Chapter II

Review of Literature

Stuttering has been called a riddle. It is a complicated multi-dimensional jigsaw puzzle with many pieces still missing. It is also a personal, social and a scientific problem with many unknowns.

Van Riper, 1982

Wingate (1976) gave the "standard" definition, which included seven separate and related elements in three primary categories, as follows: I. (a) Disruption in the fluency of verbal expression, which is (b) characterized by involuntary, audible or silent, repetitions or prolongations in the utterance of short speech elements, namely: sounds, syllables, and words of one syllable. These disruptions (c) occur frequently or are marked in character and (d) are not readily controllable. II. Sometimes, the disruptions are (e) accompanied by accessory activities involving speech apparatus, related or unrelated body structures, or stereotyped speech utterances. These activities give the appearance of being speech-related struggle. III. Also, there are infrequently (f) indications or report of the presence of an emotional state, ranging from a general condition of 'excitement' or 'tension' to more emotion of a negative nature such as fear, embarrassment, irritation, or the like. (g) The immediate source of stuttering is some in-coordination expressed in the peripheral speech mechanism; the ultimate cause is presently unknown and may be complex or compound".
The causes and treatment of stuttering are not known in spite of the enormous research conducted in the area. However, the research has brought out several therapy methods. But the efficacy and long-term effects of these methods are questionable. There is a vast body of basic research in the area of fluency, but the clinical research is not well founded. The measures used for measuring the efficacy of therapy are many and not all clinicians use all types of measures. This has resulted in a non-comparison of efficacy of therapy methods. As the present study has investigated the efficacy and long-term effects of non-programmed prolonged speech treatment in adults with stuttering using acoustical and perceptual measures before, after and 6-months after therapy, the review will be dealt under the following headings.

1) Novel speech pattern and stuttering: Historical Perspectives
2) Novel speech patterns and professional treatment programs
3) Various variants of prolonged speech techniques,
4) Efficacy measures
5) Long-term efficacy of prolonged speech techniques.

1) Novel speech patterns and stuttering: Historical perspectives

Ingham (1984) traced the evolution of novel speech patterns. An early example of the use of rhythmic speech concerns Demosthenes, a Greek orator who lived in the third century and who stuttered badly. Demosthenes was advised by his actor friend Satyrus to talk in front of the mirror, to speak with pebbles in his mouth, and to practice his speech while taking uphill. Much later, Colombat Del’sere, who lived in France in the 1830s, promoted
the use of rhythm to control stuttering. Del’sere invented a device called as muthoname, which is similar to metronome. He believed the cause of stuttering to be a lack of harmony between nervous system activity and the muscles involved in speech production, and that this harmony could be restored by speaking syllables in time to the regular beat of the muthonome. Del’sere was awarded the Monthyon prize by the French academy for work in stuttering. However, history did not look kindly on Del’sere: he was later ridiculed for his use of rhythm and the Academy was thought to be gullible for recognizing this work.

Mather, who was a Puritan minister, a student of eighteenth century medicine, and a Fellow of Royal Society of London, advocated the use of legato speech in 1724. He also stuttered, and was the first American to write about the condition. Mather wrote a treatise ‘The angel of Bethesda’, in which he preferred this advice to people who stutter.

“While you go to snatch at words and are too quick at bringing of them out, you’ll be stop’d a thousand times a day. But first use yourself to a very deliberate way speaking; a drawling that itself be little of singing. Even this drawling will be better than stammering; especially if what you speak be well worth our waiting for. By this deliberation you will be accustomed anon to speak so much without the indecent hesitation that you’ll always be in a way of it. Yea, the organs of your speech will be so habituated into right speaking that you will, by degrees and sooner than you imagine, grow able to speak as
fast again as you did when the law of deliberation first of all began to govern you. Tho’ my advice is beware of speaking too fast, as long as you live”.

There is a striking similarity between this prescription for ameliorating stuttering and the prolonged speech treatment programs of today. It is clear that Mather recognized the benefits of this speech pattern about two and a half centuries ago, and even advocated shaping the stutter-free speech that resulted from this novel way of speaking by advising the speaker to gradually increase speech rate, in much the same way as current prolonged speech treatments do.

It is interesting to note that, historically the use of speech patterns to control stuttering has been cyclic. For example, although novel speech patterns fell into disrepute in the nineteenth century, there was a resurgence of interest in them in the early part of the twentieth century with the emergence of the commercial stuttering schools that proliferated in England and America. Students usually attended these residential schools for many weeks typically for a substantial fee and achieved fluent speech by unusual speech patterns. Van Riper gave an extraordinary account of his own experiences in these schools: ‘one used arm swinging, another the swaying of eyes or hands or body, the third a lalling rhythmic form of continuous utterance in which all words joined and all consonants were slurred’ (Van Riper, 1982). The stuttering schools typically guaranteed a quick and permanent cure but the reality was that most students suffered relapse soon after finishing the courses. The blatant commercialism of the stuttering
schools, and their failure to consider the permanence of the fluency they induced, did little to enhance the reputation of novel speech patterns in the treatment of stuttering. So, once again this fell into disrepute.

It is likely that interest in novel speech patterns has waxed and waned because, as occurred in the commercial schools their effects do not appear to generalize. Thus, it has been said that these speech patterns reduce stuttering through trickery, and the beneficial effects dissipate once the novelty has worn off. However, Wingate (1981) argued that although this ‘artificial’ fluency is temporary, it probably lasts for as long as the novel speech pattern is maintained. He took support from the finding of Silverman (1976), who wore miniature metronome fitted to an earpiece in order to facilitate rhythmic speech in everyday situation. Silverman found only minimal dissipation of the effects of rhythm on his stuttering when he wore the device for 16 months. Further, the effect slowly wore off over three years, probably because he attended less to his metronomic beat.

To summarize, the ameliorative effects of these speech patterns aren’t due to their novelty but rather due to something inherent in them that suppress stuttering. Presumably, the speech patterns fell into disrepute because in the past little or no attention was paid to assisting people who stutter to maintain the particular speech pattern in everyday situations and over time. In any event, rhythmic speech and prolonged speech have found a lasting place in the fabric of stuttering treatment. One thing is certain; they have been the most potent modifiers of stuttering.
2) Novel speech patterns and professional treatment programs

In the 17th and 18th centuries, novel speech patterns like rhythmic speech and legato speech were used. But no attempts were made to assist persons with stuttering to maintain the particular speech patterns in everyday situations and over time. Owing to these reasons, these novel speech patterns were not used in the treatment of stuttering until the second half of the twentieth century. Also, emergence of psychoanalysis contributed to this decline. According to psychoanalytic thought, stuttering is a sign of underlying psychopathology (Bloodstein, 1995), and treatment must address the presumed psychopathology rather than the overt manifestation of the disorder. The use of novel speech patterns to treat stuttering was also rejected by the Iowa school, which emerged during the 1940s. This movement proposed that any effective avoidance of stuttering must involve the fear and avoidance of stuttering and establishing an objective attitude towards it. Although the methods for modifying and controlling stuttering are also advocated, eliminating stuttering is not of paramount importance. In this school of thought, there is no place for replacing stuttering with a novel speech pattern.

However, the emergence of behavior therapy in the 1950s greatly influenced the treatment of stuttering in the long term. From this perspective, stuttering is regarded as aberrant speech behavior that can be modified without reference to possible causes of underlying processes. In contrast to the deterministic view of psychoanalysis, behavior therapy emphasizes the
role of antecedent and contingent events in maintaining behavior. Early laboratory studies showed that, altering the environmental consequences can modify stuttering and so the use of contingences was incorporated into current treatment practices. In contingency management, desirable behavior is reinforced and undesirable behavior is punished. In the context of stuttering treatment, stuttering is undesirable behavior and is therefore punished. Stutter-free speech is desirable behavior and is, therefore, reinforced. This was probably responsible for a renewal of interest in novel speech patterns; for it was well known that rhythmic speech could quickly and effectively produce the desired behavior, namely stutterer-free speech.

Thus in the 1960s, rhythmic speech again became the basis of stuttering treatments, because it could replace the aberrant behavior of stuttering with stutter-free speech. Interestingly, these treatment programs were typically conducted intensively and in groups, similar in format to the stuttering schools that gained such notoriety in the early part of the century. However, this time rhythmic speech was used within the behavioral paradigm (Van Riper, 1973; Wingate, 1976; Ingham, 1984), which advocates the use of experimental method, the operationalization of treatment objectives and the continuous evaluation of treatment effects.

The variant of rhythmic speech that was prominent in the early group behavioral programs was syllable-timed speech. Participants in these groups learned syllable-timed speech at a slow rate, with the help of metronome, if necessary. This stutter-free speech was then shaped towards normal rate with
programmed instruction, and participants then used the novel speech pattern to control their stuttering outside the clinical setting, in much the same way that participants in prolonged speech programs do today. However, reports indicated that only about 50% of clients obtained any long-term gains from rhythmic speech programs and that participants were reluctant to use the speech pattern outside the clinic.

There was a resurgence of interest in the use of legato speech to control stuttering in the 1950s. This was mainly due to the laboratory findings that this drawling type of speech could be induced by delayed auditory feedback during speech, (Goldiamond, 1965). Goldiamond called this legato speech as ‘prolonged speech’, and with single case studies he demonstrated that subjects could increase speech rate and achieve more normal-sounding speech as the delayed auditory feedback (DAF) intervals were systematically reduced. In this way the stutter-free prolonged speech patterns could be used to control stuttering in everyday situations. This procedure was quickly adopted by clinicians who were interested in incorporating the systematic methods of behavior modification into stuttering treatments, and clinicians soon found that prolonged speech could be taught without DAF by simply providing a model (Ingham, 1984). Prolonged speech replaced rhythmic speech as a method of controlling stuttering in behavioral treatments because comparative research suggested that, prolonged speech was a better procedure for establishing stutter free speech. Ingham and Andrews (1973) found that although both syllable timed speech and prolonged speech reduced stuttering, participants using prolonged speech were able to speak faster after
treatment, and their residual stuttering consisted of repetitions of sounds rather than blocks.

Many who worked with Goldiamond’s procedure ultimately realized that this speech pattern could be learned just as easily through clinician instructed models of the pattern (Webster, 1980) or from recordings of those models (Ingham & Andrews, 1973). This led to numerous variations on the speech pattern that emerged from Goldiamond’s procedure. Consequently, “prolonged speech” became a generic term applying equally to procedures with labels such as “precision fluency shaping”, “smooth motion speech”, “breath stream management”, “regulated breathing” and the like, all are now considered to be variants of prolonged speech.

Since the research of Goldiamond, a number of treatment centers have developed their own variants of prolonged speech. The variants that predominate in Australia are smoothed speech and the prolonged speech pattern used in the Ingham (1981) program. In North America, variants of prolonged speech include those that have developed in the Monterey Program, the Comprehensive stuttering program, the rate control breath stream management program, and the Precision Fluency Shaping program. The Monterey variant is used in Holland.

In general, the prolonged speech treatment programs involve the instatement, shaping, generalization, and maintenance of fluent prolonged speech. There are two hallmarks of the prolonged speech therapies: The
unique speech skill and the specific training procedure. The speech skill in the prolonged speech originally referred to the slowing of speech by prolonged vowels, a pattern which usually occurs artificially during delayed auditory feedback of speech (DAF) at about a quarter of a second delay. However, over the years, the term-prolonged speech has embraced various combinations of gentle onset of words, soft articulatory contacts, smooth transition between sounds, and exaggerated continuity of speech. Several researchers have used prolongation and it is claimed that prolongation serves as a distraction, provides more time for the stutterer to move his articulator smoothly, reduces prosodic load, and enhances coarticulation.

