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Preliminary study : the effects of instrumentation on the air intake times of the esophageal speaker

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AN ABSTRACT OF THE THESIS OF Sandra I. Pasak Neuburger for the Master of Science in Speech Communication, with an emphasis in Speech-Language Pathology/Audiology presented April 26, 1983.

Title: Preliminary Study: The Effects of Instrumentation on the Air Intake Times of the Esophageal Speaker.

APPROVED BY MEMBERS OF THE THESIS COMMITTEE:


Mary E. Gordon, Chairperson


Joan McMahon


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This research examined the use of visual feedback provided by electronic instrumentation to reduce air intake times of esophageal speakers during speech management. The subjects were six esophageal speakers from the Portland Metropolitan area. Three subjects made up the experimental group

and three were placed in the control group. Prototype instrumentation was used to measure air intake times and give visual feedback to the experimental group during twelve sessions of speech management. The control group participated in traditional speech management procedures to reduce air intake times without benefit of instrumentation. Rate of improvement was measured using the prototype instrumentation without visual feedback for both groups at the end of each session.

The Mann-Whitney U revealed a significant difference between the experimental and control groups on improvement of air intake means as determined by pre- and post-test measures. The experimental group reduced their mean air intake times significantly beyond the .05 level of confidence when compared to air intake means achieved by the control group. The experimental group's rate of improvement differed from that of the control group in a "surge" of initial improvement as early as the first session of the experiment and in improvements ranging from .144 second to 1.114 second when compared with their pre-test mean.

The accurate measurement and visual feedback provided by electronic instrumentation was useful in reducing air intake times in the speech management setting and appeared to be responsible for greater initial gains on the rate of improvement measures.

This study suggests that instrumentation used in the clinical setting can function to give the Speech-Language

Pathologist specific information about the client's performance, give the client specific information about his performance independent from the clinician and provide a data base to make comparisons of progress and regression at a later date. The accurate measurement of esophageal speech skills by instrumentation allowed the clinician to concentrate her skills on reinforcement and suggestions of compensatory behaviors rather than in making time estimates.

PRELIMINARY STUDY: THE EFFECTS OF INSTRUMENTATION ON THE
AIR INTAKE TIMES OF THE ESOPHAGEAL SPEAKER

by

SANDRA I. PASAK NEUBURGER

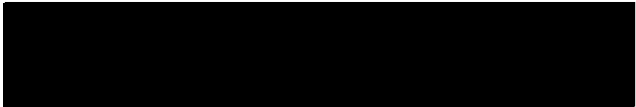
A thesis submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN SPEECH COMMUNICATION:
with an emphasis in
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Portland State University
1983

TO THE OFFICE OF GRADUATE STUDIES AND RESEARCH:

The members of the Committee approve the thesis of
Sandra I. Pasak Neuburger presented April 28, 1983.

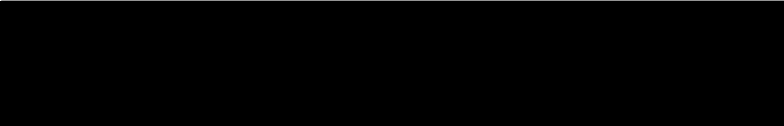

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CHAPTER I

INTRODUCTION AND STATEMENT OF PURPOSE

Introduction

A laryngectomy is the surgical removal of the larynx usually due to laryngeal lesions. Following surgery, the laryngectomee, though most often cured of cancer, is unable to vocalize due to the loss of the phonological vibrator and the pulmonary air supply which is no longer available for speech purposes. Using the remaining structures, the laryngectomee must develop a new form of communication (Diedrich, 1980; Finkbeiner, 1968; and Pressman and Bailey, 1968).

One form of alaryngeal phonation, called esophageal speech, utilizes the upper third of the esophagus or the pharyngoesophageal (PE) segment as a substitute sound generator. To speak, the esophageal speaker must learn to relax the normally constricted PE segment at the same moment air is taken into the esophagus via the oral and pharyngeal airway. The air is momentarily trapped there until thoracic and abdominal effort forces the air back through the tensed PE segment causing it to vibrate. The sound produced is then amplified and the articulators shape it into speech (Berlin, 1963; Diedrich, 1980; King, Marshall, and Gunderson, 1971; Salmon, 1979; Snidecor and Isshiki, 1965a and 1965b; Winens,

Reichback, and Walrap, 1974).

A basic and difficult task in learning esophageal speech is the filling of the esophagus with air in order to initiate phonation (Snidecor, 1968b). While speaking, esophageal speakers must pause often to refill their substitute sound generator with air. The frequency, speed, and ease of this air intake reflects the proficiency and acceptability of their speech (Berlin, 1963; Snidecor, 1968d; and Winens et al, 1974). Listener judgments of esophageal speech production is more favorable if the time taken to fill the esophagus is reduced allowing more time to be spent in phonation (Hoops and Guzek, 1974).

The ability to take air into the esophagus quickly and prolong the phonatory sound is an important and basic goal in teaching esophageal speech (Salmon, 1979). Methods of teaching the air intake process do not address the issue of how to measure its speed (Gardner, 1971 and Snidecor, 1968c). In the speech management setting, the clinician usually estimates the speed of the air intake process and gives the esophageal speaker feedback on his progress. Stone (1979) hypothesized, however, that these estimates can result in the inadvertent reinforcement of inefficient air intakes.

Instrumentation has been used in research to measure accurately the air intakes of esophageal speakers for the purpose of rating their speech productions (Diedrich and Youngstrom, 1966; Hoops and Guzek, 1974; Kelsey and Ewanowski, 1970; Ship, 1970; Snidecor and Curry, 1959, 1960; Snidecor

and Isshiki, 1965a and 1965b; and Zinner and Fleshler, 1972). Some clinicians have used instrumentation in speech management to monitor the intensity and duration of esophageal speech with some success (Martin, 1979; Shanks, 1979; and Simpson and Martin, 1975). In his study, Berlin (1963) used a stopwatch to measure a portion of the air intake process, but depended on the esophageal speaker to indicate when inflation of the esophagus had begun. The use of instrumentation to measure more adequately the air intake process in the speech management setting has not been reported in the literature. If an instrument proved effective in measuring air intake, it would enable the clinician to provide correct and immediate feedback to the esophageal speaker in his effort to learn a more proficient air intake.

Statement of Purpose

This study was designed to assess the influence of instrumentation on the speed of air intake in esophageal speakers over time. Specifically, its purpose was to determine if accurate measurement and immediate feedback provided by electronic instrumentation is effective in decreasing air intake time of esophageal speakers.

