BEHAVIOURAL AND ACOUSTIC OUTCOMES OF RESPONSE CONTINGENT TIME OUT IN ADOLESCENTS WHO STUTTER: A CASE SERIES

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CERTIFICATE

This is to certify that this dissertation entitled **"Behavioural and Acoustic Outcomes of Response Contingent Time Out in Adolescents Who Stutter: A Case Series"** is a bonafide work submitted in part fulfillment for the Degree of Master of Science (Speech-Language Pathology) of the student Registration Number P01II24S123029. This has been carried out under the guidance of the faculty of this institute and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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This is to certify that this dissertation entitled **"Behavioural and Acoustic Outcomes of Response Contingent Time Out in Adolescents Who Stutter: A Case Series"** has been prepared under my supervision and guidance. It is also being certified that this dissertation has not been submitted earlier to any other university for the award of any other Diploma or Degree.

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DECLARATION

This is to certify that this dissertation entitled **"Behavioural and Acoustic Outcomes of Response Contingent Time Out in Adolescents Who Stutter: A Case Series"** is the result of my own study under the guidance of Dr. Mahesh B V M., Assistant Professor in Speech Pathology, All India Institute of Speech and Hearing, Mysuru and has not been submitted earlier to any other university for the award of any other Diploma or Degree.

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Chapter 1

Introduction

Stuttering is an extremely diverse condition that varies greatly between people and circumstances and has major psychosocial effects on individuals' well-being. Wingate (1964) proposed one of the well-known three-part, lengthy definitions of stuttering, in which the first part identifies core features, whereas the second and third parts list other features associated with stuttering that warrant mention. According to him:

> The term "stuttering" means:
>
> 1. (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) usually occur frequently or are marked in character and (d) are not readily controllable.
> 2. Sometimes the disruptions are (e) accompanied by accessory activities involving the speech apparatus, related or unrelated body structures, or stereotyped speech utterances. These activities give the appearance of being speech-related struggle.
> 3. Also, there are not infrequently (f) indications or report of the presence of an emotional state, ranging from a general condition of "excitement" or "tension" to more specific emotions of a negative nature such as fear, embarrassment, irritation, or the like. (g) The immediate source of stuttering is some incoordination expressed in the peripheral speech mechanism; the ultimate cause is presently unknown and may be complex or compound. (p. 488)

Despite the stuttering incidence ranging from 0.7 to 17% across the age groups, the commonly cited incidence rate of stuttering is 5% (Bloodstein & Ratner, 2008; Yairi & Ambrose, 2013). Lee (2023) found that the overall prevalence was 1.5%, while the incidence of stuttering was 3.9%. This disparity could be attributed to several factors, such as spontaneous recovery (Manning & DiLollo, 2018), age (Craig et al., 2002; Lee, 2023; Yairi & Ambrose, 2013), gender (Craig et al., 2002; Lee, 2023; Manning & DiLollo, 2018; Yairi & Ambrose, 2013), and family history (Ambrose et al., 1993; Devi et al., 2018; Yairi & Ambrose, 2013). Phonological skills, articulatory rate, variation in the pattern of disfluencies, and trend in the severity of stuttering during the previous year after beginning were also found to be reliable predictors of stuttering persistence and recovery (Sugathan & Maruthy, 2021).

Stuttering has negative impacts that begin in childhood and may worsen social well-being during puberty. The impacts of stuttering can be exacerbated during adolescence due to changes in identity formation, bodily development, peer dynamics, and scholastic expectations. This can result in decreased self-esteem, social disengagement, and an elevated risk of anxiety. According to Erickson and Block (2013), adolescents who stutter are more likely than their fluent peers to be the targets of bullying and teasing. Subsequently, they may experience difficulties in making friends (Hartford & Leahy, 2007) and a lower overall acceptance in society (Davis et al., 2002). Feelings of shame and embarrassment following their peer group evaluations and other people's unfavourable reactions from significant others are reported in adolescents with stuttering (Iverach & Rapee, 2014). Adolescent stuttering can impact a person's quality of life and last into adulthood if treatment is not received. Effective management strategies are crucial considering these psychosocial hazards, and therapists have used a variety of therapy frameworks to lessen the severity of stuttering and enhance communication over the years.