3) Variants of prolonged speech techniques

a) Conversational rate control therapy and breath stream management therapy

(Curlee & Perkins, 1969, 1973): Curlee and Perkins (1969, 1973) saw the potential of Goldiamond’s findings and developed the approach further in their conversational rate control therapy. They took advantage of the fact that the duration of auditory feedback delay determines the rate of the resulting speech. That is, the rationale was that the duration of delayed auditory feedback (DAF) determines the rate of speech, which can be controlled in persons with stuttering. This made it possible to use DAF to elicit slow prolonged speech and then gradually increase persons with stuttering speech rate to normal by stepwise decreases in feedback delay, while requiring clients to demonstrate zero stuttering at each step. The steps of the therapy were (a) establishment of the baseline, (b) use of DAF to elicit prolonged
speech, (c) decreasing delay when client shows zero stuttering, (d) eliminating delay, and (e) extending the new fluent speech in increasingly demanding situations. But the authors noted that client’s unrecorded speech was less fluent than the recorded samples and the speech of persons with stuttering sounded unnatural. Perkins broadened this approach with addition of breath stream management, phrasing and prosody which resulted in improved long-term results, both in terms of greater reduction in stuttering frequency and more normal speech rates (Perkins, Rudas, Johnson, Michael & Curlee, 1974). The treatment involves the consecutive acquisition of seven skills with mastery of each required before progress on to next is permitted. These skills included slow rate, phrasing, easy voice onset, soft contacts, breathy voice, blended words, and normal stress. But the mastery of these skills is largely based on subjective judgments, which, Perkins argues, are best made by the clinician (Perkins, 1981).

b) **Intensive token economy therapy (Ingham & Andrews, 1973):** Ingham and Andrews (1973) substitute their highly structured, token reinforced rhythmic speech with DAF induced prolonged speech. But they later found that instruction and modeling of prolonged speech was as effective as DAF. The rationale of this technique was that a behavior punished decreases and behavior rewarded is reinforced. Speech was then gradually shaped to normal rates in structured group conversations. A unique feature of this treatment was that clients could be required to speak at quite specific rates at each step in therapy, because clinicians were trained to carry out online measurement of rate, and individual display units provided clients with constant feedback on
their stuttering and speech rate. This contrasts with Perkins’ use of DAF to regulate speech rate.

The original Ingham and Andrews’s program aimed for total stimulus control over fluency during the entire speaking day. The various steps included the following: (1) model prolonged speech, (2) shape into normal conversation in group conversation, (3) client should speak at specified rate at each step, and (4) give penalties for stuttering and rewards for fluency and speech rate targets. At every step in the program, zero stuttering was the criterion for progress. Clients were hospitalized for 5 weeks of intensive treatments and a full token economy was used, with penalties for stuttering and rewards for achieving fluency and speech rate targets. Transfer and maintenance phases were carefully programmed and rewarded also. Yet the entire treatment was carried out in the conversational context, and treatment took place during group conversations around a circular table with clients and a clinician who rated the speech from a central sole. Transfer assignments were carried out in the real world with the aid of concealed, portable tape recorders and were evaluated later in the clinic. Maintenance was structured, with decreasingly frequent contact for clients who met speech target criteria.

Since the original Ingham & Andrews’s program, it has undergone various modifications in terms of more structured maintenance procedures, self-evaluation training and no use of token economy rewards (Ingham, 1980; Andrews, Craig, & Feyer, 1983).
c) Precision fluency program (Webster, 1974): Developed by Webster in the early 70s (Webster, 1974, 1975a; 1975b), this approach is based on the premise that stutterers’ articulatory and phonatory gestures are distorted and require reconstruction through intensive over learning of appropriate speech targets. The targets are stretched syllables, smooth transitions between syllables, and slow change within syllables, diaphragmatic breathing, and gentle onsets. Initially the clinician works with single syllable and then moves to longer words and phrases. Feedback on the major two speech targets is the objective. Prolongation (“stretched syllables”) is checked with a stopwatch, and gentle onsets. Continuity is acquired with the aid of feedback from a computerized voice onset monitor (VOM) that monitors voice amplitude at the beginning of an utterance and its rate of increase.

In this program, the strict behavioral approach is largely restricted to the over learning of the stretched syllables. Gentle onsets and continuity targets are not quantified. Speech rate increase is not systematically programmed as in the DAF therapies and the transfer and maintenance phases of treatment are much less rigorously programmed than the intensive target practice phase.

d) Operant DAF therapy (Ryan, 1979): This technique is based on the classical behavioral approach developed by Ryan and Kirk (1974). This program consisted of several steps to teach the patient to read, engage in monologue, and converse in slow, prolonged, fluent pattern with the aid of delayed auditory feedback apparatus. The first six steps as reported by Ryan and Kirk
were to teach the patient to correctly identify stuttered words in reading and monologue. Criteria of one minute and 90% accuracy of identification were used in these steps. The next seven steps were in reading and used DAF starting with 250 ms. Delay was gradually reduced in 50 ms steps until the patient could read in the prolonged, fluent pattern without the DAF equipment. The next seven steps were the same except that these were in monologue. The final seven steps were same except that these were in conversation. The patient had to reach a criterion of five minutes of fluency in each of the 28 steps to pass, i.e. the patient had to obtain 5 minutes of stutter-free speech at each step. Verbal reinforcement, such as “good” was administered for the completion of steps. This program included a carefully planned hierarchy of increasingly difficult to transfer assignments. The patients also continued home practice throughout the transfer program. Dramatic decrease in stuttering frequency and the achievement of normal speech rates have been reported.

**e) The prince Henry program (Andrews, Craig, & Feyer, 1983):** This program is the outcome of Ingham and Andrews’s (1973) program and it is based on systematic acquisition and generalization of a prolonged speech pattern. The speech pattern taught is labeled as smooth motion speech. This smooth speech is characterized by a gentle onset of phonation, continuous airflow, continuous movement of articulators throughout each utterance, soft contacts and extension of vowel and consonant duration. The required speech pattern is trained using instruction and modeling (not DAF), at a speech rate of 50 syllables per minute (SPM), which is approximately a quarter of normal rate.
At this rate, if the correct speech pattern is used, stuttering is virtually removed and secondary symptoms of stuttering disappear automatically. This speech rate is then gradually shaped to normal rate over the course of the week in gradual increment of 5 SPM. In this treatment program the patient is admitted in the hospital for 3 weeks and 12 hours daily treatment is given. After the patient has got control over this speech, tape-recorded home assignments are given to maintain control over speech outside the clinical situation. As this treatment is done in series of steps, at each step the patient must display zero stuttering. Each stutterer’s speech is rated on-line by the clinician, and constant feedback on fluency and speech rate is provided on individual display units. Later on in the program three other characteristics - intonation, presentation, and appropriate pauses are also evaluated. It has been reported that by the end of the 1\textsuperscript{st} week the patients are stutter-free in the clinic and they speak at normal rates. Patients transfer these skills to real world situation during the 2\textsuperscript{nd} and 3\textsuperscript{rd} week. There are 30 assignments given to the patients at 3\textsuperscript{rd}, 6\textsuperscript{th} and 9\textsuperscript{th} week and six months after the treatment. The patients are required to come for follow-up.

f) Non-programmed, instrument free method of prolonged speech (O’Brien, Onslow, Cream, & Packman, 2003): There are four components in this program: (a) individual teaching sessions, (b) a group practical day, (c) individual problem solving sessions, and (d) a maintenance phase. During individual teaching sessions, clients learn the prolonged speech pattern in a slow and exaggerated fashion, imitating a video exemplar. No reference is made to specific target behaviors such as soft contacts or continuous
vocalization. At this stage, clients also learn to evaluate their stuttering severity according to a nine-point scale (1= no stuttering, 9= extremely severe stuttering). The purpose of this component is to determine whether clients can learn the basic behaviors required during the treatment. During the group practice day, clients complete a number of trials. Each trial consists of a sequence of three tasks: (a) practicing prolonged speech in an exaggerated manner, (b) speaking with instructions to use whatever features of the prolonged speech pattern they need to, control stuttering while attempting to sound as natural as possible, and (c) using nine-point scale to evaluate their stuttering severity and speech naturalness. Clients are taken through any systematic speech shaping procedure. The trials occur in one-to-one and then group settings. The purpose of this component is for clients to gain consistent control over their stuttering. Subsequently, during individual problem solving sessions, clients visit the clinician regularly in order to develop strategies for generalizing stutter-free speech. Finally, when stuttering has reduced to minimal levels for several weeks, across a variety of situations beyond the clinic, clients move into a performance-contingent phase.

To summarize, in prolonged speech techniques, participants control their stuttering at a slow speech rate that is then systematically shaped towards more normal sounding speech. This stutter free speech is then used outside the clinic. Despite the similarity of some aspects of these programs to the stuttering schools, most treatment programs now incorporate procedures
designed to assist clients to generalize and maintain the benefits of the clinic-based stage of treatment.

4) **Efficacy measures**

Ingham (1993) stated that, behavioral stuttering treatments should include “the quantification of treatment targets, plus the systematic evaluation of relevant behaviors across clinically important settings and over clinically meaningful periods of time. **Efficacy** is the extent to which a specific intervention, procedure, regimen or service produces a beneficial result under ideally controlled conditions when administered or monitored by experts. In contrast **treatment effectiveness** is the extent to which an intervention or treatment employed in the field does what it is intended to do for a specific population (Last, 1983). Treatment efficacy research can be characterized as an investigative tool for examining the effects of environmental variables on orgasmic variables (i.e., communication behaviors). Moreover, it has been suggested that beauty of efficacy research is its ability to address theoretical and clinical questions simultaneously (Olswang, 1993). Recent concern has been expressed about the absence of rigorous documentation regarding the efficacy of particular interventions (Ansel, 1993; Conture, 1996; Cordes & Ingham, 1998). It has even been asserted that the state of stuttering treatment research, at least up to early 1996, was abysmal and that some leaders in the field appear to have abandoned basic scientific principles that are at the heart of any attempt to establish treatment efficacy (Cordes, 1998). A number of outcome studies have indicated that current PS programs can reduce or
eliminate stuttering in the short term and to a lesser degree in the long term. In a review of worldwide stuttering treatment practices, Andrews, Guitar, and Howie (1980) concluded that the most effective treatments for advanced stuttering are those based on prolonged speech. Andrews and colleagues (1980) reviewed 42 studies and examined symptom reduction treatments in adults who stuttered. Results revealed that prolonged speech, gentle onset, rhythm, airflow, attitude change and desensitization were the six most common principal treatment formats. Both prolonged speech and gentle onset yielded the greatest effectiveness and appeared to be the strongest treatments in both long and short-term evaluations. Sheehan (1984) suggested that the positive results of these prolonged speech, gentle onset, and rhythm investigations were heavily based on frequency and rate measures. This could be because initially it was thought that stuttering is a comparatively simple disorder to measure (Ingham & Andrews, 1973), and counting the moments of stuttering which began in the 1930’s not only operationalized the measurement of stuttering but brought with it the rigor of scientific enquiry. The available data are not always complete. The representation of the speech measures reported is sometimes less than satisfactory, and speech rate and naturalness are not always evaluated. But in general the picture is a consistent one. Regardless of the specifics of treatment, on average, as long as a year after treatment, persons with stuttering can be expected to demonstrate fluency at less than 2% syllables stuttered (SS) with normal speech rate (between 160 and 240 SPM). Any new therapies would need to equal or better this outcome.
Although prolonged speech treated persons with stuttering rarely stutter and do not speak extremely slowly, the results of the naturalness studies show that their speech can be distinguished from nonstutterer’s speech, though the basis is not clear. If the basis of this discriminability can be established, then it may be possible to improve the outcome of prolonged speech treatments. The effectiveness of these treatments do not appear to depend on whether they are intensive or spaced, group or individual, molar or molecular in emphasis. Similarly, the particular aspects of prolonged speech that are emphasized in training do not appear to be critical to the success of treatment, i.e., although the slowed articulation rate may be more effective than simply increasing pausing and soft attacks and continuity may be important. It may be possible that a major value of prolonged speech treatments is that they force a client to slow his speech sufficiently to allow him to pay attention to what he does when he is fluent and to reprogram his articulators accordingly. The reasons as to why prolonged speech therapies work is not known. Some of the recent evidence of aberrant laryngeal behavior, speech pattern and breath characteristics and abnormalities in speech motor control among persons with stuttering, suggests that the modification of these aspects of speech is a proper concern of stuttering treatment. Beyond that, the basis for the potency of these techniques remains a mystery (Howie, Tanner & Andrews, 1981). Systematic assessment of the efficacy of treatments utilized by a profession is essential to the maintenance of the clinical integrity of any profession (Curlee, 1993). Efficacy in the past has been measured by the use of several perceptual and acoustic measures.
A) Perceptual measures