The research questions posed were:

1. Over time, do esophageal speakers who receive reliable and immediate visual feedback utilizing electronic instrumentation significantly decrease their air intake time in comparison to a control group receiving traditional speech management?

2. Does the rate of improvement in air intake times differ between the experimental and control group?

CHAPTER II

REVIEW OF THE LITERATURE

Air Intake

In esophageal speech, the site of the new phonatory vibrator is the pharyngoesophageal (PE) segment while directly below it, in the esophagus, lies the air chamber that must set the PE segment into vibration. Using these mechanisms, the production of esophageal can be described as a 3-part process, i.e., air intake, air retention, and air return.

The first and most fundamental step in learning esophageal speech is the act of taking air into the esophagus via the oral cavity (Salmon, 1979 and Snidecor, 1968b). A basic task is to take air into the esophagus through the naturally-contracted PE segment. Normally, the muscle fibers of the segment open long enough to allow food and liquids to enter into the esophagus while eating; whereas, at rest, the PE segment is closed to prevent air from entering the esophagus during respiration. It also functions to prevent air from entering the esophagus during activities such as sneezing, playing a wind instrument, and speaking. Opening the PE segment during such activities is unnatural (Weinberg and Bosma, 1970). The laryngectomee must overcome this natural resistance by relaxing the muscle fibers of the PE segment

to allow air to pass from the oral cavity into the esophagus.

Once the esophagus is filled, the muscle fibers of the PE segment must be tensed to trap a sufficient amount of air for phonation (Diedrich and Youngstrom, 1966). Tensing the PE segment is also necessary for phonatory vibration during the expulsion of air. Ideally, the esophageal speaker should take air into the esophagus quickly and emit the phonatory sound in a prolonged fashion (Salmon, 1979 and Shanks, 1979). Efficient esophageal speech is produced smoothly and quickly as one unit of behavior (Diedrich and Youngstrom, 1966). Duguay (1979) said the process of "air in," "retention," and "return" cannot be neatly fractionalized. He added it is impossible to say when one part of the process ends and the other begins.

Speed of Air Intake

A number of studies have measured the air intake of esophageal speakers who had various skill levels in order to define "good" esophageal speech and establish boundaries for a skilled performance (Berlin, 1963, 1965; Diedrich and Youngstrom, 1966; Hoops and Guzek, 1974; Kelsey and Ewanowski, 1970; Snidecor and Curry, 1959, 1960; Snidecor and Isshiki, 1965a and 1965b; and Zinner and Fleshler, 1972). While these studies varied in their definitions of air intake, the types of speech samples, and the instrumentation used for measurement, they found air intake to be rapid for "good" esophageal speakers (see Table I).

TABLE I
MEAN AIR INTAKE LATENCIES AND METHODOLOGIES
OF STUDIES REPORTED IN THE LITERATURE

Study	Portion Measured			Speech Sample	Mean Latency of Air Intake for Proficient Esophageal Speech
	Preparatory Behaviors	Air into the Esophagus	Prephonation Time		
Berlin (1963)		X	X	Phonation of /a/	.24 second
Berlin (1965)		X	X	Phonation of /a/	.40 second*
Zinner and Fleshler (1972)		X	X	Phonation of /a/	.25 second
Kelsey and Ewanowski (1970)	X	X	X	Phonation of /a/ & Phrases	.57 second
			X	Phonation of /a/ & Phrases	.14 second
Diedrich and Youngstrom (1966)	X	X	X	Phonemes	.50 second
			X	Phonemes	.12 second
Hoops and Guzek (1974)	X	X	X	Connected Speech	.20 to .80 second
Snidecor and Curry (1959, 1960)	X	X	X	Connected Speech	.42 to .80 second
Snidecor and Isshiki (1965a, 1965b)	X	X	X	Connected Speech	instantaneous to .75 second

*This latency time was reported for the "very good," "adequate," and "poor" esophageal speakers who could be measured.

Some researchers have used instrumentation to measure pause or interruption in the continuous flow of speech during the reading of a passage. Their definition of air intake thus included the time taken for oral movements used to develop air pressure prior to filling the esophagus. Snidecor and Curry (1959, 1960) reported their "skilled" esophageal speakers air intake times to be .42 to .80 second. "Effective" speakers in a study by Snidecor and Isshiki (1965a and 1965b) had air intake times with a range of almost instantaneous to .75 second. Hoops and Guzek's study (1974) found esophageal speakers who had air intake times longer than .80 second were rated as "poor" esophageal speakers.

Two studies used the same criteria as those described above for defining air intake, but with shorter speech samples. Diedrich and Youngstrom (1966) measured air intake times at .2 to 1.0 second (\bar{x} = .5 second) in "skilled" esophageal speakers in phonating a variety of phonemes from a position of rest. Kelsey and Ewanowski (1970) recorded air intake times of .57 and .64 second for "good" esophageal speakers in their productions of isolated phonemes and phrases. The "poor" esophageal speakers in their study attained mean air intake times of .76 and .77 second.

Two researchers recorded the time between the "audible" beginning of air intake or insufflation of the esophagus and the beginning of phonation using instrumentation responding to intensity (Berlin, 1963, 1965 and Zinner and Fleshler,

1972). Their definition of air intake, therefore, did not include events prior to the filling of the esophagus. Their subjects phonated /a/ from a position of rest. Their reported times are somewhat less than the studies reported above. Zinner and Fleshler (1972) recorded mean air intake times for their "acceptable" esophageal speakers to be .25 second. Berlin's (1963) "good" esophageal speakers air intake times ranged from .20 to .60 second ($\bar{x} = .24$ second) while the "poor" esophageal speakers ranged from .2 to 2.0 seconds ($\bar{x} = 1.3$ second). In a 1965 study, Berlin reported mean latency times of .40 second for all the speakers in his study including the "very good," "adequate," and "poor" esophageal speakers who could be measured.

Diedrich and Youngstrom (1966) termed the segment of air intake measured by Berlin (1963, 1965) and Zinner and Fleshler (1972) to correspond to what they called the prephonation period of air intake, i.e., they did not include the preparatory events to filling the esophagus. In their 1966 study, Diedrich and Youngstrom recorded a prephonation time for their "good" esophageal speakers of approximately .12 second. Kelsey and Ewanowski (1970) measured prephonation time for their "good" esophageal speakers to be .14 second. These prephonation time results compare similarly to results of the studies whose definition of air intake begins with the "audible" insuflation of the esophagus (Diedrich and Youngstrom, 1966).