Stuttering management techniques could be broadly categorised into speech

restructuring and stuttering modification. Easy onsets, prolonged speech, continuous phonation, light articulatory contacts, and rate control are some of the strategies used in speech restructuring. Cancellations, pullouts, and preparation sets are examples of stuttering modification techniques (Van Riper, 1973). There have been several studies on intensive therapy methods for stuttering adolescents, with varying outcomes. A two-week intensive group treatment for adolescents, which included role-playing, relaxation, time-outs, prolonged speech, parent counselling, and video feedback, was evaluated by Rustin (1978) and reported improvement in fluency; however, no quantitative outcome data were gathered; therefore, the conclusions are questionable. Laiho and Klippi (2007) investigated programs for 21 children and adolescents in the age range 6.8–14 years, reporting a two-thirds reduction in %SS, avoidance, and struggle behaviours, with sustained benefits at 9 months. For older adolescents and young adults, Fry et al. (2009) and Fry et al. (2014) examined group therapy that combined fluency shaping, stuttering modification, CBT, and communication training, finding long-term fluency gains in participants aged 17–19 years. When the Camperdown Program was delivered via webcam, for adolescents in the age range 12-17 years, they were able to minimise stuttering by up to 83% and maintain the results for a full year (Carey et al., 2012, 2014). Similarly, a Scandinavian residential program for adolescents aged 13–17 years reported reduced stuttering severity and improved social skills, although no significant changes were found in locus of control (Nilsén & Ramberg, 1999).

Operant learning methods have also been used as a treatment strategy to reduce stuttering dysfluencies. Operant conditioning is the process through which the occurrence of a behaviour is modified depending on its consequences (Yairi & Seery, 2023). The consequences that are dependent on an operant response have the capability to either raise increase or lower the probability that the response will occur in the future. Yairi and Seery (2023) defined a reinforcer as any stimulus that increases the frequency of a behaviour when it

is made contingent upon it. A punisher is any stimulus that decreases the frequency of a behavior as a result of which it depends (Azrin & Holz, 1966). Removing a stimulus can be used as punishment if it reduces the frequency of a behaviour or as negative reinforcement if it increases it (Nittrouer & Cheney, 1984). Some of the operant methods used to reduce speech dysfluencies of persons who stutter include positive reinforcement of fluency, response-contingent time-out (RCTO), response-cost, verbal contingencies, and token economy.

When fluent statements are followed by an instant reward, such as praise, tokens, or tangibles, this is known as positive reinforcement of fluency. This increases the occurrence of stutter-free speech. While Costello (1980) showed that systematically extending the interval for reinforcement from one stutter-free word to longer periods of fluent speech resulted in a considerable reduction in stuttering frequency, Shaw and Shrum (1972) emphasized the need to individualize reinforcers. Another operant technique is response-contingent time-out (RCTO), in which the clinician gives reinforcement (such as attention and eye contact) during fluent speech but momentarily removes the eye contact contingent upon stuttering dysfluencies after stuttering. After a brief pause, the clinician makes eye contact again. This withdrawal of reinforcement reduces the frequency of stuttering, while maintaining eye contact while conversing may reciprocally increase fluent speech. The Lidcombe Programme (Harris et al., 2002; Jones et al., 2000), one among the effective treatment regimens to treat stuttering, is dependent on the verbal contingencies applied by the clinician and parents. Here, fluent speech attracts positive verbal reinforcement in the form of praise, acknowledgements, or requests for self-evaluation whereas dyfluencies are followed by corrective feedbacks. Using these methods, the clinician enhances fluent speech production in individuals with stuttering without giving specific directions like "speak smoothly" or "speak slowly" that alters the naturalness in speech. Several studies in the past have used operant methods to increase fluency in individuals with stuttering (Einarsdóttir et al., 2025; Franklin et al., 2008; Hewat et al., 2006;

Ingham & Andrews, 1973; James et al., 1989; Wagaman et al., 1993).

