeal constrictor action. Neuromuscular impairment of the swallowing reflex can allow food or liquid to penetrate the laryngopharynx, compromising the airway (Buchholz, 1994). Kilman & Goyal (1976) described a delayed or absent swallowing reflex, inadequate velopharyngeal closure, and reduced pharyngeal peristalsis as aspects of the pathophysiology of dysphagia. Velopharyngeal closure and laryngeal elevation and closure are well-known functions of both swallowing and speech. Thus, the same neurological disease that reduces strength and coordination of the pharyngeal musculature active in swallowing may also alter nasopharyngeal resonance and affect laryngeal phonatory function. The swallowing reflex may be defective without significant dysarthria (Kennedy, Pring and Fawcus, 1993), such as might occur in impairment of the afferent aspect of the reflex.

Methods

Subjects

Subjects were forty patients residing in two skilled nursing facilities in Las Vegas, Nevada. Experimenters assigned subjects to two groups according to their medical records: a dysphagia group of thirty patients with neurogenic swallowing disorders (either oral and/or pharyngeal) and a group of ten patients with neurological disease but normal muscular function in swallowing. The non-dysphagia group included two subjects with normal neuromuscular swallowing mechanics who required percutaneous endogastric nutrition supplement because of diminished food appetite. Other subjects in both groups required alterations in food consistency because of dental insufficiency. Appendices A and B contain details about the neurological diagnoses, per os status and cognitive-linguistic screening results of the subjects. Some medical records were incomplete, lacking ages or time post onset information for several patients.

To identify subjects for the sample, investigators reviewed medical records and compiled a list of candidates. They then screened those potential subjects who consented to participate. Investigators determined subjects' general communicative and swallowing statuses by reviewing a standard bedside communicative screening and a bedside swallowing screening form contained in the subjects' medical records. The communication screening covered subjects' communicative modalities, communicative efficiency, comprehension, cognition and orientation. The general communication screening employed a 0-3 rating system that measured the level of speech intelligibility, cognitive and communicative abilities. A score of zero indicated normal function, while a score of three represented severe impairment. The swallowing screening report included observations of the patient's oral anatomy, oral motor control, oral sensitivity, laryngeal elevation, and mastication abilities. Several bedside swallowing evaluations indicated cineradiographic study for further assessment. Of the thirty subjects in the dysphagia group, twenty-seven required puree or mechanical soft diets. Seven of the ten non-dysphagia group subjects tolerated a regular diet.

Participants met the following entry criteria for inclusion in the study: 1) presence of a neurologically-based swallowing disorder or a neurogenic disorder; 2) verbal and auditory skills adequate for labeling and answering open-ended questions; 3) no history of aphasia, apraxia or developmental speech disorder; 4) lack of anatomical anomalies. Because of the normally high frequency of hearing impairments among elderly patients (Weinstein, 1994), subjects with peripheral hearing disorders remained in the sample provided they responded satisfactorily to five of the questions appearing in Appendix C.

Procedure

An examiner first introduced twenty open-ended questions (see Appendix C) designed to evoke open-ended responses and conversation. Next, a trained examiner presented the picture portion of Fisher-Logemann Test of Articulation Competence (Fisher & Logemann, 1971), using only the picture section for 22 single consonants. One investigator observed and recorded the test data. The protocol for the Fisher-Logemann Test of Articulation Competence organized subjects' responses in "place-manner-voicing" categories. The conversational responses were useful in several ways. First, they provided a medium for establishment of rapport between the examiner and the subject. Second, they allowed investigators to compare speech response patterns elicited in a structured context to those evoked in a less structured context. Third, they provided an opportunity for the experimenter to observe and record the subjects' nonsegmental speech characteristics (Crystal, 1969). Testing occurred in a quiet therapy room setting, controlled to reduce visual and auditory noise by eliminating as many visual distractions in the room as possible and placing a sign reading, "Do-Not-Disturb: Testing in Progress," on the door.

Results

The purpose of this study was to examine patterns of articulation and consequent neural substrates in a group of subjects with neurogenic dysphagia and dysarthria. The Fisher-Logemann Test of Articulation Competence (1971) identified such patterns by place and manner of articulation. Of the thirty dysphagia group subjects studied, twenty-three (77%) subjects exhibited a total of one hundred twenty-four identifiable anomalies in place and manner of consonant articulation. There were no changes in voicing features. Experimenters did not attempt to distinguish phonetic variations secondary to neuromuscular impairment from possible dialectical phonemic variations. Table 1 lists the number and types of errors produced by both groups.