One factor which effects the speed of air intake is its

location within the linguistic context (Diedrich and Youngstrom, 1966). During esophageal speech, air intake may occur at two different intervals within a speech segment, i.e., (1) interphrase pause which refers to a silent interval between words, phrases, or sentences or from a position of rest and (2) intraphrase pause which is a brief silent interval during the speech utterance (intraphrase interval). In Diedrich and Youngstrom's (1966) study, air intake times were .50 second for skilled esophageal speakers from a position of rest regardless of whether the air intake was followed by a vowel or consonant. Cineflourographic studies showed that oral movements necessary to accomplish air intake from a position of rest are different from the movements required for air intake from a succeeding phonetic movement. Outstanding consistency was found with which esophageal speakers moved their mandible, tongue, cranium, palate, and pharyngoesophageal segment from a position of rest to phonation (Diedrich and Youngstrom, 1966). Air flow studies by Diedrich and Youngstrom (1966), Isshiki and Snidecor (1964), and Snidecor and Isshiki (1965a and 1965b) have shown that air may be taken into the esophagus during the speech utterance. Certain articulatory movements during phonation allow these small amounts of air to be taken into the esophagus. As a result, the esophagus is partially filled with air so that the time necessary for the air intake is reduced. Diedrich and Youngstrom (1966) found air intake may be shorter during an interphrase pause between phrases than from a position of rest,

especially for phrases containing stop consonants. They found air intake to be quicker when it occurred during an intraphrase pause of stop consonants during the speech utterance (intraphrase interval). The fastest air intake observed by Diedrich and Youngstrom (1966) in cineflouographic studies was during the phonation of /s/. Air intake occurred at the same time the fricative sound was produced.

Temporal Aspects of Air Intake

In speaking, the esophageal speaker must pause to refill his phonatory system with air more often than the laryngeal speaker inhales for speech (Berlin, 1963, and Snidecor and Curry, 1959 and 1960). These pauses are dictated by phrasing and air capacity. Snidecor and Curry (1959) found esophageal speakers not only paused for air intake, but paused for emphasis similarly to the laryngeal speaker. Pauses for emphasis by the "superior" esophageal speaker were longer than the pauses for air intake and ranged from .62 to 1.3 second. The mean duration of these pauses for emphasis in esophageal speakers was greater than the mean duration of pauses for emphasis by the laryngeal speaker. The esophageal speaker takes additional time in pausing for emphasis in order to contrast pauses for emphasis with pauses for air intake.

Two studies measured the ratio of the time spent in phonation to total speaking time of esophageal speakers. Snidecor and Isshiki (1965b) reported "effective" esophageal speakers ranged from 38.4 percent to 57.4 percent ($\bar{x} = 46.3$

percent) of phonated time to periods of silence. One "superior" esophageal speaker in another study by Snidecor and Ishiki (1965a) achieved 51 percent phonated time. These findings fell below the 60 to 75 percent achieved by laryngeal speakers. Ship (1967) measured the "better" esophageal speakers in his study and found they spent 50 percent of the time in phonation while the "poor" esophageal speakers phonated 38 percent of the time. He concluded "better" esophageal speakers completed utterances in shorter periods of time than "poor" speakers by increasing phonation time and reducing periods of silence. "Adequate" esophageal speakers paused for more air intakes than "superior" esophageal speakers. The majority of silence time for the esophageal speakers was due to the refilling of the esophagus with air for phonation. When air intakes occurred frequently and were lengthy, the ratio of time spent in silence was increased while the total phonation time was reduced.

Rate

Rate of speech is the amount of time it takes to produce an utterance. Long air intake latencies interrupt the flow and rhythm of esophageal speech and are reflected in the rate of speech of esophageal speakers. Since the best measure of speech effectiveness is considered rate, a comparison of the rate of speech measured in words per minute (wpm) of "good" esophageal speakers to laryngeal speakers is important (Snidecor, 1968a and Snidecor and Curry, 1960).

Snidecor and Curry (1960) reported norms in words per minute for laryngeal speakers as established by Darley in 1940. Laryngeal speakers who read at 129 wpm were at the 0 percentile, 166 wpm at the 50th percentile, and 222 wpm at the 100th percentile. In a 1939 study by Franke cited by Snidecor and Curry, speaking rates for laryngeal speakers who exceeded 185 wpm were judged to be rapid while those with less than 140 wpm were judged as too slow.

Two studies reported "superior" esophageal speakers closely approximated the speaking rate norms established by Darley (1940) and Franke (1939). Snidecor and Isshiki (1965b) found the speaking rate of one "superior" esophageal speaker to be 153 wpm. Hoops and Noll (1969) found a range of 65.4 to 169.0 wpm for "good" esophageal speakers. In evaluating these studies, Hoops and Guzek (1974) pointed out that these results are the exception and that the rate of speech of esophageal speakers is much slower than that of laryngeal speakers.

Other researchers have shown esophageal speakers to have somewhat slower rates in wpm than the esophageal speakers in the studies above. Snidecor and Curry (1959) rated their "superior" esophageal speakers at 108 to 137 wpm (\bar{x} = 122.5 wpm). Diedrich and Youngstrom (1966) found the reading rate of their "superior" esophageal speakers to range from 83 to 129 wpm (\bar{x} = 113 wpm). The "good" speakers in Filter and Hyman's 1975 study had a rate of 35.9 to 129.4 (\bar{x} = 100 wpm). In an earlier study, Snidecor and Isshiki

(1965a) found their "good" esophageal speakers to achieve what they termed a "realistic rate" of 80 to 128 wpm (\bar{x} = 100 wpm). On a slightly longer passage, similar results were found by Snidecor (1968d) and Snidecor and Curry (1959 and 1960). Snidecor reported reading rates which ranged from 85 to 129 wpm while Snidecor and Curry recorded their esophageal speakers with a mean of 113 wpm. The "efficient" and "good" esophageal speakers in all of these studies did not exceed Darley's (1940) 50th percentile and their rate of speech would be judged too slow according to Franke's (1939) criteria (Snidecor, 1968d).

Hoops and Guzek (1974) and Snidecor and Curry (1960) determined the "superior" esophageal speakers in their study to be 80 percent as fast as the average laryngeal speaker and had significantly faster rates when compared to "poor" esophageal speakers. These studies concluded that the need for a frequent number of air intakes accounted for the reduced rate in words per minute. In comparing a 113 wpm average for the esophageal speaker to a 166 wpm average for the laryngeal speaker, Snidecor and Curry (1960) found the laryngeal speaker talks 1.41 times the rate of the esophageal speaker.