Numerous studies have examined the effects of time-out in adults and children who stutter. A study by Hewat et al. (2006) on twenty-two adults and adolescents who stutter found stuttering was reduced by more than 50% in almost half of the participants, especially among those with severe stuttering. James et al. (1989) investigated the effects of response-contingent time-out on twenty adults in the age range of 19 to 50 years. Adults who stutter attended a 32-hour fluency training session after being classified as high or low responders based on their baseline reaction to the contingent stimulation method. In both conversation and speaking-alone tasks, the results demonstrated significant decreases in stuttering (%SS) and increases in speaking rate, indicating that stuttering reductions may have increased the overall speaking rate. Both groups responded equally well to time-out at the 6-month follow-up, despite they responded differently during the baseline measurement phase. It was observed across the studies of both Hewat et al. (2006) and James et al. (1989) that there was high variation in the way the participants responded to the response-contingent stimulation. Martin and Haroldson (1982) echoed similar findings wherein AWS who used self-time out showed positive generalization in comparison to those who received time-out by an experimenter.

A study by Wagaman et al. (1993) examined the effects of time-outs combined with awareness training and a breathing technique based on stuttering episodes in eight children who stutter. After treatment, stuttering decreased by an average of 89%, and this improvement which was maintained for the next three years. Response-contingent time-out was studied with 60 adults who stutter by Franklin et al. (2008). They reported that a single continuous 40-minute session produced a marked reduction in stuttering, particularly among individuals with more severe forms of the disorder. Time out was delivered by pressing a red-light contingent upon stuttering dysfluencies that flickered for 5 seconds. Participants showed an overall faster rate following the participation in the time out, and those who had prior experience responded

favourably to the time out procedure.

Veerabhadrappa (2021) compared the effectiveness of Pause and Talk (PT) and Prolonged Speech (PS) in 30 Kannada-speaking children aged 6–12 years and found that both techniques were effective in reducing disfluencies, with effects maintained at a 3-month follow-up, and that no noticeable differences were observed between the two methods. Along with the severity of stuttering, a reduction in anxiety and negative attitudes was also observed in both groups. Onslow et al. (1997) analysed the effectiveness of Time- out in a laboratory setting for three school-age children who stutter (CWS) using ABA design. Results showed that 2 out of 3 children showed a reduction in dysfluencies with natural- sounding speech, and the acoustic analysis of the fluent speech samples of the participants revealed an overall reduction in the variability of vowel duration in spontaneous speech. Einarsdóttir et al. (2025) assessed the efficacy of time-out in 7 participants aged 9-13 years using a multiple baseline single-case experimental design. Frequency of stuttering reduced by an average of 72% among the 4 participants who completed the program, along with significant gains in speech naturalness and quality of life, and these gains were maintained over a 9-month follow-up period.

Acoustic Analysis as a Treatment Outcome Measure in Stuttering

In addition to perceptual analysis for stuttering outcome measures, acoustic analysis has been known to be informative in providing critical insights into the changing speech following behavioural treatments. Onslow et al. (1992) reported an overall reduction in the variability of articulation rate and vowel duration following prolonged speech therapy, while Packman et al. (1994) found no consistent trend across the acoustic measures that were used to compare pre-post therapy measures on four individuals who had stuttering following prolonged speech. Though vowel duration decreased in most participants, voice onset time (VOT) was either increased or decreased following the treatment. Metz et al. (1990) further linked acoustic markers such as prolonged VOT and sentence duration to be key predictors that

may influence listeners' judgments of speech naturalness of persons with stuttering following treatment. Tasko et al. (2007), in evaluating the Walter Reed Stuttering Treatment Program under speech restructuring approach, observed a reduction in syllable rate without corresponding changes in vocal intensity in fluent speech samples of 35 adults with stuttering. Some of the speech restructuring studies in Kannada have also reported increased VOT, vowel duration, F2 transition duration, voicing duration in stops, speech initiation and termination time in post-therapy recording of persons with stuttering (Santhosh, 2006; Suchitha, 1991).

In contrast to speech restructuring approaches, relatively few studies have examined acoustic parameters in operant treatment methods, particularly response-contingent time-out (RCTO). Onslow et al. (1997) investigated this by analyzing 12-second segments of stutter-free speech before and after the time-out procedure in three school-aged children, using an ABA single-subject design. Acoustic measures included unvoiced voice onset time (VOT), intervocalic interval, and vowel duration across pre- and post-therapy baselines. Two of the three participants demonstrated clear reductions in stuttering frequency following the intervention. However, apart from a decrease in overall vowel duration observed in one child during the post-therapy baseline, no consistent changes emerged in the other acoustic parameters. These findings suggest that while time-out may reduce dysfluency rates in some cases, further research is needed to clarify the mechanisms underlying RCTO-induced fluency.