(a) Frequency measures: Arguably percentage of syllables or words stuttered (% SS or % WS) is the single most useful and common speech measure in stuttering treatment. In order to obtain % SS or % WS scores, the number of syllables or words is counted along with the number of words or syllables that are stuttered. For example, if 1376 syllables are spoken and 56 syllables stuttered, % SS will be equal to 56/1376 x 100 = 4.1. One limitation of % SS and % WS measures is that they do not always reflect severity. Some clients may stutter quite infrequently, but may have long pauses. On the other hand, some clients may stutter frequently, but may not have any pauses. Also the most notable problem in this measure is reliability (Cordes & Ingham, 1995a). However, for outcome research, frequency measure is acceptable because large differences are of interest (considerable stuttering before treatment and virtually none after treatment). More than 10 studies on frequency of stuttering before and after prolonged speech, 7 on gentle phonatory onset and 7 on smooth flow of speech have been reported. Table 1 reports the results of the various studies that used percent of dysfluency as a measure to depict the outcome for prolonged speech procedure.
<table>
<thead>
<tr>
<th>Author</th>
<th>Number of subjects</th>
<th>Age of Subjects</th>
<th>Duration of treatment</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Prolonged speech</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spencer (1976)</td>
<td>5</td>
<td>Adults and children</td>
<td>4 months</td>
<td>Stuttering was reduced to less than 1% of syllables</td>
</tr>
<tr>
<td>Boberg (1976)</td>
<td>21</td>
<td>17-44</td>
<td>3 weeks</td>
<td>Stuttering decreased from mean of 21% of syllables to 1.3%</td>
</tr>
<tr>
<td>Franck (1980)</td>
<td>68</td>
<td>Mean of 20.2 years</td>
<td>1 year</td>
<td>93% of subjects increased fluency by 60% or more</td>
</tr>
<tr>
<td>Boberg (1981)</td>
<td>6</td>
<td>16-46 years</td>
<td>3 weeks</td>
<td>Mean percent syllables stuttered decreased from 16.55 or more</td>
</tr>
<tr>
<td>Howie, Tanner, &amp; Andrews (1981)</td>
<td>36</td>
<td>Adults</td>
<td>3 weeks</td>
<td>Stuttering was virtually eliminated</td>
</tr>
<tr>
<td>Evesham &amp; Huddles (1983)</td>
<td>47</td>
<td>Adults</td>
<td>3 weeks</td>
<td>91% stuttered on less than 1% of syllables</td>
</tr>
<tr>
<td>Boberg (1984)</td>
<td>12</td>
<td>18-47 years</td>
<td>2 weeks</td>
<td>Mean percent of stuttered syllables decreased from 18.9 to 0.9</td>
</tr>
<tr>
<td><strong>Gentle phonatory onset</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Webster (1975a)</td>
<td>56</td>
<td>8-59 years</td>
<td>3 months</td>
<td>Significant differences in pre-post treatment measures of stuttering</td>
</tr>
<tr>
<td>Schwartz &amp; Webster (1977)</td>
<td>29</td>
<td>9-over 50 years</td>
<td>3 weeks</td>
<td>97% improved; 72% stuttered on 6% or less of words</td>
</tr>
<tr>
<td>Webster (1979)</td>
<td>200</td>
<td>-</td>
<td>3 weeks</td>
<td>Stuttering was reduced to a mean of 1.3% of words</td>
</tr>
<tr>
<td>Webster (1980)</td>
<td>200</td>
<td>-</td>
<td>3 weeks</td>
<td>Mean percent of words decreased from 15.1 to 1.3</td>
</tr>
<tr>
<td>Mallard &amp; Kelley (1982)</td>
<td>50</td>
<td>14-50 years</td>
<td>6 weeks</td>
<td>Mean percent of stuttered words fell from 20.05 to 2.92</td>
</tr>
<tr>
<td>Heller, Schulman, &amp; Teryek (1983)</td>
<td>85</td>
<td>6-65 years</td>
<td>4 weeks</td>
<td>84% achieved normal or near-normal fluency in conversation</td>
</tr>
<tr>
<td>Franken, Boves, Peters &amp; Webster (1992)</td>
<td>32</td>
<td>15-46 years</td>
<td>3 weeks</td>
<td>Mean % of stuttered syllables declined from 25.7 to 5.8</td>
</tr>
<tr>
<td>Smooth flow of speech</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------------------------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Craig &amp; Andrews (1985)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adults 3 weeks 17  Mean % syllables declined from 12.9 to 0.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Andrews &amp; Feyer (1985)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>37  21-60 years 3 weeks  Mean % of stuttered syllables declined from 14.1 to .1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Jehle &amp; Boberg (1987)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8  17-30 years 3 weeks  Mean % of stuttered syllables declined from 18.0 to .7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Jehle &amp; Boberg (1987)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7  13-16 years 3 weeks  Mean % of stuttered syllables declined from 21.6 to 4.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Boberg &amp; Kully (1985)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17  14-38 years 3 weeks  Mean % of stuttered syllables declined from 25.1 to 1.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Randoll (1988)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7  4-9 years 4-9 weeks  In 4 cases, improvement in stuttered words per minute was observed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12  10.7- 41.6  3 weeks  Within clinic and beyond clinic % SS reduced generally to near zero.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table1: Summary of studies that used percent dysfluency as a measure of outcome (N= number of subjects)

Almost all the studies have reported percent dysfluency before and after therapy. The results of all these 24 studies indicate that the post-treatment mean percent dysfluency reduced significantly to less than 5%, which is considered as normal.

(b) **Speech rate:** Usually speech rate is measured in terms of the number of syllables or words spoken and time taken to speak those syllables or words.

For example if 1245 syllables are spoken in 6.75 minutes, the syllables per minute (SPM) is equal to 1245/6.75 =184.4. If 1200 word are spoken in 6 minutes then the words per minute (WPM) is equal to 1200/6 = 200 WPM.

This measure of speech rate is important in clinical practice because rate reduction is incorporated in some prolonged speech techniques. Onslow (1996) summarized issues related to speech rate and stuttering. Onslow
commented that, the real value of speech rate measures comes from the fact that speech rate has two relationships to stuttering severity. The first relationship is that *stuttering may decrease when speech rate decreases*. Therefore, during some treatment procedure a measure of speech rate can provide a check that it is the treatment, not just the rate reduction that reduces stuttering. The second relationship between *speech rate and stuttering is inverse* one. That is, if there is severe stuttering, then speech rate will tend to reduce because dysfluencies consume time. This means that speech rate measures can reflect the way that persons with stuttering consume time that otherwise would be occupied in producing speech. Therefore, speech rate measures are useful adjunct to stuttering severity measures. One limitation of SPM and WPM measures is that little is known about how fast any given person should speak as about the range of speech rates during everyday speech. This is especially so in case of children, in who little is known except that speech rate is a developmental variable. For adults, some treatment programs give the impression that normal speech rate is around 200 SPM. However, there is such a wide range of normal speech rate that any average value has little meaning. Another problem is that clinical attempts to time the intervals during which speech occurs have questionable accuracy. Although this measure provides information about stuttering severity, it does not accurately reflect speech rate when stuttering frequency changes in experimental or treatment studies. Recent advances in acoustic analysis software have also facilitated a measure of speech rate that does not include dysfluencies. This is usually expressed as syllables per second and is
regarded as a measure of articulation rate (AR) (Packman, Onslow, & Menzies, 2000).

Stutterers’ have been reported to commend slow speaking as an aid to overcome stuttering and have even claimed this to be a reason for their self-recovery (Shearer & Williams, 1965). Ingham, Andrews, and Winkler (1972) reported that a decrease followed by a systematic increase in speech rate occurred during a rhythmic or syllable timed speech therapy program. Prins, McGough, and Lee (1972) considered that a slow, controlled rate of speaking was important to the results they achieved with a patient operated tape-recorded traditional therapy program. Ingham and Andrews (1973) investigated the effect on stuttering, by altering and controlling rate of speaking. Frequency and percentage of words stuttered by three adult persons with stuttering were assessed under conditions designed to modify and control rate of speaking. Target rates of 50% below base rate, and base rate were sought in experimental periods by on-line signaling of proximity to the target rate. Two subjects who reduced their frequency met a criterion of rate control and percentage of words stuttered in the 50% below-base rate condition.

Ramig and Adams (1981) have shown that in addition to the expected direction changes in fundamental frequency, persons with stuttering reduce their speaking rate and modify their fundamental frequency and vocal sound pressure as they speak in higher or lower than normal pitches. In another study conducted by Ramig, Krieger, and Adams (1982) stuttering subjects
reduced their speaking rate, as well as modified their fundamental frequency range, when they spoke to children.

Ramig (1984) compared the durational (rate) characteristics in fluently read utterances spoken by persons with stuttering over several trials before and after stuttering intervention. Nine adult male persons with stuttering ranging in age from 18 to 37 years were the subjects. All the subjects were taught to initiate each sentence using light articulator contact and a slight elongation of the first sound or syllable of a 200 word reading passage. Results revealed that subjects exhibited significantly fewer dysfluencies in the post-therapy trails, compared with their performance in the five pre-therapy trials. Subject’s significantly extended initial word and middle word duration in the post-therapy, while reading in the post-therapy compared with pre-therapy trials. However, the duration of final words of sentences spoken were not statistically significant. Also, sentences spoken in the post-therapy trial were longer than sentences produced in the pre-therapy trial.

Reduced speech rate is a feature of prolonged speech particularly in the early stages of instruction. Although programs typically include a shaping procedure, it is impossible to know without speech rate data whether participants achieve stutter-free speech after treatment at the expense of normal or near-normal speech rate. Table 2 is a summary of studies reported by Onslow, Costa, Andrews, Harrison, and Packman (1996), which have used rate of speech as a measure to represent the outcome of prolonged speech therapy.
Table 2: Summary of studies that used rate of speech (SPM) as an efficacy measure.

Onslow et. al. (1996) concluded from the review of these studies that reduced rate is a feature of prolonged speech particularly in the early stages of introduction. However, in Onslow et. al. (1996) study, 12 clients who underwent a non-programmed prolonged speech treatment, stuttering reduction was not obtained at the cost of reduced speech rate. They concluded that stuttering was eliminated without using unusually slow speech pattern. In addition to measures of stuttering frequency and speech rate, measures of speech naturalness have also been reported as an efficacy measure.

(c) Speech naturalness: The adjective “natural”, is derived from the Latin word naturalis, meaning “of nature”. Till today it is unclear what the source of a definition for speech naturalness should be. Till then the concept of speech naturalness will be defined on an individual, ad hoc basis by observers using their own internal standards (Schiavetti & Metz, 1997). The impetus for studying the speech naturalness of individuals treated for stuttering came from observations that many people who had undergone successful treatment using prolonged speech strategies continued to sound less than satisfactory.
That is, although the frequency of stuttering had decreased dramatically, listeners found that many speakers continued to sound unnatural. Their speech was effortful, uncomfortable to listen to, and contained auditory or visual features that prevented the listener from fully attending to the content of the message. Despite an otherwise successful treatment experience, many speakers found that they were still regarded by themselves and others as having problems (Schiavetti, & Metz, 1997).