Esophageal Speech Proficiency

Some studies correlated the rate of esophageal speech with judgments of its acceptability and proficiency. One of the first systematic studies to relate acoustic parameters and perceptual measures to acceptability ratings of esophageal

speech was conducted by Ship (1967). He found rate of speech to be strongly related to speech acceptability and proficiency. Other researchers including Martin (1979), Shames, Font, and Matthews (1963), Stetson (1937), and Svane-Knudsen (1959) indicated rate to be related to speech proficiency. With similar findings, Hoops and Noll (1969) studied seven acoustic variables and their relationship to speech proficiency. Only rate in words per minute was found to correlate significantly to judged ratings of communicative effectiveness. The faster the rate used by esophageal speakers, the more proficient it was judged. Hoops and Guzek (1974) studied thirteen aspects of rate and phrasing and their relationships to speech proficiency. One of the variables judged to be predictive of esophageal speech proficiency was a short interphrase time; the second was the number of syllables per sentence per minute. They found perceived rate to be more closely related to interphrase rate (the pause between phrases) than to intersentence rate (wpm). They indicated that while increasing wpm would not accomplish speech proficiency, shorter interphrase times would tend to increase units per sentence and result in better judgments of speech proficiency. Hoops and Guzek (1974) concluded that the speech-language pathologist could efficiently use clinic time in an effort to reduce pause time and increase speech proficiency.

Instrumentation

Speech management strategies for teaching efficient air

intake usually does not address the issue of how to measure the speed of the air intake process, although, several methods of teaching air intake are suggested with practical tasks to help the laryngectomee become aware of what he must do to achieve this new behavior (Gardner, 1971 and Snidecor, 1968c). As the laryngectomee initiates intake and subsequent phonations, the clinician usually estimates the speed of the air intake process, makes judgments on its "goodness" and provides feedback to the esophageal speaker. Stone (1979) indicated these estimations may at times reinforce inefficient air intakes. He hypothesized that accurate measurement of air intake would avoid this problem and give selective reinforcement. This feedback would allow laryngectomees to see how they are progressing in producing efficient air intakes. Simply allowing the learner to see progress on the task may modify the behavior (Agras, 1972).

Instrumentation has been used in empirical studies to measure accurately air intake times of esophageal speakers (Diedrich and Youngstrom, 1966; Hoops and Guzek, 1974; Kelsey and Ewanowski, 1970; Ship, 1970; Snidecor, 1968d; Snidecor and Curry, 1959 and 1960; Snidecor and Isshiki, 1965a and 1965b; and Zinner and Fleshler, 1972). Two of these studies have successfully used instrumentation and visual feedback to improve and modify the skill level of the esophageal speaker in their research projects (Kelsey and Ewanowski, 1970 and Ship, 1970). Ship used electromyographic measurements with esophageal speakers for speech and non-speech tasks. Visual

feedback from the instrumentation allowed the subjects to increase duration of phonation for the normative data collection. Kelsey and Ewanowski used instrumentation with visual feedback to enable their speakers to increase the duration of phonation within the project.

Instances of instrumentation used in speech management with esophageal speakers have been found in the literature. Shanks (1979) suggested using a sound level meter to allow esophageal speakers to monitor the intensity of their speech utterances. As an adjunct to management, Simpson and Martin (1975) successfully used instrumentation which provided a digital read-out in measuring the duration of esophageal speech. Martin (1979) suggested using the VU meter on a tape recorder to monitor the intensity of esophageal speech. Berlin (1963) used a stopwatch to provide his patients with what he called simple, valid, and reliable feedback. He said it reduced the frustration of his subjects by avoiding remote goals and giving them immediate feedback. He measured portions of the air intake process and duration of phonation. He depended, however, on the esophageal speaker to indicate when inflation of the esophagus had been initiated.

The use of instrumentation to measure accurately the air intake process of esophageal speakers in the speech management setting has not been found in the literature. Instrumentation of this type might prove useful in helping esophageal speakers learn more efficient air intake processes and thus more proficient esophageal speech. A need exists to

determine if instrumentation would be beneficial in the management setting.

CHAPTER III

METHODS AND PROCEDURES

Methods

Subjects

Six laryngectomees were selected from the Portland Veterans Administration Medical Center, the Portland State Speech and Hearing Clinic, and the Portland New Voice Club, an affiliate of the International Association of Laryngectomees. Table II provides relevant descriptive information about the six subjects. All subjects had undergone a total laryngectomy and were in the process of learning or improving esophageal speech. Three subjects composed the experimental group while three composed the control group.

Selection

Each subject met the following criteria:

1. Mean latency of air intake 1.4 second or longer in 10 trials during the pre-test as measured by the Prototype Instrument Package I (PIP).
2. Rated Level 4 and below on Wepman's Esophageal Rating Scale (Wepman, MacGahan, Richard, and Shelton, 1953).
3. Read numbers displayed on the digital panel of the study's instrument in 10 consecutive trials.

TABLE II
DEMOGRAPHIC DATA

Subjects	Surgery	Age	Pre-test Mean	Wepman Esophageal Rating Scale Judge #1	Wepman Esophageal Rating Scale Judge #2	Months Post Surgery
Experimental Group						
#1	Total Laryn.	65	1.71 second	3 to 2.5*	2.5 to 3*	60
#2	Total Laryn. Rt. Radical Neck Dissection	75	1.80 second	2	1.5 to 1*	35
#3	Total Laryn.	65	1.44 second	2 to 1.5*	2 to 1.5*	20
Control Group						
#1	Total Laryn.	62	1.67 second	3	3	24
#2	Total Laryn. Rt. Radical Neck Dissection	64	1.43 second	2	2	18
#3	Total Laryn.	60	1.47 second	4 to 3.5*	4 to 3.5*	6

* Speech sample was judged to be inconsistent

For criteria number 2, a taped recorded sample of each subject reading a portion of the Rainbow Passage (Appendix A) was rated on Wepman's Esophageal Rating Scale (Wepman, MacGahan, Richard, and Shelton, 1953) (Appendix B). The Wepman Esophageal Rating Scale evaluates esophageal speech production abilities, as well as speech proficiency. It includes seven levels with Level Seven indicating no esophageal speech production and Level One representing automatic and fluent esophageal speech. Ratings were completed by two Speech-Language Pathologists who had a Certificate of Clinical Competence from the American Speech-Language-Hearing Association and who were experienced in working with laryngectomees and in teaching esophageal speech.

Subjects were randomly divided into two groups, experimental and control.

Each subject signed an informed consent form (Appendix C) which permitted their inclusion in the study.

Instrumentation

The voice-activated Prototype Instrument Package I was designed to measure the time lapse between two successive phonations of /a/. The instrument's timing device measured the silence at the end of the first /a/ and stopped timing at the beginning of the second /a/. A digital panel (approximately 2" by 4 1/2") displayed air intake times to the nearest hundredth of a second (see Appendix D).