Need for the Study

Most interventions recommended for adolescents with stuttering are either based on speech restructuring and stuttering modification strategies which are promptly extrapolated from treatment regimens targeted for preschool, school age children and adults (Blomgren, 2013, Brignell et al., 2020). We believe that such extrapolation of treatment protocols needs to be carefully applied to adolescents who stutter as this stage coincides with a complex period of biological and behavioral development. Adolescents are simultaneously navigating emerging roles, social affiliations, and privileges while striving to establish their sense of identity. During this transitional phase, stuttering-related anxiety and communication difficulties can disrupt this progress, potentially leading to long-term adverse outcomes (McAllister, Collier, & Shepstone, 2013). Adolescents with stuttering are more likely to be the targets of bullying and teasing than their fluent counterparts (Erickson & Block, 2013). It is been shown that adolescents who stutter may also lack awareness and a clear understanding of the stuttering phenomenon (Hearne et al., 2008). From a clinical perspective, adolescence may represent one of the final time periods in which effective intervention can prevent stuttering from becoming a chronic condition. However, very few studies are available on treatment efficacy research carried out on adolescents with stuttering (Carey et al., 2012, 2014; Fry et al., 2009; Laiho & Klippi, 2007; Rustin, 1978). No rigorous efforts have been made to understand treatment efficacy on this age group.

We hypothesize that compared to the two mainstream treatment methods namely, speech restructuring and stuttering modification, operant conditioning methods that controls the frequency of a given response contingent upon its consequence has the potential in reducing the speech dysfluencies without affecting the speaking rate and subsequently yields more natural speech. Although operant methods have shown promising results in reducing speech dysfluencies among children and adults who stutter, very few studies have examined their

application in adolescents (Einarsdóttir et al., 2025; Hewat et al., 2006). In contrast, most available reports focus on adults (Einarsdóttir et al., 2025; Franklin et al., 2008; Hewat et al., 2006; James et al., 1989; Martin & Haroldson, 1982; Onslow et al., 1997; Veerabhadrappa, 2021; Wagaman et al., 1993).

Most studies on stuttering therapy outcomes have focused on behavioural measures, such as percentage of syllables stuttered (%SS), speaking rate, severity ratings by parents and/or clinicians, and speech naturalness following operant treatments. While these behavioural outcomes provide evidence of treatment efficacy, they do not clarify the underlying mechanisms responsible for the reduction of dysfluencies with operant methods. To date, the reduction of stuttering under operant methods has been attributed to several factors: operant conditioning principles, where a brief interruption following stuttering serves as a mild punishment that decreases dysfluencies (Onslow et al., 1997); increased speaker awareness and self-monitoring (Martin & Haroldson, 1982); and the use of previously learned speech restructuring strategies to minimize stuttering (Franklin et al., 2008). In this context, we propose that employing acoustic measures—shown to be sensitive to post-treatment changes across various stuttering approaches—may provide further insight into the underlying mechanisms of operant treatment methods. Hence, this study explores the use of selective acoustic measures (vowel duration, voice-onset-time and F2 transitions), previously shown to be sensitive to post-treatment changes in speech restructuring, to examine their applicability in operant methods.

Aim and Objectives of the Study

The present study aims to examine the effects of Response Contingent Time Out (RCTO) in adolescents who stutter.

The objectives of the study are:

1. To investigate the effects of RCTO in adolescents who stutter by comparing the changes (if any) between pre- and post-treatment and one-month follow-up assessments for the behavioural outcome measures of
    - Percentage of syllables stuttered (%SS)
    - Speech Rate in Syllables Per Minute (SPM)
    - Clinician and Self-rated Stuttering Severity Rating
    - Speech Naturalness Rating (NAT)

2. To examine the effect of Response-Contingent Time-Out (RCTO) on acoustic parameters in adolescents who stutter by comparing pre-treatment, post-treatment, and one-month follow-up assessments, focusing on vowel duration, F2 transition duration, and voice onset time (VOT) as measured on selected Kannada words.