In an attempt to investigate this effect, Ingham and Packman (1978) studied the normalcy of speech following treatment by comparing nine adolescents and adults who had undergone treatment with a prolonged speech procedure. These subjects were compared with nine normally fluent speakers matched for age and sex. The stuttering clients were seven males and two females, ranging in age from 13 to 24 years old. Listeners rated whether one-minute speech samples were either natural or unnatural based on certain features of speech behavior (prosody, rate, fluency, and naturalness). The authors found that the listener’s ratings of naturalness of the post-treatment clients were not significantly different from those of the normal speakers and when listeners were to decide whether each sample was from a normal speaker or of a treated stutterer, the persons with stuttering received significantly fewer normal speaker judgments. Here, although an attempt has been made to scale the post-therapy speech of stutterer, the reliability of the scale was not well established.
Martin, Haroldson, and Triden (1984) began the development of a reliable scale for rating speech naturalness. This was a nine-point scale with 1 equivalent to highly natural-sounding speech and 9 equivalent to highly unnatural-sounding speech. This scale has been used in virtually all subsequent investigations of speech naturalness. The original investigations by Martin et al. (1984) did not provide listeners with a definition of naturalness and asked the listeners to “make their rating on how natural or unnatural the speech sounds to them”. Subsequent studies have typically used identical or slightly altered instruction. In Martin et al.’s (1984) study 30 listeners used the scale and to assess speech naturalness in 1-minute speech sample of 10 adults who stuttered (ages 20-53) speaking without delayed auditory feedback, 10 adults who stuttered (ages 20-51) speaking under delayed auditory feedback, and a group of 10 normal speaking adults (ages 21-45). They found that both groups of speakers who stuttered (those with and without delayed auditory feedback) sounded significantly less natural than the normal speaking group. The mean naturalness ratings for the speakers who stuttered (without delayed auditory feedback) were 6.52. The stuttering speakers under delayed auditory feedback received a naturalness rating of 5.84. The speech of the normal speakers received a score of 2.12. Based on inter-rater agreement and rater consistency, Martin et al., concluded that listeners are able to quantify speech naturalness. When the same listeners repeated the task 1-3 weeks later, 88% of their second ratings were within plus or minus one unit of their first ratings. This finding led Ingham, Martin, Haroldson, Onslow and Leney (1985) to investigate whether such highly reliable listener ratings on this 9-point scale might also mean that
these ratings could be used to modify speech naturalness. In experiments with 6 adolescent/adult persons with stuttering, they demonstrated that, when a listener’s rating on the scale was fed back to the subject after each 20 seconds of spontaneous speech, 5 subjects improved their speech naturalness. This finding raised the obvious possibilities that a listener rating procedure might be profitably blended with therapy strategies; particularly those that utilize prolonged speech, in order to improve speech quality.

Ingham and Onslow (1985) described two studies that illustrate the utility of listener’s ratings of speech naturalness during a prolonged speech program on 5 adolescent persons with stuttering. In study A, a clinician used a 9-point rating scale to score the speech naturalness, of 1-minute speaking samples of each stutterer made at various intervals, over the course of the program. The results demonstrated predictable trends in speech naturalness during the program, but they also showed that natural sounding speech is not a predictable outcome of a procedure that removes stuttering, controls speaking rate, and exposes clients to transfer procedures. In study B, 3 of 5 persons with stuttering participated in single subject experiments partway through their therapy program. These experiments were designed to assess the effect of regular feedback of speech naturalness ratings on the stutterer’s spontaneous speech. The results showed that each stutterer’s speech naturalness ratings could be modified toward a target level of speech naturalness.
To evaluate the speech naturalness rating scales potential to differentiate between treated stutterers and nonstutterers, naturalness ratings were made of speech samples produced by 15 treated persons with stuttering and 15 normal fluent speakers matched for age and gender (Ingham, Gow, & Costello, 1985). The persons with stuttering had completed the instatement and transfer phases (but not the maintenance phase) of a stuttering therapy program that utilized prolonged speech (Ingham, 1981). At the completion of the therapy phase it was anticipated that each subject should have achieved stutter-free speech and a speaking rate consistent with that of normally fluent speakers. Speech samples of 1 minute in length were randomly selected from 5-minute monologues produced by both groups. All samples were judged stutter-free by two independent student clinicians whose syllable counts were also highly correlated (r = 0.91). The mean number of syllables in the treated stutterers’, sample was 183.91 and for nonstutterers’ sample it was 182.5. This difference was not significant [t (28) = 0.115, p> 0.05]. A group of 30 listeners (beginning students in health science courses) listened to a randomly ordered presentation of the 15 stutterers’ and 15 nonstutterers’ speech samples, plus 4 subjects’ samples located at the end of each tape. The listeners were asked to use the 9-point scale to rate each sample for speech naturalness and were given the same instructions regarding the scale as Martin et. al.’s (1984) listeners. Four weeks later they listened to the 34 samples and, on this occasion, were asked to judge whether each sample was the speech of treated stutterer or a normal speaker (after Ingham & Packman, 1978). The listeners’ data for the 15 treated persons with stuttering produced a mean naturalness rating of 4.26, and the 15 nonstutterers received a mean
naturalness rating of 2.39. The difference between these scores was significant \[ t(28) = 4.02; p<0.01 \]. In contrast, the mean percentage of normal speaker judgments was similar to speech samples of treated persons with stuttering (M = 62.5%) and nonstutterers (M = 64.1%). These mean scores were not significantly different. The data supplements the findings reported by Martin et. al. (1984). The results of this study reconfirmed that the 9-point speech naturalness scale may be valid and reliable instrument for measuring the speech quality of stutterers’ speech.

Ingham, Ingham, Onslow, and Finn (1989) were interested in finding how naturalness felt and sounded to the speaker, and thus considered the effects of instructions to clients to rate and change their own speech naturalness. Three males between the age of 22 and 30 volunteered for this study. All of them were in a prolonged speech program. Two experimenters listened to each subject as he spoke for five minutes during a series of two-to four-hour sessions. One experimenter counted stuttered and non-stuttered syllables, while the other experimenter made naturalness ratings between 1 and 9 every 30 seconds. The clients also rated their own speech naturalness. The results indicated that when the clients were asked to make their speech sound more unnatural, both the subjects’ and judges’ ratings were similar. When the clients were asked to improve their speech naturalness ratings, they judged their speech to be more natural, but the judges did not note the same improvements. The authors suspected that two groups of listeners were using different criteria for making the judgment of speech naturalness. The clients indicated that they listened for unusual prolongations or prosody in their
speech to help them rate their naturalness. These results indicated that naturalness ratings by trained and untrained judge might differ.

Metz, Schiavetti and Sacco, (1990) compared the naturalness rating in treated persons with stuttering (15 males & 15 females, ranging in age from 9 to 20 years with a mean age of 14.5 years) who underwent prolonged speech with nonstutterers using 9-point rating scale of Martin et. al.’s (1984) scale. The speech of the nonstutterers was judged more natural than the speech of the treated persons with stuttering. The results suggest the possibility that stuttering treatments that employ strategies like gentle voicing onset and prolonged speech may result in somewhat slower post-therapy speech patterns. This could influence listeners to judge the speech of persons with stuttering as more unnatural than the speech of nonstutterers.

To examine the possible therapeutic application of the 9-point speech naturalness scale, Runyan, Bell, and Prosek (1990) examined the relationship between percentage of correct identifications (stutterer - nonstutterer judgments) of those samples produced by treated persons with stuttering and the naturalness ratings applied to each sample. They suggested that determining any potential association between naturalness ratings assigned to pre-treatment severity ratings (e.g., mild, moderate, and severe) and post-treatment naturalness ratings could produce valuable prognostic information. In order to achieve this, the authors prepared an audiotape recording that consisted of 280 samples from normal speakers and treated persons with stuttering who had participated in one of six different therapy programs:
traditional (Van Riper, 1973), metronome-conditioned speech retraining (Brady, 1971), delayed auditory feedback (Ryan & Van Kirk, 1974), operant conditioning (Mowrer, 1975), holistic therapy (Perkins, 1973), and the precision fluency shaping program (Webster, 1974). Ten graduate students in speech-language pathology who had received training in fluency and fluency disorders served as judges. These listeners identified whether each speech sample was from a client or nonstutterer. Once this was decided, they again listened to the sample and rated each speaker’s naturalness using Martin et. al.’s (1984) nine-point scale. Listener responses were examined and speech samples were divided into two groups; easy-to-identify and treated, or difficult-to-identify clients. The results showed that significant differences were found between speech naturalness ratings of treated clients and fluent speakers. Listeners judged the treated clients’ speech as being more unnatural than that of normal speakers. Moreover, the difficult-to-identify clients were rated as sounding significantly more natural than the easy-to-identify clients (p<0.003). The difficult-to-identify clients’ mean speech naturalness score (2.38) was not significantly different from the normal speakers’ mean score (2.79). Finally, the authors found that post-treatment naturalness ratings of all clients were similar despite differences in pre-treatment severity ratings. Post-treatment scores were 4.26 for subjects judged to be mild, 3.82 for subjects judged to be moderate, and 3.68 for subjects judged to be severe.

However, these results were contradicted by Onslow, Hayes, Hutchins, and Newman (1992). These authors considered the effect of pre-treatment severity on both pre- and post-treatment naturalness ratings. Thirty-six
subjects between 9 and 50 years of age (mean of 21 years) who underwent prolongation therapy were studied. Fifteen listeners rated the naturalness of a 30-second speech sample from each subject. The results indicated that the most severe clients’ speech prior to treatment had naturalness scores that were more than two values higher (less natural) than the least severe clients. These results differed from those of Runyan, Bell, and Prosek (1990), who found similar post-treatment speech naturalness rating of all speakers regardless of pre-treatment severity.

Nearly all investigators of speech naturalness have used monologue speech or some combination of monologue and oral reading. Some were not specific concerning the speech tasks. Onslow, Adams, and Ingham (1992) were the first to investigate the effect of speaking task by comparing the influence of monologue and conversational speech. Subjects were seven males ranging in age from 14 to 36 years (average age of 21) who had received prolonged speech treatment. The subjects were matched in age (within six months) with seven nonstuttering male speakers. All subjects were recorded during conversation and monologue on three different occasions. Listeners selected 96 speech samples for analysis. Using the 9-point scale developed by Martin et. al. (1984), a group of 29 undergraduate university students assigned naturalness scores. The results showed no significant differences in the naturalness scores of conversation or monologue for either the speakers who stuttered or those who did not. The results confirmed the external validity of previous studies that were based only on monologue speech or failed to make the speech task clear.
In another study, Onslow, Adams, and Ingham (1992) considered the reliability of the nine-point scale in a clinical situation. Their intent was (a) to determine the reliability of listeners’ repeated ratings of one subject’s speech, (b) to compare the reliability of sophisticated and unsophisticated judges’ speech naturalness, and (c) to evaluate the influence of the duration of the speech sample. Speech samples were obtained from 10 adults and adolescents who were receiving treatment in a prolonged speech program. The listeners were 30 sophisticated and 30 unsophisticated judges. Subgroups of listeners rated speech samples of 15, 30 or 60 seconds in duration. The results indicated that the judges were inconsistent in their ratings, suggesting that procedures for rating naturalness need to be developed. There were no important differences between sophisticated and unsophisticated raters. Ratings made for 30 and 60 seconds resulted in the highest agreement and intraclass correlation.

All the studies discussed thus far used audio recordings of speech samples. There are, of course, many visual components of stuttering that are related to judgments of speech naturalness in the everyday world. In a first attempt to distinguish possible visual components, Martin and Haroldson (1992) studied six male and four female speakers who stuttered (ages 20-62 years) and six male and four female fluent speakers (ages 21-64 years). Twenty-four undergraduate college students made speech naturalness ratings of one-minute speech samples. Using the 9-point scale, subjects rated both audio and audiovisual speech samples. Another group of 30 undergraduate
students rated stuttering severity of the stuttered speech samples using a 9-point scale, with 1 representing very mild stuttering and 9 representing very severe stuttering. The results indicated that the naturalness judgments of fluent speakers were not significantly different for audio and audiovisual samples (2.30 and 2.27, respectively), However, for the subjects who stuttered, audiovisual samples were consistently judged as being more unnatural than audio only samples (6.81 and 6.04, respectively). The rating of stuttering severity was influenced by the fact that the speech samples of the stuttering subjects in this study were not stutter free with stuttered words averaging 17.4%.