Procedures

This study involved a total of 14 sessions for each subject, with 2 sessions for recording pre- and post-test information and 12 speech management sessions designed to reduce air intake times. The total project was completed in a 15 month period. The subjects were seen in the following temporal order: 1) two experimental subjects; 2) two control subjects; 3) one experimental subject, and 4) one control subject. All subjects were given a pre-test to obtain a mean latency for 10 trials of air intake using instrumentation. During the pre-test, the subjects were not allowed to view the digital read-out panel. Twelve individual management sessions were conducted for all subjects 2 or 3 times per week for 30-minute sessions during a 4 to 6 week period. The sixth week was used to make up absences. The procedure approximated a standard clinical session, including clinically supportive responses by the experimenter. Following completion of the 12 management sessions, a post-test was administered following the same procedures as the pre-test. At the end of each session, someone other than the experimenter and knowledgeable of the instrument, measured 5 trials of air intake. The experimenter and the subject, however, were not allowed to view the digital panel during the measurement or to see the results from each session until after all sessions were completed. Clinical procedures differed for the two groups of subjects and are described below.

Experimental Group

During the 12 sessions of speech management, subjects in the experimental group produced 25 trials of 2 successive phonations of /a/ per session in order to measure air intake latencies. The subjects were instructed to phonate as long as possible, then quickly initiate another air intake and phonate /a/ a second time. After each trial, the experimenter recorded the air intake time achieved. Rest periods between each 5 to 10 trials were taken as needed. Instrumentation was used to measure the air intake and to indicate the latency achieved on a digital panel. Air intake times were selectively reinforced by the experimenter. The subjects were encouraged to watch the digital panel to determine their air intake time. Instructions were repeated when the subject requested them or made no response. Air intake times were recorded by the experimenter and the subjects were encouraged to evaluate and compare their progress. Rest periods consisted of additional encouragements, instructions for improvement, and relaxation.

Control Group

Each subject in the control group achieved 25 trials of 2 successive phonations of /a/ per session in order to assess air intake latencies. Subjects were instructed to phonate /a/ as long as possible, then quickly initiate another air intake and phonate /a/ a second time. Instructions were repeated when the subject requested them or made no response.

Instrumentation was not used during the speech management part of these sessions. Judgments of speech of the air intake were made by the experimenter who positively reinforced what was estimated to be a "good" air intake and made suggestions for a faster and/or smoother air intake for those considered to be "slow." The experimenter recorded the quality of each air intake for a visual record for each subject of the control group. Rest periods were given between each 5 to 10 trials as needed and consisted of additional encouragements, instructions for improvements, and relaxation.

Data Measurement and Analysis

In this study, air intake times were defined as the silent time which elapsed between 2 successive phonations of /a/. Measurement by the electronic instrument began at the end of one phonation of /a/ and ended at the beginning of the second phonation of /a/. This procedure accounted for the lip and tongue movements prior to air intake and before the air injection noise is heard as described by Diedrich and Youngstrom (1966).

The 2 phonations of /a/ for each trial were required to be of sufficient length to insure

- (1) the first phonation of /a/ emptied the esophagus of usable air so the subsequent air intake represented an adequate air intake.
- (2) the second phonation was of adequate length to show that the esophagus had indeed been fully charged.

The clinical judgment of adequate length of air intake was approximately 2 seconds in duration. If either of the two phonations of /a/ were judged too short, the trial was designated a mistrial.

The experimenter recorded all air intake times for the 6 subjects during the pre- and post-testing using the prototype instrument. Each air intake response was represented with the time achieved to the nearest hundredth of a second. The difference was computed for each subject between pre- and post-test performance. The Mann-Whitney U was employed to determine the difference between pre- and post-test results for the experimental and control groups (Siegel, 1956).

A mean of 5 trials of air intake latencies recorded at the end of each session for both the experimental and control groups were displayed graphically to document the rate of improvement over time.

CHAPTER IV

RESULTS AND DISCUSSION

Results

The purpose of this investigation was to assess the influence of instrumentation on the speed of air intake in esophageal speakers. Specifically, its purpose was to determine if accurate measurement and immediate visual feedback provided by electronic instrumentation is effective in decreasing air intake times in esophageal speakers. In the experimental group, prototype instrumentation was used to measure and display visually the air intake times of esophageal speakers in an effort to reduce air intake latencies during speech management. The control group participated in traditional speech management to reduce air intake times without the benefit of instrumentation for accurate measurement. At the end of each session, five air intake trials were recorded by instrumentation for subjects in both groups without visual feedback information in order to track rate of improvement.

The first research question posed was: Over time, do esophageal speakers who receive reliable and immediate visual feedback utilizing electronic instrumentation significantly decrease their air intake time in comparison to a control group receiving traditional speech management? Improvements

in air intake times for the experimental group ranged from .891 to .945 second with a mean of .911 second and the control group ranged from .133 to .782 second with a mean of .393 second. These data were analyzed using the Mann-Whitney U to determine if the 2 groups differed on improvement of air intake times. The Mann-Whitney U revealed a significant difference between the experimental and control groups on improvement of air intake time means as determined by pre- and post-test measures. The experimental group reduced their mean air intake time significantly beyond the .05 level of confidence when compared to air intake means achieved by the control group (Table III). While both the experimental and control groups reduced their air intake latencies, results indicated the accurate measurement and visual feedback of electronic instrumentation augmented traditional speech management and enabled the esophageal speakers in the experimental group to reduce their air intake latencies significantly in comparison to a control group who received traditional speech management.

The second question posed was: Does the rate of improvement in air intake times differ between the experimental and control groups? Tables IV and V show the rate of improvement in mean air intake times for the experimental and control groups for all sessions. The percentage of improvement as compared with the air intake mean of the pre-test for each subject over all sessions is displayed in Tables VI and VII.