Null Hypothesis

- There will be no statistically significant effect of RCTO in adolescents who stutter on the behavioural outcome measures, like Percentage of syllables stuttered (%SS), Speech Rate in Syllables Per Minute (SPM), Clinician and Self-rated Stuttering Severity Rating, Speech Naturalness Rating (NAT).
- There will be no statistically significant effect of RCTO in adolescents who stutter on the acoustic parameters like vowel duration, F2 transition duration, and voice onset time (VOT).

Chapter 2

Review of Literature

Definition and Characteristics of Stuttering

The World Health Organization (WHO, 2018) defines developmental speech fluency disorder, or stuttering, as the "pervasive disruption of the normal rhythmic flow and rate of speech characterised by repetitions and prolongations in sounds, syllables, words, and phrases, as well as blocking and word avoidance or substitutions" (Section 6A01.1). Numerous definitions of stuttering exist; while all consider the speech disruptions experienced by the speaker, they differ in their specificity, the inclusion of reactions and effects, and the descriptions of non-speech behaviours. In 2014, Guitar proposed a definition where the speech disruptions in stuttering were primarily considered: "an abnormally high frequency and/or duration of stoppages in the forward flow of speech. These stoppages usually take the form of (a) repetitions of sounds, syllables, or one-syllable words, (b) prolongations of sounds, or (c) "blockages" or "blocks" of airflow or voicing in speech. (p.7). American Speech-Language-Hearing Association (ASHA, 1999) defined stuttering by including speech characteristics as well as the secondary behaviours as follows:

> "Stuttering refers to speech events that contain monosyllabic whole-word repetitions, part-word repetitions, audible sound prolongations, or silent fixations or blockages. These may or may not be accompanied by accessory (secondary) behaviours (used to escape and/or avoid these speech events)". (pp. 4–5)

While many clinical organisations and researchers focused on speech disruptions and secondary characteristics, some also considered the internal experiences of the speaker. According to Perkins et al. (1991), stuttering can be considered as a speech disruption

perceived by the speaker as a loss of control. Yairi and Seery (2023) gave a multidimensional view of stuttering and stated:

> [W]e define stuttering as when speech is characterized by periods of frequent and/or intense articulatory/phonatory gestures in a holding pattern (repetition, prolongation, block) in an attempted delivery of syllables... When the disorder persists, it expands to acquire additional characteristics reflected in dynamic, multidimensional patterns of overt body tensions and motor-physiological adaptations as well as emotional, cognitive, and social reactions. (p. 19)

Overt and Covert Features

According to Yairi and Seery (2023), stuttering is a complex disorder with six major dimensions that can be broadly categorised into overt and covert features. The overt features include behaviours that can be directly observed, such as overt speech characteristics and physical concomitants. Overt speech behaviours are the core behaviours of stuttering, which include part-word repetitions, single-syllable word repetitions, and dysrhythmic phonation (blocks/prolongations) commonly referred to as Stuttering-Like Disfluencies (SLDs), which can be distinguished from Other Disfluencies (ODs), which are common in fluent speakers. Physical concomitants, also known as secondary characteristics, include various tense body movements associated with stuttering events.

Covert features are experiences that can impact the speaker but cannot be directly observed by the listener, including physiological activity, affective behaviors, cognitive processes, and social dynamics. Involuntary bodily changes, such as altered blood flow, brainwave activity, and skin reactions, that occur during stuttering and require specialised technology to measure are also included under covert measurements. Affective features include strong emotional reactions associated with stuttering, such as frustration, fear/avoidance of

speaking, shame, guilt, low self-esteem, lack of confidence. Cognitive processes refer to the speaker's awareness and ability to anticipate stuttering on specific words/situations, which affects communicative choices and planning. Additionally, negative self-perceptions, avoidance tendency, overestimation of listener reactions, and rumination about past speaking experiences are also part of cognitive reactions to stuttering. Avoidance of social interaction and restricted participation due to fear of the listener's reaction or judgment are part of the social dynamics of stuttering. This social dimension includes a cluster of adverse experiences that can begin in early childhood and can persist throughout the lifespan.