Almost all the studies have looked into the naturalness characteristics of treated persons with stuttering as assessed by listeners who are either trained clinicians or undergraduate students. But the self-rating of persons with stuttering before and after therapy may be different. Finn and Ingham (1994) studied stutterers’ self-ratings of naturalness. Twelve adult persons with stuttering (11 males, 1 female) in the age range of 19-71 years volunteered to be subjects for this study. The results of the study showed that persons with stuttering were relatively consistent and valid self-raters of speech quality and levels of speech monitoring and they were also able to consistently differentiate how natural their speech felt and sounded.

Previously, the severity of stuttering was not part of the study. But, the severity of stuttering may also affect naturalness rating. Therefore, Kalinowski, Nobel, Aromson, and Stuart (1994) determined the pre- and post
treatment speech naturalness of five adult speakers with more syllables stuttered (23% or greater). Sixty-four naive listeners (32 male and 32 female college students) rated these adult speakers using Martin et. al. (1984) nine-point scale. The listeners rated both pre- and post treatment one-minute videotape recordings of conversational speech. All subjects had taken part in the Precision Fluency Shaping Program (Webster, 1975a, 1975b) and, at the completion of formal treatment, were either nearly or completely stutter-free. However, despite the post treatment reduction in the frequency of stuttering for mild as well as severe subjects, both groups of speakers were rated as being significantly more unnatural sounding (higher scores on the naturalness scale) following treatment. In addition, subjects with severe pre-treatment stuttering were rated as significantly less natural than those with mild stuttering. These findings coincide with those of Franken, Boves, Peters and Webster (1992), who found that the naturalness scores of 32 clients with severe stuttering; who underwent fluency shaping treatment remained unchanged from pre-treatment to post treatment. That is, while it is to be expected that severe stuttering is likely to result in listener judgments of highly unnatural speech, increased fluency that is produced in an effortful and carefully controlled manner will also be judged as unnatural. Thus even with increased fluency, some therapy procedures often tend to diminish the quality of a person’s speech.

Most of the studies are restricted to limited speech samples. However, speech samples across situations may provide different ratings. To verify this, Onslow et. al. (1996) used extensive speech outcome measures across a
variety of situations in evaluating the outcome of an intensive prolonged speech treatment (Ingham, 1987). The speech of 12 clients in this treatment was assessed on three occasions prior to treatment and frequently on eight occasions after clients were discharged from the residential setting. For 7 clients, a further assessment occurred at 3 years post treatment. Concurrent dependent measures were percent syllables stuttered, syllables per minute, and speech naturalness. The dependent measures were collected in many speaking situations within and beyond the clinic. Dependent measures were based on speech samples of substantive duration, and covert assessments were included in the study. Detailed data were presented for individual subjects. Results showed that 12 subjects who remained with the entire 2-3-year program achieved zero or near-zero stuttering. The majority of subjects did not show a regression trend in % syllables stuttered (%SS) or speech naturalness scores during the post treatment period, either within or beyond the clinic. Some subjects showed higher post treatment % SS scores during covert assessment than during overt assessment. Results also showed that stuttering was eliminated without using unusually slow and unnatural speech patterns. This treatment program did not specify a target speech rate range, and many clients maintained stutter-free speech using speech rates that were higher than the range typically specified in intensive prolonged speech programs. A significant correlation was found between speech rate and perceived post treatment speech naturalness.

Harrison, Onslow, Andrews, Packman, and Webber (1998), investigated the speech measures in adult persons with stuttering between the age range of
13-36 years who underwent prolonged speech program adopted by Ingham (1987) program. But, here they reduced the instate phase of the program to a single, 12 hour day and transfer phase was dispensed altogether. Speech measures included percent syllables stuttered, SPM and speech naturalness ratings developed by Martin et. al. (1984). Speech samples were based on one-minute recordings of conversational speech, and the samples were collected at different speaking situations such as, with family, with friends, and speaking on telephone. Results revealed post treatment regression of % SS scores in the range of 0-1% SS, and some subjects achieved speech naturalness scores in the normal range. The results were similar to Onslow et. al. (1996) study even after considering the fact that the instatement phase was shortened to a single 12-hour day and the “transfer” phase was deleted. So, there might be aspects of the original treatment that may not contribute to its outcome.

Following this, O’Brian, Cream, Onslow and Packman (2003) investigated outcome evaluation of a non-programmed prolonged speech without intensive format, formal transfer phase and standardized prescriptive prolonged speech target behavior and instrumentation for the online counting of stuttering rate and speech rate. Three adults who stutter participated as subjects. For the purpose of establishing treatment outcome, each subject was required to collect a total of 21 x 10 minute recordings of speech beyond the clinic. The samples were collected on two occasions before treatment (1 month and 1 day) and on five occasions following the group practice day (1 day, 1 month, 3 month, 6 months, and 12 months). On each occasion,
clients were instructed to audio record their speech, conversing with a family member, with a friend, and conversing on the telephone. An independent clinician rated the samples for speech naturalness, % SS scores and SPM. Results revealed progress of each client in terms of severity and naturalness ratings across the group practice day. By the end of the day all clients had achieved natural sounding speech that was essentially stutter-free. There was no clinically significant decrease in speech rate for any of the clients after the treatment. Their low levels of stuttering were maintained for 10-13 months. The results revealed a number of issues that need consideration when relating the experimental results to therapy practice. To begin with they relate to therapy program, which contains relatively distinctive characteristics. The therapy program is conducted under intensive conditions with relatively tight controls over stuttering and speech rate. Second, the duration of many of these prolonged speech programs may be much greater than necessary. Third, the present program and the Harrison et. al. (1998) program achieved similar results despite considerably reducing the amount of clinician time involved (an average of 18 hour). Forth, the clients learned prolonged speech without reference to any of the traditional target speech descriptors. Finally, the results also challenged the programmed instructed feature of traditional prolonged speech program.

In all these research, starting from Martin et. al. (1984) to Harrison et. al. (1998) the 9-point scale was primarily used as an instrument in the assessment of treatment. Clients are urged to speak more naturally if the clinician feels that the clients’ speech sounds unnatural. Franken, (1987), and
Franken, Boves, Peters, and Webster (1995) showed that naturalness is a multifaceted variable that is related to a number of other perceptual characteristics of a speech sample. Thus, speech may fail to sound natural for a number of reasons. Because of the multidimensional nature of speech naturalness, the probability that a clinician can help a stutterer to improve the overall speech quality becomes higher if he or she can diagnose the dimensions that are most deviant. However, reliability measures appropriate for scales to be used by a single clinician are different from the measures when averages are obtained from many raters (Kreiman, Gerratt, Kemster, Eerman & Berke, 1993). Keeping this in mind, Franken, Boves, Peters, and Webster (1995) developed a *speech quality instrument* that described the quality of speech samples and included a speech naturalness scale. The instrument consists of 14, 7-point bipolar (equal appearing interval) rating scale, defined by contrastive terms that label extreme analogous to the semantic differential. The scale covers seven dimensions, five speech and two general. This scale includes low pitch-high pitch, slow-quick, slovenly-polished, flat-expressive, shrill-deep, soft-loud, monotonous-melodious, tense-relaxed, week accentuation-strong accentuation, unpleasant-pleasant, slurred-precise, fluent-halting, weak-powerful and unnatural-natural. Thirty-two male persons with stuttering and 20 male nonstutterers provided speech samples. Mean age of the persons with stuttering was 25.3 years. Subjects’ speech was recorded immediately before they started a Dutch adaptation of Webster’s precision fluency shaping program. The stutterers’ speech was also recorded immediately after completion of treatment (post treatment) and 6 months after the treatment (follow-up). The samples were
collected on conversation. Naive listeners were used to the rate the samples. Analysis of the ratings obtained with the speech quality instrument showed that naturalness is a multidimensional characteristic. The psychometric characteristics of the instrument are analyzed in detail. It was concluded that mixing of samples of persons with stuttering and nonstutterers in one rating experiment may artificially inflate the reliability of the ratings. Also, ratings on equal appearing interval scales cannot be interpreted in an absolute sense.

Subramanian, (1997), and Kanchan, (1997) developed a naturalness scale to rate the speech naturalness in persons with stuttering and compared the ratings from a group of unsophisticated listeners (Subramanian, 1997) with those from a group of sophisticated listeners (Kanchan, 1997). Initially, a pilot study was carried out. Twenty-nine speech samples, including pre-therapy speech, post-therapy speech and speech of normals was rated by three sophisticated (graduates in Speech & Hearing, Subramanian, 1997) and three unsophisticated (graduates in other discipline, Kanchan, 1997) listeners on a 9-point scale (highly natural to highly unnatural). The results indicated a correlation between mean naturalness scores, percent dysfluency and rate of speech. However, using a 9-point scale, it was not possible to differentiate between pre-therapy speech, post-therapy speech and speech of normals. Therefore, it was decided to use a binary scale to rate naturalness.

In Subramanian’s (1997) study, 60 postgraduate students of Speech and Hearing listed the parameters contributing to speech naturalness. The percent times a parameter contributed to speech naturalness was calculated and
weightage was given to all the parameters listed. Based on the percent weightage of each parameter, naturalness scale was constructed. This scale included confidence, command over language, clarity, speed, continuity, stuttering, and overall rating. Using a binary scale (natural, unnatural), six judges (3 unsophisticated and 3 stutterers) rated 68 samples of spontaneous speech and reading which included seven normal speech samples, 32 pre-therapy samples of persons with stuttering and 29 post-therapy speech samples of persons with stuttering. Six of the samples were repeated to check intra judge reliability. A score of “1” was given when the parameter was judged “natural”. The naturalness score, the percent dysfluency and the rate of speaking (words per minute) were calculated. The results indicated that unsophisticated listeners and persons with stuttering rated the pre-therapy samples, post-therapy samples (4.97 and 4.66, respectively) and speech of normals (3.55) differently. No significant difference between the ratings of persons with stuttering and unsophisticated judges was observed. Low naturalness was correlated with slow rate of speaking and increase in percent dysfluencies. Factor analysis indicated that confidence, continuity, speed, clarity, stuttering and overall rating were some of the important factors determining naturalness. However, command over language did not influence naturalness. A high inter-and intra judge correlation (0.99) was observed.

Kanchan (1997) followed the same method. However, the binary naturalness scale included rate, continuity, effort, stress, intonation, rhythm, articulation, breathing pattern and overall rating. Five sophisticated listeners (all postgraduate students of speech and hearing) rated samples for
naturalness on a 2-point scale (natural-unnatural). The judges rated the speech of persons with stuttering, both pre- and post-therapy as, unnatural. There was a significant difference between the naturalness score of the speech of normals and persons with stuttering. Naturalness score increased from pretherapy sample (5.52) to post-therapy sample (4.64) to normal speech (3.08). Speech naturalness scores were better on post-therapy sample and normal speech. Mean naturalness score correlated with naturalness rating of various parameters. Low naturalness score for pre-therapy speech samples was attributed to slow rate of speech, disrupted intonation pattern and increased effort. Naturalness score increased with increase in speaking rate and decrease in dysfluency. Factor analysis indicated rate, continuity, effort and stress to be important factors in the judgment of naturalness.

The results of these two studies indicated that there were some common parameters like continuity and rate, which, both unsophisticated and sophisticated listeners employed in judging naturalness of speech. Though termination from therapy is based on the judgment of sophisticated listener (speech pathologist), the stutterer has to face the unsophisticated listeners after therapy. Therefore, the parameters identified by the unsophisticated listeners as contributing to naturalness should also be the deciding factor for termination from therapy.