TABLE III

MEAN AIR INTAKE LATENCY TIMES FOR PRE-TEST AND POST-TEST MEASURES
AND THE MANN-WHITNEY U FOR THE PROBABILITY OF GROUP DIFFERENCES

Subject	Pre-test	Post-test	Difference	U	P
<u>Experimental Group</u>					
#1	1.710 second	.811 second	.899 second		
#2	1.800 second	.891 second	.891 second		
#3	1.440 second	.495 second	.945 second		
				0	.05*
<u>Control Group</u>					
#1	1.670 second	1.405 second	.265 second		
#2	1.432 second	.648 second	.782 second		
#3	1.470	1.337 second	.133 second		

* significant

TABLE IV
 RATE OF IMPROVEMENT IN MEAN AIR INTAKE TIMES
 FOR THE EXPERIMENTAL GROUP

Session	Subject #1	Subject #2	Subject #3
Pre-test	1.710 second	1.800 second	1.440 second
1	1.120 second	1.380 second	.728 second
2	.820 second	1.656 second	.696 second
3	.830 second	1.398 second	.674 second
4	.812 second	1.070 second	.654 second
5	.666 second	1.286 second	.508 second
6	.998 second	.850 second	.408 second
7	.972 second	.872 second	.360 second
8	.744 second	1.300 second	.442 second
9	.586 second	.902 second	.478 second
10	.670 second	1.372 second	.626 second
11	.664 second	1.150 second	.380 second
12	1.074 second	.870 second	.490 second
Post-test	.811 second	.891 second	.495 second

TABLE V
 RATE OF IMPROVEMENT IN MEAN AIR INTAKE TIMES
 FOR THE CONTROL GROUP

Session	Subject #1	Subject #2	Subject #3
Pre-test	1.670 second	1.430 second	1.470 second
1	1.678 second	1.332 second	1.604 second
2	1.158 second	1.406 second	1.632 second
3	1.346 second	1.388 second	1.018 second
4	1.580 second	1.060 second	1.416 second
5	2.054 second	.964 second	1.616 second
6	1.636 second	.896 second	1.228 second
7	.756 second	.708 second	1.336 second
8	1.030 second	.876 second	1.124 second
9	1.446 second	.796 second	1.108 second
10	.928 second	1.098 second	1.300 second
11	1.502 second	.782 second	1.584 second
12	1.232 second	.798 second	1.510 second
Post-test	1.405 second	.648 second	1.337 second

TABLE VI
 EXPERIMENTAL GROUP: PERCENTAGE OF IMPROVEMENT
 FROM THE PRE-TEST MEAN

Session	Subject #1	Subject #2	Subject #3
Pre-test	1.71 second	1.80 second	1.44 second
1	35%	23%	49%
2	52%	8%	52%
3	51%	22%	53%
4	53%	41%	55%
5	61%	29%	65%
6	42%	53%	72%
7	43%	51%	75%
8	56%	28%	69%
9	66%	50%	66%
10	61%	28%	57%
11	61%	36%	74%
12	63%	52%	66%
Post-test	.811 second	.891 second	.4950 second

TABLE VII
 CONTROL GROUP: PERCENTAGE OF IMPROVEMENT
 FROM THE PRE-TEST MEAN

Session	Subject #1	Subject #2	Subject#3
Pre-test	1.670 second	1.432 second	1.470 second
1	0%	7%	- 9%
2	31%	2%	-11%
3	19%	3%	31%
4	5%	26%	4%
5	-23%	33%	0%
6	2%	37%	16%
7	55%	50%	9%
8	38%	38%	24%
9	13%	44%	25%
10	44%	23%	12%
11	10%	45%	- 7%
12	26%	44%	- 3%
Post-test	1.405 second	.648 second	1.337 second

The experimental and control groups achieved their most improved mean or their best air intake percentage within the sixth through the ninth sessions except for control subject #3, whose best performance was during session #3. The air intake times of both groups tended to level-out after their most improved session with longer mean air intake times.

The experimental group showed greater improvement during the initial sessions than did the control group subjects (Figure 1). Air intake means for the experimental group were never longer than their pre-test mean. For each session, the experimental group reduced their air intake times ranging from .144 second to 1.114 second from the pre-test mean.

Both before and after their most improved air intake mean, the control group at times approximated or equaled their pre-test mean except for control subject #2 whose performance reflected a gradual improvement trend. The control subject's initial sessions did not show the "surge" of initial improvement shown by the experimental group. Control subjects #1 and #3 had air intake means which were longer than their pre-test mean times during the first half of the experiment and subject #3 had air intake means longer than his pre-test during the eleventh and twelfth sessions as well.

Results indicated the experimental group's rate of improvement differed from the control group's in that the experimental group showed a "surge" of initial improvement as early as the first session of the experiment with improvements ranging from .144 to 1.114 second when compared to their