Place-of-articulation may be described as the location of greatest constriction along the vocal tract (Tiffany and Carrell, 1967). Place-of-articulation anomalies identified for the dysphagia group were most frequent at the blade-prepalatal site. Frequencies of articulatory changes involving place, listed in order of occurrence (most-to-least), were blade-prepalatal (22%), blade-alveolar (17%), tip-alveolar (12%), tip-dental (12%), labio-dental (11%), back-velar (9%), bilabial (8%), and central-palatal (8%).

Manner-of-articulation refers to the degree of vocal tract closure and the way the speaker manages the speech air stream (Daniloff, Schuckers and Feth, 1980). Manners-of-articulation range from complete closure for plosives (stops) through partial closure for fricatives and approximants. Common variations include changes in air stream release and in phonetic durations. Manner of articulation anomalies among the dysphagia group occurred most often for fricatives (45%), with stops accounting for (19%), affricates for 15%, nasals, 9%, glides 8%, and the lateral 4%.

Table 1. Summary of Speech Articulation Patterns in Neurologically Impaired Nursing Home Residents With and Without Dysphagia.

Place of Articulation	Dysphagia Group Number (%)	Non-Dysphagia Group Number (%)
Bilabial	18 (8%)	-0-
Labio-Dental	24 (11%)	2 (22%)
Tip-Dental	25 (12%)	2 (22%)

Tip-Alveolar	26 (12%)	3 (34%)
Blade-Alveolar	37 (17%)	-0-
Blade-Prepalatal	48 (22%)	-0-
Front-Palatal	-0-	-0-
Central-Palatal	17 (8%)	-0-
Back-Velar	20 (9%)	2 (22%)
Total	**215**	**10**

Manner of Articulation	Number (%)	Number (%)
Stop	40 (19%)	1 (10%)
Fricative	94 (45%)	5 (50%)
Affricate	32 (15%)	-0-
Glide	17 (8%)	-0-
Lateral	8 (4%)	1 (10%)
Nasal	18 (9%)	3 (30%)
Total	**209**	**10**

Table 2 lists the incidence of perceptual quality errors in the two groups. Perceptual quality errors identified any remarkable characteristics perceived in vocal quality, vocal intensity, and rate of speech production. Among dysphagia group subjects, perceptual changes of soft or weak intensity were most common, at 26% of the sixty-three total anomalies. Quality differences rated as "Breathy" or "Hoarse/Harsh/Gravelly" accounted for the next highest proportion of the perceptual anomalies among the dysphagia group subjects.

Proportional comparisons between the two samples were interesting. Size differences between the groups limited the validity of statistical comparisons and emphasized the frequency with which dysarthria and dysphagia was concurrent in neurological disease among the residents of these nursing facilities.

There were proportional differences in communication and intelligibility screening statuses of the two groups. Nineteen (63%) of the subjects in the dysphagia group had communicative deficits as rated by the screening instrument. Of these, four were severe. Sixteen (53%) of the subjects with dysphagia had speech intelligibility deficits. These ranged from ranging between severe/moderate-severe (30%) to mild (13%). Only one (10%) of the dysphagia subjects had severe general communication impairments, as rated with the screening instrument. Three of the non-dysphagic subjects had some changes in intelligibility, and only one of these was severe.

Of the ten subjects in the non-dysphagia group, only three (30%) displayed place or manner of articulation deviations as compared to twenty-three subjects (77%) in the dysphagia group. Place-of-articulation changes for the non-dysphagia group occurred most often at the tip-alveolar site (22%) with labio-dental, tip-dental and back-velar each accounting for 22% of the total non-standard articulations among that group. Non-dysphagic manner anomalies were also most often produced in fricative articulation, with nasals next in frequency at 30% and stops and the lateral each at 10%. Again, there were no voicing feature anomalies among the subjects without dysphagia.

Subjects in the dysphagia group also presented more perceptual quality changes than those in the non-dysphagia group. Subjects with dysphagia had at least one presentation of difficulty in each of the fifteen perceptual categories, while non-dysphagic subjects presented problems in only eight of the categories. Soft/weak intensity scored as the most common perceptual quality error for both groups.

Table 2. Summary of Perceptual Quality Errors in Neurologically Impaired Nursing Home Residents With and Without Dysphagia.