In summary, the naturalness of speech is becoming recognized as an important parameter in determining the success of treatment. Currently three scales 9-point scale (Martin et. al., 1984), 14, 7-point bipolar scale (Franken
et. al., 1995), and 8, 2-point scale (Kanchan, 1997; Subramanian, 1997) are available. The scale developed by Martin et. al. has been widely used and reliable for either oral reading or spontaneous speech. Some (but not all) clients improve their speech naturalness as a result of treatment and they do so at their own rate. Speakers who differ on naturalness ratings at the outset of treatment may be rated much the same after treatment, although pre- and post-treatment severity ratings influence judgments of naturalness. Moreover, feedback appears to enhance the speaker’s ability to improve naturalness, although listeners and clients may have different criteria for determining naturalness. Listeners tend to evaluate an audio recording of a speaker as being more natural than when both audio and visual signals are presented. However, most of the research has addressed naturalness ratings as used during treatment; less attention has been given to naturalness ratings in treatment outcome evaluation. Also, it does not necessarily mean that the ratings made by two observers would agree in terms of absolute scale values. Finally, the real meaning of speech naturalness remains somewhat unclear. Naturalness may depend on several, possible independent perceptual and physical characteristics of a speech sample as shown by Franken et. al. (1995), Subramanian (1997) and Kanchan (1997).

(d) Assessment conditions: Ideally the speech samples should be obtained under multiple conditions and on multiple occasions (Conture, 1996). This can be particularly important for a young child as stuttering has been reported to fluctuate greatly over time (Ingham & Riley, 1998). Speech measures should be collected without client’s knowledge that their speech is being evaluated.
so that they do not react to being assessed and try to create a favorable outcome and speech outcome measures should reflect everyday speech performance free from clinic stimulus controls. Table 3 summarizes assessment conditions used in prolonged speech therapy technique.

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Author &amp; Year</th>
<th>N</th>
<th>Stuttering severity</th>
<th>Speech rate</th>
<th>Speech task</th>
<th>Sample size/duration</th>
<th>Frequency of assessment</th>
<th>Situation</th>
<th>Nature</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Andrews &amp; Ingham (1972)</td>
<td>23</td>
<td>% SS</td>
<td>SPM</td>
<td>Monologue</td>
<td>1,000 syllables</td>
<td>4 times in 18 months</td>
<td>Within &amp; beyond clinic</td>
<td>Overt &amp; Covert</td>
</tr>
<tr>
<td></td>
<td>Howie, Tanner &amp; Andrews (1981)</td>
<td>36</td>
<td>% SS</td>
<td>SPM</td>
<td>Phone conversation</td>
<td>3 min</td>
<td>Twice in 9 weeks</td>
<td>Within clinic</td>
<td>Overt</td>
</tr>
<tr>
<td></td>
<td>Webster (1980)</td>
<td>-</td>
<td>% Words disfluent</td>
<td>-</td>
<td>Reading</td>
<td>500 words</td>
<td>Twice in 10 months</td>
<td>Within clinic</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Bobberg (1981)</td>
<td>16</td>
<td>% SS</td>
<td>-</td>
<td>Conversation</td>
<td>3 min</td>
<td>3 times in 12 months</td>
<td>Beyond clinic</td>
<td>Overt</td>
</tr>
<tr>
<td></td>
<td>Andrews &amp; Feyer (1985)</td>
<td>37</td>
<td>% SS</td>
<td>SPM</td>
<td>Phone</td>
<td>3 min</td>
<td>Twice in 13 months</td>
<td>Within clinic</td>
<td>Overt</td>
</tr>
<tr>
<td></td>
<td>Andrews &amp; Craig (1988)</td>
<td>84</td>
<td>% SS</td>
<td>SPM</td>
<td>Phone</td>
<td>600 syll</td>
<td>Twice in 18 months</td>
<td>Within clinic</td>
<td>Overt</td>
</tr>
<tr>
<td></td>
<td>Boberg &amp; Kully (1994)</td>
<td>42</td>
<td>% SS</td>
<td>SPM</td>
<td>Phone</td>
<td>2 min</td>
<td>4 times in 24 months</td>
<td>Within clinic</td>
<td>Overt</td>
</tr>
</tbody>
</table>

Table 3: Summary of assessment conditions used by various authors (N= number of subjects).
To summarize, many of the speech outcome data are based on single within-clinic speaking situations or telephone calls from staff in the clinic. In such on-off speaking situations, which clearly exist for the purpose of assessment, clients may be able to control their stuttering with a pronounced speech pattern that they may not or cannot use in everyday speaking situations. Discriminated learning is clinical reality in intensive prolonged speech treatments as is reactivity to assessment (Onslow, 1996). For this reason, it is advised to incorporate a covert component in an assessment protocol. With this in mind, Boberg and Kully (1994) acknowledge the potential validity problems associated with telephone calls, which are not free of clinic based stimulus control, but argue that surprise telephone calls are an adequate compromise between within clinic and completely covert assessment.

Further, in order to minimize the influence of clinic stimulus control, it is critical to assess speech not only several times during the post treatment interval, but also in many everyday-speaking situations during that interval. This is important because there are many components of daily life that may affect stuttering rate: fatigue level, the purpose of conversation, the identity of the conversational partner, the size and nature of an audience, the client’s level of autonomous arousal, and so on. Consequently, repeated assessment during the post treatment interval, with each assessment based on a variety of speaking situations, is necessary to determine the client’s speech performance in a range of environmental conditions that are likely to
influence stuttering. Accurate information about a client’s stuttering in everyday conditions cannot be acquired by conducting a few assessments.

To summarize, the perceptual measures include (a) frequency measures, (b) speech rate, and (c) speech naturalness measures. Emphasis is also placed on (d) the conditions of assessment. Although perceptual procedures are widely used, they are widely criticized on account of the superficiality of approach and apparent over simplification of the measurement technique. Owing to this criticism, researchers have tried to use acoustic analysis.

B) Acoustic measures: Acoustic measures contribute to modern speech motor perspective of stuttering. The use of a novel speech pattern to eliminate stuttering is a speech motor adjustment, and temporal aspects of motor activity are reflected in temporal patterns of acoustic activity (Boves, 1987; Kent, 1999). In addition to contributing conceptualization about the disorder, many functional benefits might accrue from acoustic investigations of treatments based on prolonged speech. Discovery of the functional acoustic components of those speech patterns could lead to the development of more cost- and time-effective treatments for advanced stuttering (Onslow & Ingham, 1989). One way such a development might occur was highlighted by Ingham, Montgomery, and Ulliana (1983), who showed that stuttering could be ameliorated with the use of acoustic data feedback. Many other problems and issues could be resolved with the discovery of the functional acoustic components of treatments based on prolonged speech. But, it is unclear at present as to how effectively these treatment procedures can be replicated in
clinical or experimental settings, and it is unclear whether the numerous variants of prolonged speech are essentially similar or different (Ingham, 1984). Further, it is unclear at present which of the acoustic features of speech patterns in these treatments have a functional relationship to stuttering frequency. Additionally, it is of enormous clinical interest to discover whether the controlling acoustic features of these speech patterns are similar or different across subjects (Onslow & Ingham, 1989).

There are 14 studies on the acoustic analysis of speech of persons with stuttering before and after therapy. Of these, 12 studies are on adult persons with stuttering and two studies on children. As the present study is on adult persons with stuttering only those studies on adult persons with stuttering will be reviewed.

Metz, Onufrak, and Ogburn (1979) reported results for 9 adult subjects whose treatment was based on procedures recommended by Van Riper. These treatment procedures involved instruction to “slowly initiate phonation and maintain a forward flow of air” and to reduce rate of articulation. Acoustic analysis showed that vowel durations and the durations of phonation during stop consonants were greater after the treatment program. This study indicated that stuttering therapy could alter certain acoustic properties of the stutterers’ fluent speech. This study has advanced our knowledge regarding which acoustic variables associated with the fluent speech of persons with stuttering change concomitantly with the growth of fluency. However, study is based on group data and consequently provides
limited information about the nature of the relationships between acoustic variable changes and fluency enhancement. Furthermore, there is no priory reason to assume that all systematic changes in the acoustic properties of stutterers' speech are necessarily related to fluency enhancement. While, some of these alterations may reflect changes in the operation of speech motor control processes that underlie fluency enhancement, others may be systematic by-products of the particular fluency-enhancing condition. That is, a given fluency enhancing procedure may have two types of effects on a stutterers’ speech (a) one that imposes changes in speech that directly enhance fluency, and which are reflected in certain acoustic changes and whose occurrence is probably common, to greater or lesser degrees, to all fluency enhancing conditions, and (b) one that imposes changes in speech that do not directly enhance fluency, and which are also reflected in certain acoustic changes but whose occurrence is probably an idiosyncratic result of ancillary aspects of the particular fluency-enhancing condition. By examining the relationship between stuttering frequency and various acoustic features of stutterers’ speech across individuals (in addition to examining group data), one may obtain some clues regarding those variables that are most closely related to stutterers’ frequency. This will reflect the control processes underlying fluency than variables that are statistically independent of the stuttering frequency dimension within the population of stutterers.

Metz, Samar, and Sacco (1983) explored such relationships in more detail. They examined the relationships between those acoustic variables and fluency within a group of mild to severe persons with stuttering both prior to
and after stuttering therapy (Van Riper, 1973) daily for 5 weeks. Twelve male and two female adult persons with stuttering, whose stuttering frequency ranged from 2 to 54 per 100 words read, participated in the experiment. On both first and last day of the clinic, each subject read a 1,000-word prose passage designed by Bryton & Conture (1978). Sixteen stop consonant-vowel-stop consonant (CVC) target words were located in the middle section of the passage. Additionally each subject read a list of 24 monosyllabic (CV) English words consisting of 12 word-initial voiced and 12 word-initial voiceless consonants. Each target word was embedded in the carrier phrase say – again and individually typed on 3 x 5 inch cards. Readings were recorded prior to and after therapy. Dysfluent words in pre- and post-therapy readings were eliminated from the final data pool. Nine measurements including inter-consonantal vowel (CVC) durations, voice onset time (VOT), absolute time of frication, voicing and silence associated with the intervocalic intervals of both voiced and voiceless stop consonants were measured. The results indicated a dramatic decrease in stuttering frequency between the pre- and post- test. Furthermore, both voiceless and voiced VOT duration and vowel duration significantly increased following therapy. Of the intervocalic interval parameters, frication duration significantly increased during production of voiceless stop consonant intervocalic intervals and voicing duration significantly increased during production of voiced stop consonant intervals. Also, though silence in the stop consonant intervocalic interval is a significant correlate of stuttering, it did not display a significant change in the group data. The principle finding of this research is the association of stuttering frequency and silence in the
voiced stop consonant intervocalic interval. However, these measures must be carried out in consonance with more objective measures of post-therapy progress, including measurement of some features of the acoustic signal, perceptual rating and comparison with normal speech. Thus a maintenance program which focuses on normalization of ‘tenuous fluency’ after treatment might most effectively prevent relapse.