Research shows that young individuals who stutterer might experience isolation, social exclusion, bullying, and mockery from their peers (Davis et al., 2002; Iverach & Rapee, 2014; Langevin et al., 2009), which in turn can significantly increase the risk of developing anxiety disorders (Iverach et al., 2016; Iverach & Rapee, 2014). Adolescents who stutter may experience reduced self-esteem and diminished self-perception of communicative competence (Blood et al., 2001; Blood & Blood, 2004). Adults who stutter may experience heightened negative psychosocial experiences such as feelings of shame and guilt (Boyle, 2018, 2020; Murphy, 1999), anxiety (Craig & Tran, 2014), and embarrassment (Tran et al., 2021). Stuttering is also linked with restricted educational achievement, such as reduced likelihood of high school graduation, lower grades and diminished educational aspirations (Butler, 2013; Daniels et al., 2012; Rees & Sabia, 2014). Individuals who stutter also experience disparities in employment and income (Gerlach et al., 2018), as their stuttering interferes with job performance and limits hiring and promotional opportunities (Klein & Hood, 2004).

Stuttering as an Operant Behaviour

According to Psychobehavioural theories, stuttering is a learned, acquired behaviour rather than an innate disorder. As per Pavlov's classical conditioning (1927) and Skinner's

operant conditioning (1953), stuttering may occur when certain environmental stimuli are linked to a response (classical conditioning) and can be sustained or altered by reinforcement or punishment (operant conditioning). By manipulating responses through the removal or presentation of stimuli that are functionally positive or negative for the individual, operant behaviours could be controlled. Response-contingency (RC) refers to an treatment strategy in which the presentation or removal of a stimulus is contingent upon the occurrence of the desired behaviour. Extinction, or the failure to provide subsequent stimuli that sustain a response, also lowers the frequency of operant behaviours (Costello & Ingham, 1984). Hegde (1979) posited that children's stuttering disfluencies belonged to the operant response class as their subsequent stimuli influenced their frequency.

According to Shames and Sherrick's (1963) operant theory, stuttering persists due to various environmental consequences. Through different forms of positive and negative reinforcement with various schedules, stuttering may be sustained, and intermittent reinforcement makes it particularly resistant to extinction. During the initial stages of disfluencies, a child might try to terminate negative listener reactions associated with stuttering by modifying their speech through struggle behaviours or silence. This modification might be negatively reinforced, as it temporarily terminates the aversive stimulus (the listener’s reaction or the speaker’s own frustration). Over time, these reinforced coping mechanisms may transform the initially observed simple repetitions into more complex forms, which subsequently become characteristic features of persistent stuttering.

Conversely, certain disfluencies might be positively reinforced to gain attention from others. For example, certain repetitions occur as a form of “manding,” in which the listener may start attending to the needs of the child, thereby positively reinforcing the disfluency behavior. Such behaviors may show resistance to extinction as they are reinforced through intermittent reinforcement schedule.. Secondary advantages, such as avoiding speaking

situations, may also occur in certain cases, thereby strengthening the behaviour. Some children may get attention that unintentionally fosters disfluency, even if many children's disfluencies are reduced by mild punishment or ignoring. According to Shames and Sherrick (1963), these behavioural changes desist when a “dynamic equilibrium” is achieved, in which positive reinforcements outweigh the negative consequences of stuttering. Thus, stuttering is seen as an operant behaviour that is formed and sustained by its outcomes.

Principles of Operant Conditioning

Operant learning methods have also been used as a treatment strategy to reduce stuttering disfluencies. In these methods, the stuttering disfluencies are modfied by either through reinforcement or punishment procedures (Yairi & Seery, 2023). It is also been reported that more immediate the consequence of a behaviour, the greater its impact on whether that particular behaviour will occur again in the future (Costello,1980). The consequences can either increase or decrease a specific behaviour. An increase in the likelihood of a behaviour following a desirable response is known as *positive reinforcement*and the stimulus that increases the frequency of occurrence of a specific behaviour when it is made contingent upon it is referred to as a *positive reinforcer* (Yairi & Seery, 2023). Another method for increasing the behaviour is *negative reinforcement*, in which the termination of an unpleasant stimulus (negative reinforcer) increases the likelihood of the behaviour (Costello, 1980). If the frequency of a particular behaviour can be reduced by introducing an undesirable stimulus or removing a desirable stimulus, the process is referred to as *punishment* (Costello, 1980). A punisher is any stimulus that decreases the frequency of a behaviour when it is contingent upon a specific behaviour (Azrin & Holz, 1966).