	Dysphagia Group Number (%)	Non-Dysphagia Group Number (%)
Soft/Weak Intensity	17 (26%)	3 (19%)
Monoloudness	1 (2%)	2 (13%)
Breathy	7 (11%)	-0-
Hoarse/Harsh/Gravelly	7 (11%)	3 (19%)
Denasal	5 (8%)	-0-
Hypernasal	1 (2%)	1 (6%)
Strained/Strangled	1 (2%)	-0-
Tremulous	2 (3%)	2 (13%)
Pitch Break	2 (3%)	-0-
Gurgly	2 (3%)	-0-
Aphonic	3 (5%)	-0-
Monopitch	3 (5%)	1 (6%)
Lowpitch	1 (2%)	3 (19%)
Slow/Labored Rate	7 (11%)	1 (6%)
Slurred	4 (6%)	-0-
Total	**63**	**16**

Discussion

The high incidence among dysphagia group subjects of non-standard articulations involving lingual blade elevation to palatal and prepalatal (or postalveolar) positions, particularly in fricative production, suggested a pattern involving degradation of fine coordination in the anterior tongue musculature of these subjects. According the Fisher Logemann (1971) phoneme matrix, blade-prepalatal fricatives include /•/ and /¥/, and blade-alveolar fricatives are /s/ and /z/. Other blade-prepalatal consonants are the affricates, /t•/ and /d¥/. Static consonant postures, such as those implied by Fisher and Logemann’s (1971) place-manner-voicing descriptions occur in speech about as rarely as any single static posture occurs in swallowing. Instead, closed juncture or “Consonant-Vowel-Consonant-Vowel…” flow of syllables in running speech is a series of gliding movements from the closed postures associated with consonants to the open postures associated with vowels and back to the closed postures. Such movements require the interplay of timing and intensity with intrinsic and extrinsic oral, pharyngeal and labial muscle groups combined with various degrees of mandibular elevation. Fricative, affricate, and stop articulation also require increased source energy, narrow or complete vocal tract constriction and controlled breath support. Articulation of these obstruent consonants requires mandibular, lingual and labial mobility coordinated with velopharyngeal and respiratory muscle function.

Just as the sites of production for blade-alveolar and blade-prepalatal consonants involve elevation of the mandible, tongue blade or body to contact the palate or upper teeth, similar juxtapositions are seen in the transfer of material from oral cavity to pharynx in swallowing. Depending upon the phoneme, there are several configurations of intrinsic and extrinsic lingual muscle groups that accomplish these particular articulatory postures (Edwards, 1992). Similarly, in swallowing, Hamilton and McMinn (1977) and Logemann (1995) reported that the lateral and anterior lingual dorsum is normally sealed against the palate in the initial stages of bolus transfer. If the present results are typical, clinicians might often expect to encounter distortions of anterior fricatives. Further, if the low incidence of articulatory problems among the non-dysphagic group is typical, clinicians might also expect that, as fricative production improved, initial stages of bolus transfer might also improve.

Non-dysphagia group subjects had no errors in affricate or glide articulation as categorized by the Fisher-Logemann, but it is noteworthy that the current (1993) revision of the International Phonetic Alphabet categorizes affricates as plosives and stops as unreleased plosives (and eliminates the “glide” concept altogether). Current phonetic thinking regards affricates as plosives with ejective releases. Practically, the relative frequencies of manner anomalies would remain unchanged by counting affricates as plosives among the present subjects' responses. The important consideration relevant to neuromuscular function is that the manner of articulation requires complete vocal tract occlusion by juxtaposition of fixed and mobile articulators.

The low incidence of approximant involvement suggested that the antero-posterior excursions required for palato-alveolar glide production may be dissimilar to those required for bolus transfer. The effects of phonetic context may be such that the direction and extent of such “gliding” movements were not great enough to have an effect on speech articulation. These results bolster the position that bolus transfer may require more strength and range of movement than palatal approximant gliding.

The most frequent nonsegmental anomalies were weak phonatory intensity and breathy or Hoarse/Harsh/Gravelly phonatory quality. This held true for both dysphagic subjects and the group of non-dysphagic subjects who also had neurological disorders. Weak vocal fold adduction decreases efficient use of pulmonary air and decreases the periodicity of the phonatory source. The result is reduced phonatory loudness and quality (Zemlin, 1998). Investigators did not review the respiratory statuses of the subjects, and it is possible that the cause of some subjects' weak loudness was insufficient pulmonary function of other than neurological etiology.

The relationship of speech articulation patterns and swallowing disorders by no means implies a relationship between phonological language functions and solid food or liquid intake. Phonological aspects of a language include the inventory of permissible speech sounds and the way they are combined, manifested by speech articulation. While it may be assumed that all or most animals swallow, the range of their phonological abilities is not as presumed. It was neither within the purpose of this study to establish a relationship between phonology and motor speech disorders. Instead, the present study examined speech characteristics of patients having a normal history of speech and swallowing functions, with disorders of both functions occurring later in life.

Future Research

Given the results of the current study, future research should explore predictive factors related to articulation place-manner-voicing factors and the existence and severity of dysphagia. In addition, future research might explore the use of concomitant articulation and dysphagia therapies in patients with dysarthria and neurogenic dysphagia.

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