In view of this, Shenker and Fin (1985) designed to supplement the clinical stage of treatment. This supplemental training was designed to normalize those elements of speech that are characteristic of tenuous or therapy altered fluency in treated persons with stuttering. This was done in order to determine if (a) the fluency of treated persons with stuttering would be different from nonstutterers, and (b) if fluency training during maintenance would decrease the magnitude of acoustically measured differences between persons with stuttering and nonstutterers. Eighteen adults i.e., two groups of persons with stuttering and a normal control group, served as subjects. The experimental stuttering group consisted of 3 males and 3 females in the age range of 18 to 40 years. The control stuttering group was six males ranging in age from 21 to 40 years. Three males and three females in the age range of 18-40 years participated in the normal control group. Subjects reading of the ‘Rainbow passage’ before therapy were recorded. Fluency training of 8 weeks (1- 1/2 hours / week) was given to all persons with stuttering. The control group of persons with stuttering received ongoing maintenance therapy, which consisted of weekly clinical contact geared toward practice of clinical skills in difficult transfer situations. Two
months following the termination of the experimental program, both stuttering groups’ reading of the ‘Rainbow passage’ was re-recorded. The experimental training program concentrated on rate, pausing, hesitation, intensity, and voice onset. In the 1st week of training these four variables were defined and demonstrated. In the 2nd and 3rd week each stutterer practiced all phrases of the program weeks 4-7, stressed home and clinical practice of those areas ‘troublesome’ to each client. In the final session, each client gave a 5-minute verbal presentation for evaluation of fluency by the group. Voice onset time (VOT) of /p/ in the word /pot/ was measured before and after therapy. The results indicated that, the experimental group of persons with stuttering had significantly decreased their post-treatment VOT in the direction of the normal speaking group. Whereas the control group of persons with stuttering had a greater VOT between pre- and post-treatment tapes. Therefore, the tendency was for the ‘fluency trained’ persons with stuttering to move closer to the normal group. While the control group of stutterers were experiencing an opposite trend. The results warranted clinical investigations into the phenomenon of ‘tenuous fluency’. In addition to long term following of maintenance of fluency characteristics, the pre-treatment fluency characteristics of persons with stuttering might be predictors of clinical success or failure. Further, whether the improvements found in this study are applicable to other kinds of treatment approaches is doubtful.

Mallard and Westbrook (1985) used Precision fluency shaping program (PFSP- Webster, 1980) as the therapy of choice. They investigated vowel duration changes in the fluency of persons with stuttering who participated in
PFSP. Twenty-six persons with stuttering participated in the study. They read an all-voiced passage before and after PFSP. Only fluent sentences were selected. Of the 26 persons with stuttering, 9 subjects spoke fluently on one of the sentence, the initial phrase of which was selected for the study. Durations of vowels /a/, /i/, /I/, and phrase durations were measured. The results indicated that the percent dysfluency decreased in the post-treatment reading compared to the pre-treatment reading. On an average, persons with stuttering increased vowel duration as a result of participating in PFSP. Three findings emerged from this study - (a) persons with stuttering who participated in PFSP tended to prolong vowels as one possible means of controlling stuttering, (b) vowel durations were shortened as the stuttering moved from the initial to the final part of the phrase, and (c) variability existed among the persons with stuttering with regard to the extent of vowel duration change after therapy. However, the authors were unable to study a wide range of persons with stuttering using specified phonetic contexts. In addition, the severity of stuttering in persons with stuttering in this study was relatively mild. More severe persons with stuttering may have to develop other strategies to control stuttering, such as combining phonemic duration with longer pause times, increased time achieving respiratory control, or starting the voice with a longer rise time.

In a similar study, Webster, Morgan and Cannon (1987) used PFSP and tried to answer questions such as (a) do voice onset time characteristics change as a function of dramatically increased syllable durations, and (b) do realtered voice onset time characteristics evident in post-therapy speech. Ten
male persons with stuttering (19-42 years) enrolled in the PFSP participated in the experiment. Ten CV words printed on 3 x 5 inch index cards were used as material. Subject’s repetitions of visually presented words prior to, at specified points during therapy, and at the conclusion of the therapy were recorded. The duration of each utterance and length of three intervals of time separating the first four pulses of the fundamental frequency of the speech signal were measured. In addition, amplitude values were acquired for the three initial fundamental frequency pulses as well as the 8th, 9th and 10th pulse. The pulse amplitude values were substituted in the following formula to establish voice onset time index (VTI) value for each utterance.

$$\text{VTI} = \frac{[\text{AV}(8) + \text{AV}(9) + \text{AV}(10)] - [\text{AV}(1) + \text{AV}(2) + \text{AV}(3)]}{[\text{AV}(1) \times \text{AV}(2) \times \text{AV}(3)]}$$

The voice onset time index was considered to be a quantitative representation of the relative abruptness with which voicing was initiated for the respective utterance. An abrupt voice onset would be one in which the voice rapidly increased in amplitude. In contrast, the voice onset time index for a gentle voice onset would be relatively high. The results indicated that the voice onset time index increased significantly in post-therapy readings compared to pre-therapy readings. That is, voice onsets become gentler. The authors attributed the increase in voice onset time index to reduced muscle forces. The effects of gentle voice onset training may be accounted for by a number of different mechanisms. Intensive training in therapy could parameterize and coordinate structures involved in speech. It is also possible
that background activity of motor neuron pools may be reduced by virtue of magnitude and specificity of training in intrinsic muscle control. Finally, there may be an alteration in the mechanisms by which the client controls motor behavior. The client may shift reliance on cues used for speech guidance away from auditory channels and toward proprioceptive sources. Clearly, a good deal of research remains to be completed before the range of possibilities can be narrowed further.

In a single case study, Mohan Murthy (1988) investigated simultaneous laryngeal and acoustic, and aerodynamic and acoustic measures before and after modified airflow technique and soft contacts. Dysfluencies in the spontaneous speech of the 17-year-old Kannada speaking severe stutterer and the same words after therapy were analyzed using electroglottography, electroaerometer, and wide-band spectrograms. The results indicated the presence of (a) atypical transition, (b) inappropriate voicing, (c) inappropriate duration of segments, (d) inspiratory frications, (e) articulatory fixations, (f) abnormal articulatory constrictions (e.g. frications for stop), (g) longer closing phases on the laryngograph (Lx) indicating excessive vocal fold adduction, and (h) stop like patterns in the opening phase of the Lx in pre-therapy speech which were not found in the post-therapy speech. These were attributed to abnormal functioning of speech musculatures or abnormal functioning of the higher speech centers. The study suggested a method for multidimensional measurements. The study showed the acoustic changes in therapies other than prolongation therapies. However, the results can’t be generalized, as it is a single case study.
Although treatment may contribute to changes in stutterers’ fluency, it also might be important to consider the length of time persons with stuttering have been exposed to treatment. What is not known is whether changes in certain acoustic measures obtained from stutterers’ fluency occur only as a result of long periods of treatment or occur at some point in the early stages of treatment. Also, there might be a relationship between length of treatment and stuttering severity given that severe stutterers’ fluency is easier to differentiate than persons with mild stuttering. In order to assess the relationship between length of treatment and stuttering severity on various temporal measures in the stutterers’ perceptibly fluent speech, Healey & Ramig (1989) conducted a study that included 17 adult male persons with stuttering in the three severity groups. Two of the subjects had not received any treatment for their stuttering at least for 7 years prior to the participation in the study. The remaining 15 subjects were enrolled in “speak more fluently” (SF) method or combination of “stutter and speak more fluently” (SSF) method. Two speech tasks were used to elicit responses from each subject. On one task subjects reported the nonpropositional phrase /ipi saw ipi/ five times. In the second task, subjects read aloud the first paragraph of the ‘rainbow passage’ five times. The stutter free utterances (in the silent period before the phrase /ipi saw ipi/ or on the words ‘there and ‘of’ that preceded and followed the phrase ‘take the shape’) were analyzed. Wide-band bar type spectrograms were used to measure voice onset time, and vowel, consonant, and total phrase durations. The results indicated no significant differences between the temporal measures of fluency for any of the three severity groups of subjects in the two treatment categories. Thus,
stuttering severity and treatment length had little effect on the temporal measurers of stutterers’ fluency obtained from either the propositional or the nonpropositional speech tasks. Data from this study suggest that alterations in the temporal aspects of stutterers’ fluency can occur even in the early stages of treatment. But multiple repetitions of speech tasks might have minimized the differences among severity, treatment or treatment duration groups. Large samples of subjects in each severity and treatment length category would be necessary to draw a conclusion. Additionally, control over the type of therapy received prior to inclusion in the study would assist in better interpretation of the results. Data is also needed to determine if other factors such as the type of speech or type of treatment affect temporal measures obtained from stutterers’ fluent speech.

In a study of a Dutch version of Precision Fluency Shaping Program, Franken, Boves, Peters and Webster (1991) investigated the prosodic features before and after therapy in four severe male persons with stuttering (mean age 32.4 years). Recording of 20 utterances before and after therapy were analyzed for F0 and amplitude envelope. Against a common background of an overall decrease in prosodic variation, each of the four persons with stuttering showed specific aspects that seemed to contribute more saliently to the decrease of expressiveness than others. But, it might be useful to follow speech changes during the therapy process in a number of subjects, instead of only comparing pre and post measures in order to trace these changes.
Most investigators cited earlier have based their results on passage or sentence readings or monosyllabic words. The authors have presented sound reasons for the use of such methodology. Nonetheless, there are reasons to believe that spontaneous, connected speech samples should be a prerequisite to any valid conclusion about the acoustic effects of treatment on the speech of people who stutter. First, it would be incautious to assume that, speech during reading or monosyllabic utterances resembles everyday speech. Second, the repetitive nature of the tasks used in the earlier reports might have induced reductions in intrasubject variability which, intern, might have concealed differences between experimental groups. Therefore external validity of data in essential.

Onslow, Van Doorn, and Newman (1992) designed an experiment to contribute externally valid data about the acoustic effects of treatment based on prolonged speech. Concerns about the external validity of existing data were addressed (a) by using children as subjects, (b) by using subjects who had not experienced any formal treatment based on a variant of prolonged speech, and (c) by conducting acoustic analysis on spontaneous speech samples. Subjects were 10 school-age children who stuttered, and who had not previously received any treatment incorporating a novel speech pattern. Voice onset time, interphonatory interval, vowel duration (VD), and articulation rate (AR) were measured during stutter free segments of spontaneous speech before and after a prolonged speech treatment program. No changes in duration of acoustic segments were found. However, decreased variability of both VD and AR was found after treatment. As noted
by the authors, the rate of reduced variability in this study was unclear. It may have been a by-product of the treatment program or a critical treatment variable. This finding (reduced variability of VD) is intriguing because it is not a target in prolonged-speech treatments. It is not known if there is a relationship between reduced variability of VD and other variables known to influence stuttering, such as phonation intervals. It is possible that in Onslow et. al.’s study, the programmed instruction inadvertently produced more uniform vowel duration in stuttering, despite the fact that reduced variability of VD was not a target behavior.

Packman, Onslow, and Van Doorn (1994) replicated the findings of Onslow et. al. (1992) and investigated whether variability in vowel duration reduced when prolonged speech is used without programmed instruction. In part two, naturalness was judged. In part three, acoustic and EGG signals were analyzed to look for changes in VD and other speech parameters that might be associated with this experimental procedure. Subjects were 4 young adults in the age range of 18-32 years and spoke Australian English. Subjects spoke in continuous monologue for 5 minutes in six speaking sessions. A multiple-baseline across subjects design was used. The baseline was followed by non-programmed prolonged speech technique. Treatment was followed by 5-minute monologues. Two stutter-free samples were selected from each subject to measure vowel duration (VD), intervocalic interval (IVI), voice onset time (VOT), and articulation rate (AR). The results indicated that, reduction in stuttering, in all subjects was associated with changes in the duration and distribution of acoustic and EGG segments. Stutterers’ acoustic
and EGG data suggested that they were not using all or even the same features of prolonged speech for example; subjects 2 and 3 decreased the frequency of short PIs and increased VD. However, the frequency of short phonation intervals and vowel duration did not change in subject 1. Only one subject showed a clear decrease in AR. VOT increased in two persons with stuttering and decreased in one stutterer. A further line of research that is likely to be profitable is to investigate how changes in variability in individual subjects relate to stuttering reduction, and whether such changes have a role in stuttering treatment other than prolonged speech.