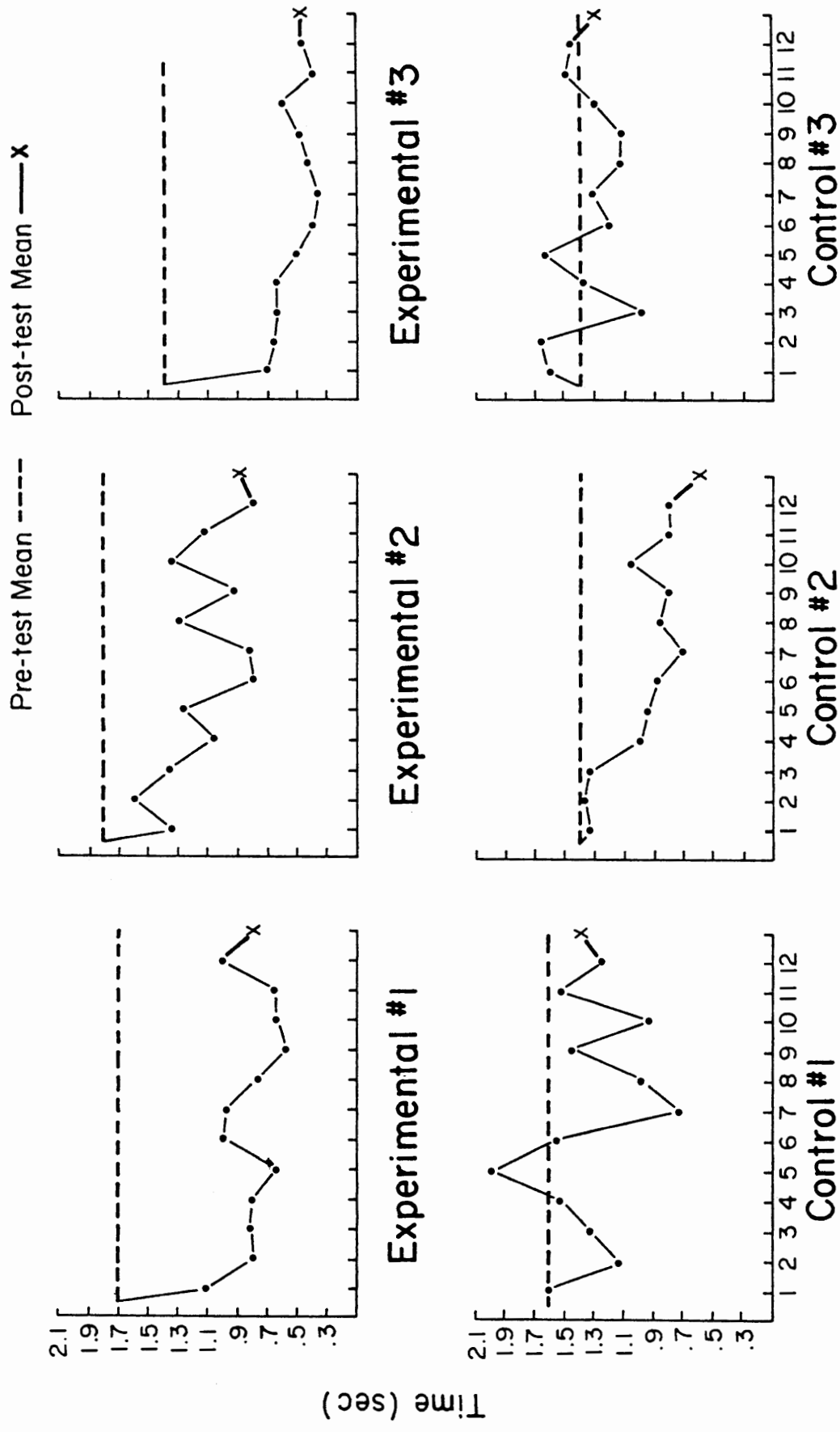


Figure 1. Rate of improvement in mean air intake times for the experimental and control groups.

pre-test mean.

Discussion

The statistical procedure employing the Mann-Whitney U to show a difference of the improvement of air intake times between the experimental and control groups indicated the experimental group had significantly improved their air intake times on the post-test measure as compared to the control group. This study, therefore, has shown the combined use of visual feedback information provided by electronic instrumentation can result in significant reductions in the mean air intake times of esophageal speakers when compared to a control group receiving traditional speech management. Additionally, specific differences in the rate of improvement were observed between the experimental and control groups. The experimental group showed greater initial gains, with improvement ranging from .144 to 1.114 second as compared with their pre-test mean.

It is apparent that visual feedback information provided by instrumentation provided a type of biofeedback information which allowed the experimental group to monitor closely their air intake times by developing a self-awareness of the physiological process of air intake. Subjects appeared to gain a certain degree of voluntary control of their air intake and thus effect their mean air intake times. The assessment made and presented by the instrumentation allowed the subjects of the experimental group to evaluate and reflect upon the

results of each air intake. The visual display provided feedback to the subjects as to what worked and what did not work for them. If the visual display revealed a long air intake, the experimental subjects could hasten their air intake on subsequent trials. The experimental group was also reinforced for even small improvements in their air intake times due to the measurement to the closest hundredths of a second.

The experimental group's rate of improvement indicated that after 20 trials of self-monitoring, through instrumentation, transfer occurred at the end of each session when no visual feedback was provided. The experimental group utilized the visual feedback of instrumentation to not only develop a self-awareness of the physiological process of air intake but self-regulatory abilities which enabled them to reduce air intake times when instrumentation was withdrawn. To a certain extent new behaviors learned as a result of visual feedback were transferred to a condition of no feedback.

The control group's improvement from the pre-test measure indicates that traditional speech management was useful to them; however, the amount of improvement on the post-test measure and rate of improvement was not as great for 2 of the 3 control group subjects as the gains of the experimental group. This investigator believes this to be a result of an inability to monitor their air intake in the exacting manner allowed the experimental group. The control group relied on the estimates of the examiner to determine the rate of air intake. While fast and slow air intakes were more likely

judged accurately by this examiner, those which fell in between may have been more difficult to judge. A number of air intakes may therefore have been judged incorrectly. As a result, the subjects of the control group may have been placed at a disadvantage in their speech management program. The questionable feedback given them on a number of trials may not have been useful to them in monitoring or in reducing their air intake times. This is in agreement with the hypothesis of Stone (1979). The realization that a number of air intake trials were difficult if not impossible to "call" was a frustration to this investigator because it became obvious that appropriate feedback could not be given consistently to the control group subjects. Efforts to "tune-in" to these air intakes not only met with failure but might have been responsible for distracting the investigator from other important observations during the management session.

The experimental subjects' attitudes toward the speech management sessions were somewhat different. A competitive attitude appeared to develop. The motivation to improve air intake times from the previous session appeared to create an enthusiasm not seen in the control group. In addition, the experimental group subjects were allowed to assume a more independent role in reducing their air intake. They appeared to take more responsibility for their esophageal speech behaviors than the control group who were more dependent upon the judgments of the investigator.

The means of measurement of the air intake tended to

designate a different role for the examiner in each group. In the experimental group, instrumentation made judgments of the air intake time so the machine appeared to become an object to work against. The examiner and the subject seemed to be "aligned against the machine." Measurement also acted to free the examiner to be a more observant participant in the management session. On the other hand, when judgments of the air intake times of the control group were dependent on the estimates of the examiner, some degree of stress between the examiner and the subject may have been present especially when the control subjects disagreed with the examiner's judgments of air intake.

Use of instrumentation within the session allowed the investigator to feel more confident in the effectiveness of the speech management process. Since the accurate measurement of air intakes was not in question, concentration on "time estimates" was not necessary, providing the investigator more freedom to observe the management setting. Instrumentation functioned to allow the investigator to "tune-in" and observe much more of the air intake process itself. In a sense, the investigator was allowed to take advantage of the machine's feedback abilities much like the subjects of the experimental group. She was able to increase her awareness and isolate areas of the phonation/air intake/phonation trial. This may have played a part in observing particular behaviors of the subject and resulted in specific suggestions for improvement.

The visual feedback of the electronic instrument enabled

the experimental group to compare the immediate and accurate information regarding the speed of air intake with the physiological process of air intake. This type of biofeedback provided concrete and instantaneous information which reduced the "noise" in the session, and was less frustrating than verbal directives.

Electronic instrumentation allowed the experimental group to align themselves with the investigator and monitor their air intake in order to attain faster air intake times, achieve greater initial gains, and a more consistent rate of improvement in comparison to the control group. At the same time, the experimental group was encouraged to have a certain degree of responsibility for and competition in making progress on the speech task. The subjects of the control group depended on the estimates made by the investigator, but did not always agree, causing some tension in the management setting. The use of instrumentation alleviated the stress of estimating air intake times for the investigator which occurred in the control group and allowed a feeling of confidence in accurate measurement. The feedback was also useful in allowing the investigator to monitor the phonation/air intake/phonation trial and observing behaviors needing modification.

CHAPTER V

SUMMARY AND IMPLICATIONS

Summary

This research examined the use of visual feedback provided by electronic instrumentation to reduce air intake times of esophageal speakers during speech management. The subjects were six esophageal speakers from the Portland Metropolitan area. Three subjects made up the experimental group and three were placed in the control group. Prototype instrumentation was used to measure air intake times and give visual feedback to the experimental group during twelve sessions of speech management. The control group participated in traditional speech management procedures to reduce air intake times without benefit of instrumentation. Rate of improvement was measured using the prototype instrumentation without visual feedback for both groups at the end of each session.

The Mann-Whitney U revealed a significant difference between the experimental and control groups on improvement of air intake means as determined by pre- and post-test measures. The experimental group reduced their mean air intake times significantly beyond the .05 level of confidence when compared to air intake means achieved by the control group. The experimental group's rate of improvement differed from that

of the control group in a "surge" of initial improvement as early as the first session of the experiment and in improvements ranging from .144 second to 1.114 second when compared with their pre-test mean.

The accurate measurement and visual feedback provided by electronic instrumentation was useful in reducing air intake times in the speech management setting and appeared to be responsible for greater initial gains on the rate of improvement measures.

This study suggests that instrumentation used in the clinical setting can function to give the Speech-Language Pathologist specific information about the client's performance, give the client specific information about his performance independent from the clinician and provide a data base to make comparisons of progress and regression at a later date. The accurate measurement of esophageal speech skills by instrumentation allowed the clinician to concentrate her skills on reinforcement and suggestions of compensatory behaviors rather than in making time estimates.

Research Implications

There are a number of implications for further studies as indicated by this research. The present study could be replicated using more subjects to determine if results would be comparable.

A second needed study is to compare the ability of more recent laryngectomees to reduce their air intake times with

those who have had their surgery for two or more years, but who continue striving to improve their esophageal speech.

A single case design could incorporate multiple baselines to evaluate what effect improvements in air intake times has on ratings of esophageal speech at different speech levels. Or, a single case design could be initiated with multiple baselines which evaluates the reduction of air intake latencies over time and documents results when visual feedback is systematically withdrawn.

A comparison study between the client's independent work with instrumentation and the same tasks under the direction of a Speech-Language Pathologist would determine the value of instrumentation as an augmentative device in the speech management situation.

A final suggestion is to design studies which extend the use of instrumentation to other components of esophageal speech, e.g., duration of phonation and phonation on demand.

Clinical Implications

Results of this study indicate that the accurate measurement and visual feedback provided by an electronic instrument is useful in reducing air intake times in the speech management situation. Instrumentation can function to give the Speech-Language Pathologist specific information about the client's performance, give the client specific information about his performance independent from the clinician, and provide a data base to make comparisons of progress and

regression at a later date.

Instrumentation can be an additional mode of treatment used in the speech management setting. It could greatly increase the flexibility of Speech-Language Pathologists at several levels extending their services and allowing the client independence in improving and maintaining certain speech skills. When the instrument is used independently by clients, it would give them more responsibility for the quality of their esophageal speech early in the process. The client could be instructed to work on specific skills with criterion determined by the Speech-Language Pathologist. The clinician's time would be free to see other clients or perform other duties. This alone would make instrumentation cost-effective for clinical use.

The competitive aspect of using instrumentation as noted in the discussion section of this paper brings in a different dimension to speech intervention. The client competing against himself to improve his speech skills might make learning to some degree more exciting and make the client an active participant in the remediation process.

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APPENDIX A

INITIAL PORTION OF THE RAINBOW PASSAGE

When the sunlight strikes raindrops in the air, they act like a prism and form a rainbow. The rainbow is a division of white light into many beautiful colors. These take the shape of a long round arch, with its path high above, and its two ends apparently beyond the horizon.

APPENDIX B

THE WEPMAN ESOPHAGEAL SPEECH RATING SCALE
(Wepman, MacGahan, Richard, and Shelton, 1953)

<u>LEVEL</u>	<u>ESOPHAGEAL SPEECH PRODUCTION</u>	<u>SPEECH PROFICIENCY</u>
7	None	No speech
6	Involuntary only	No speech
5	Voluntary, part of the time	No speech
4	Voluntary, most of the time	Vowel sound differentiated monosyllabic speech
3	At will	Single word speech
2	At will with continuity	Word grouping
1	Automatic esophageal speech	Esophageal speech

APPENDIX C

INFORMED CONSENT

I, _____, hereby agree to serve as a subject in the investigation of a Preliminary Study: The Effects of Instrumentation on the Air Intake times of Esophageal Speakers.

I understand that the study involves twelve sessions of speech intervention to improve air intake times and two additional sessions for measuring air intake times before (pre-test) and after (post-test) the twelve sessions.

I understand that this study will involve some demand on my time.

It has been explained to me that the purpose of the study is to learn the effects of instrumentation on air intake times of esophageal speakers and a direct benefit may be that I learn to decrease the time it takes me to get air into and out of my esophagus for speaking.

Sandra Neuburger has offered to answer any questions I may have about the study. I have been assured that all information I give will be kept confidential and that the identity of all subjects will remain anonymous.

I understand that I am free to withdraw participation in this study at any time without jeopardizing my relationship with Portland State University.

I have read and understand the foregoing information.

Date _____ Signature _____

If you experience problems that are the results of your participation in this study, please contact Richard Streeter, Office of Graduate Studies and Research, 105 Neuburger Hall, Portland State University, 229-3423.

APPENDIX D

DESCRIPTION OF INSTRUMENT

PROTOTYPE INSTRUMENT PACKAGE I (PIP)

The instrument was designed by Dennis Best, Department of Engineering, Portland State University, for use during speech management with a Laryngectomee population. The study was in partial fulfillment of a Master's Degree by Sandra Neuberger, directed by Mary E. Gordon from the Department of Speech Communication/Speech and Hearing Sciences.

The voice-activated instrument measures the time lapse between two successive phonations of /a/ produced by the subject. The counting device is activated during the first phonation of /a/, but does not initiate counting until the pause time occurs between the first phonation of /a/ and the beginning of the second phonation of /a/. To minimize the acceptance of respiration (stoma) noise, a hand-held microphone is used. The instrument measures time lapses as short as .01 and as long as 99 seconds. The time measured by the instrument is displayed on a digital panel and gives a read-out to the nearest hundredth of a second. The measured time displayed on the read-out panel remains constant during the second phonation of /a/. The size of the digital panel is approximately two by four and one-half inches. The total size of the instrument is approximately one and one-half by one foot and is a portable device.