Madhavilatha (1997) investigated the intonation patterns in the speech of persons with stuttering before and after therapy. One normal 47 year-old female (model) and 10 persons with stuttering, in the age range of 15-30 years participated in the study. The material consisted of 10 audio-recoded sentences uttered by the model with different intonation patterns depicting emotions such as anger, sarcasm, surprise, command, question and statement. The subjects were instructed to imitate the intonation patterns before and soon after prolongation therapy. The audiotaped fluent utterances were analyzed acoustically and perceptually. The sentences were digitized at 16 KHz sample using a 12-bit A/D converter. Using the F0 edit program (Speech Science Lab), mean F0, effective maximum, effective minimum, effective range of F0, mean, effective minimum, effective maximum and effective range of intensity, voicing (% of voiced and unvoiced) and sentence duration were extracted. Three judges perceptually evaluated the sentences uttered by the model and the imitations, and indicated whether the intonation
patterns in subjects with stuttering was the ‘same’ or different’ from the model. The results indicated significantly reduced F0 range (normals = 128.31 Hz, persons with stuttering = 53.5 Hz) and longer sentence duration in stutterers’ speech (normals = 1350.2 ms, persons with stuttering = 2294.02 ms). All frequency and amplitude parameters were significantly lower in persons with stuttering compared to those in normal subjects. Pre- and post-therapy speech of persons with stuttering differed significantly in mean F0 and % voiced. The mean F0 was lower and the % voiced was higher in the post-therapy speech compared to that in pre-therapy speech. Also, sentence duration was shorter in the post-therapy speech. The results indicated changes in F0 and intensity related parameters in the post-therapy speech of persons with stuttering.

In a similar study, Ananthi (2002) investigated production of word-stress in adult persons with stuttering before and after prolongation therapy. Ten Kannada adjective noun phrases as spoken by a 35-year-old Kannada speaker with stress on the adjective was audio recorded (model). Ten persons with stuttering and ten normals, in the age range of 12-30 years, participated in the study. All of them were Kannada speakers. Subject’s imitation of the model was audio-recorded. In persons with stuttering, the first sample was recorded before therapy and the second sample immediately after therapy. All the subjects underwent prolongation therapy. The experimenter listened to the recorded samples and identified those phrases in which words were stressed. These words were acoustically analyzed to measure word duration, peak F0, lowest F0, and F0 range. All the parameters obtained before and after therapy
were compared and parameters of post-therapy were compared with those of normals. The results indicated no significant difference in word duration (pre-therapy = 502 ms, post-therapy = 507 ms, normals = 457 ms). No significant difference in the F0 range between post-therapy samples of persons with stuttering (58 Hz) and speech of normals (56 Hz) was found. However, F0 range in 60% of persons with stuttering (post-therapy) was narrower than that in normals.

Savithri (2002) evaluated the efficacy of prolongation therapy by measuring some acoustic parameters in the pre- and post-therapy samples of persons who stutter. Five adult persons with stuttering in the age range of 12 to 25 years participated in the study. Subjects read a standard passage before and after prolongation therapy. Wide band spectrograms of the stutterers’ words in the pre-therapy sample and same words in the post-therapy sample were obtained. Terminal frequency of the second formant, direction of movement of F2, and voicing were measured. Other features relating to articulatory, laryngeal and aerodynamic errors were observed. The results indicated no significant difference between F2 terminal frequencies of the pre- and post-therapy samples. In the pre-therapy samples, subjects showed various types of miscoordinations that included frication before trill, atypical F2 transition, missing F2 transition, error in place and or manner of articulation, dental clicks before trill, nonnasal for nasal and vice versa, omissions, half voiced murmur for voiced phonemes, absence of voicing, voicing for unvoiced phonemes, audible inspiratory frication, aspiration for unaspirated phonemes and vice versa. Not all types of miscoordinations were
noticed in all persons with stuttering. No articulatory miscoordinations were observed in the post-therapy sample of any stutterer. It appeared that prolongation therapy was successful in eliminating only the articulatory miscoordinations and not the other two. No generalizations were drawn as the study included only 5 subjects. The author warranted research involving more number of subjects.

To summarize, acoustic studies on the efficacy of prolonged speech treatment report of increase in the duration of voice onset time, vowel duration, and syllable duration. Few researchers have also reported that this increase in duration is not significant but there is a significant decrease in the variability of these acoustic parameters.

4) Long-term efficacy of prolonged speech measures

Over the years, other than reduced naturalness in post-therapy speech of persons with stuttering who undergo prolonged speech, researchers have also reported of frequent relapse. In a literature review of the current clinical status of maintenance of fluency following treatment for stuttering, Boberg and Kully (1985) concluded that this area continues to be the most challenging aspect of fluency management. Although treatment procedures such as prolonged speech, while in use, may reduce or eliminate stuttering, the results of the long-term effects are not satisfactory. The primary consideration in development of maintenance therapies is that their gains be durable over clinically meaningful time intervals (Ingham, 1982). Post
treatment maintenance of fluency then, is essential for the stabilization of clinical gains in order to prevent relapse. Table 4 summarizes the studies on long-term efficacy of the prolonged speech therapy technique.
Boberg and colleagues (Boberg & Sawer, 1977; Boberg, 1981; Boberg & Kully, 1985; Boberg, 1986) have developed a 3-week residential prolonged speech program, which is conducted in Alberta, Canada. Boberg (1981) reported data for 16 clients in this program who were given a variation on Ingham’s (1980) performance–contingent schedule, and six clients who did not receive maintenance were assessed at pre-treatment, immediately post treatment and at 12 and 16 months follow up. The 16 clients who received the performance- contingent maintenance were assessed, at pre-treatment, immediately post treatment, and at 12 and 16 months follow up. Speech measures reported are “percent dysfluency”, which is equivalent to % SS. At each assessment occasion, 2 or 3 minutes of speech was recorded in four situations, being interviewed by a stranger outside the clinic, reading, a conversation with a stranger which the clients tape recorded, and a telephone conversation with a stranger. Mean percent dysfluency scores for the group at the four assessment occasions across assessment situation was, 16.38 (range 3.80- 46.31), 1.86 (range 0.29-6.69), 2.30 (range 0.64-6.13) and 2.54 (0.76- 7.41), respectively. The group that did not receive maintenance program was assessed only in the first two speaking situations described above, and were assessed at 12-months and 24 months follow-up. Consequently, it is difficult to judge from these subjects’ data whether their outcome was worse for not having the maintenance program. Also, data was available only for three subjects at each follow up assessment. And the pre-treatment percent dysfluency scores of these subjects as a group were nearly double that of the other group and their immediate post treatment scores were higher. Nonetheless, the data at least suggested that absence of the maintenance
program worsened outcome at the 12-month follow-up, with these subjects scoring a mean of 7.49 percent dysfluency (range 1.30-13.60) compared to a mean of 2.30 in the group who received maintenance.

In many ways these data are more informative about treatment outcome than those reported for other programs. The mean scores can be interpreted better because they are accompanied by the scores for individual clients. Further, Boberg and Colleagues’ studies share with Ingham’s studies, the advantages that clients are assessed several times and beyond clinic speaking situations. Boberg and Kully also present details of how clinicians were trained to collect “percent dysfluency measures”. Also, care was taken not to imply that the residential phase of treatment was all that was needed to achieve the reported results.

Boberg and Kully (1985) reported the outcome of seven clients (all of whom attended for “refresher weekends”). They state that these clients “illustrate typical performance” of clients in their program. Within-clinic, 3-minute pre-treatment speech samples show a mean of 25.12 percent dysfluency (range 50-7.35), and 3-minute post treatment samples collected at the conclusion of the 3 week residential program show a mean of 1.03 percent dysfluency (range 0- 2.10). These clients were assessed at post treatment intervals of 4 months, 6 months, 8 months, 16 months, and 24 months. These data were based on telephone call enquiries made from within the clinic, consisting of 2 minutes of accumulated speaking time. Mean percent dysfluency scores were, 4.64 (range 10.8-1.3) 3.16 (range 1.45-4.94),
2.60 (0.57-3.08), 7.22 (range 1.87-22.5), and 3.89 (range 2.32-8.0), respectively.

One problem with the measures in the Boberg and Kully report is that the pre-treatment and immediately post treatment data were collected by clinicians, but all the post treatment data were based on average counts of persons with stuttering as judged by “six adults selected from the community”. The rationale for this was to determine “how much of the clients residual stuttering would be noticed by people outside the clinic”. This makes it difficult to compare the follow-up measures with the pre-treatment and immediate post treatment measures, especially since different speaking tasks were involved.

The same authors in 1994 aimed at investigating the long-term effects of an intensive group program for adult and adolescent persons with stuttering that combined fluency shaping strategies with techniques to promote attitude change, avoidance reduction, and social skill development. Forty-two adult and adolescent subjects were tested two or three times during the follow-up period after they had completed the 3-week comprehensive stuttering program. The follow-up measures included surprise phone calls made to subjects at their home or work, plus a questionnaire that asked them to rate their speech performance and attitudes. Telephone samples were chosen as the assessment condition because they provided a stringent measure of post treatment performance, were relatively free of treatment stimulus cues, and permitted the collection of speech samples from the largest number of
subjects regardless of where they lived. The surprise telephone calls were audio recorded directly from the telephone line and then analyzed by two trained undergraduate students who served as raters. An analysis of the speech samples obtained from the phone calls (Pre-and post-treatment and on two or three occasions in the follow-up period) revealed a sharp decrease in mean % SS scores from the pre- to post-treatment recordings but with some increase in the mean % SS scores during the follow-up period. Both the adult and the adolescent groups showed a similar pattern.

Although there are a good number of studies with respect to long-term efficacy, Bloodstein (1995) commented that the studies he surveyed varied widely in scientific rigor and sophistication. He also pointedly observed that the terms used to indicate significant improvement are likely to have different meanings for different clinicians. Most studies did not specify the conditions in which speech performance was measured, what measures were used, or how the speech raters were trained. In almost all the studies the percent dysfluency increased after the follow up for almost 50% of the cases.

The reports outlined above appear to have satisfied only some of Bloodstein’s criteria for determining whether a treatment is effective. They evaluated clients for periods of between 9 and 24 months, and it is the matter for some debate whether that constitutes the “long term follow-up investigations” called by Bloodstein. They certainly are “based on objective measures of speech behavior such as frequency of stuttering or rate of
speech” (Bloodstein, 1987). But none reported long term efficacy using objective methods such as acoustic analysis.

To go over the main points, the review of the historical perspectives of the novel speech pattern reveals that both rhythmic speech pattern and prolonged speech pattern emerge as the potent modifiers of the stuttering. Of the two, prolonged speech pattern emerged as most widely used and most widely modified technique. Several variants of this technique have emerged, and there are commonalities between these programs. However, efficacy of the prolonged speech has been measured mostly with perceptual measures. In almost all studies, percent dysfluency and SPM have been used and have been found to decrease in the post-therapy compared to pre-therapy condition. Recently, speech naturalness studies have revealed that post-therapy speech even though devoid of stuttering blocks, still sounds unnatural. Naturalness has been assessed with respect to several variables like, effect of feedback, effect of speech task, audio and visual samples, stuttering severity and, different assessment conditions such as covert and overt measures, and type of naturalness scale, i.e. 9-point scale or the binary choice method. The acoustic analysis of the post-therapy speech revealed that durations such as voice onset time and vowel duration increased in post-therapy speech compared to pre-therapy speech. Few studies have revealed that the increase in the duration of the acoustic parameters is not significant, but there is significant decrease in the variability of the acoustic segments; only one study has compared the relationship between the perceived naturalness and duration of the acoustic parameters. The review of the long-
term efficacy of the prolonged speech therapy revealed that there are fewer
studies, which have looked into this issue, and almost all the studies have
used perceptual measures to assess the efficacy.

The review indicates that there are no studies that have considered both
perceptual and acoustic parameters as a measure of efficacy. Such a study
would provide a complete picture of fluency. Further, spectrograms can be
used as a means to observe the various errors in the subsystems of speech.
Also, effect of factors such as age at the time of treatment is not addressed in
great detail. Considering these aspects, the present study investigated the
efficacy of prolonged speech techniques on two age groups of stutterers and
evaluated the long-term effects of prolonged speech techniques. Perceptual,
acoustic and spectrographic measures have been used to obtain a complete
description of subjects’ fluency.