Operant Treatment Methods

Operant learning methods are effective means of modifying stuttering behaviours. The implementation of the principles of operant conditioning in stuttering management will be initiated through close observation of the client and the clinician's accurate descriptions of the stuttering behaviours. Treatment involves relating the consequences to the behaviours of interest. The clinician organises the treatment so that it begins at a level suitable for the client and baseline performance, then advances in smaller, systematic stages, progressively requiring longer and more challenging responses from the client with progressively less assistance from the clinician. The client progressively assumes greater responsibility and develops greater skill, thereby achieving a high degree of success throughout the process. This kind of programmed instruction utilises the operant conditioning principles (Costello, 1977). For most clinicians who employ an operant viewpoint, the primary aim of treatment is for the individual receiving treatment to overcome stuttering and achieve naturally fluent, speech (Costello, 1980). Various operant methods have been in use to manage stuttering. Some of these approaches include positive reinforcement of fluency, response-contingent time-out (RCTO), response-cost, the Lidcombe Program, the Extended Length of Utterance Program, and the Gradually Increased Length and Complexity of Utterance Program.

When fluent statements are followed by an instant reward, such as praise, tokens, or tangibles, this is known as positive reinforcement of fluency. This increases the occurrence of stutter-free speech. While Costello (1980) showed that systematically extending the interval for reinforcement from single stutter-free word to longer periods of fluent speech resulted in a considerable reduction in stuttering frequency, Shaw and Shrum (1972) emphasised the importance of individualise reinforcers. A study by Hegde and Brutten (1977) highlighted the use of reinforcement contingent on particular intervals of stutter-free speech. The Lidcombe Programme (Harris et al., 2002; Jones et al., 2005), one of the effective treatment regimens for

stuttering, relies on verbal contingencies set by the clinician and parents. In this context, fluent speech attracts positive verbal reinforcement in the form of praise, acknowledgments, or requests for self-evaluation, whereas disfluencies are followed by corrective feedback.

The GILCU (Gradual Increase in Length and Complexity of Utterance) Program is a structured 54-step operant conditioning program designed to build fluency. It starts with single-word fluent utterances and progresses to five minutes of fluent speech across three modes: reading, conversation, and monologue (Ryan, 1971). The method uses verbal punishment contingencies for disfluencies and verbal contingent rewards for fluent speech. Ryan and Ryan (1995) reported nearly zero stuttering in school-age children with superior initial generalisation of fluency compared to DAF, demonstrating the effectiveness of GILCU.

Prins and Hubbard (1988) conducted a meta-analysis of 68 experimental investigations that used response-contingency paradigms to study stuttering. More than 70% showed that the introduction or removal of a reinforcing stimulus given soon after stuttering episodes modified stuttering. Some of the positive stimulus that were used by investigators while delivering fluency therapy include money, tokens, and the usage of the term ‘right’. The impact of positive stimulus presentation on stuttering has been investigated in several studies, Table 2.1 sheds light on these studies.

Table 2.1

Studies on positive stimulus presentation on stuttering disfluencies

Author	Year	Subjects	Method	Findings
Cooper et al	1970	14 AWS and 14 AWNS	Presented 3 kinds of verbal stimuli contingently after each disfluency (Right, wrong, tree).	All 3 stimuli resulted in a decrease in disfluency, suggesting that the meaning of the word is not a factor; instead, drawing attention to the disfluencies may lead to the reduction.
Shaw and Shrum	1972	3 children with stuttering (9-10 years)	Fluent utterances produced during specified time intervals were reinforced through the contingent delivery of participant-selected tangible rewards.	Stuttering frequency decreased for all 3 participants.
Patty and Quarrington	1974	21 young adults with stuttering (AWS)	Participants were divided into 3 groups: contingent nickel payment for stuttering, non-contingent rewards, and a control group in which light indicated the occurrence of stuttering.	A reduction in the frequency of struggle behaviour in contingent and non-contingent conditions, and an increase in the frequency of struggle behaviour in the control group, were noted.
Oelschlager and Brutten	1974	4 male AWS	Response-contingent positive stimulation upon part-word repetitions (monetary rewards)	No significant change in the frequency of part-word repetitions.

Table 2.1 *(Continued)*

Author	Year	Participants	Method	Findings
Lanyon and Barocas	1975	Study 1: 4 AWS Study 2: 6 AWS	Study 1: 10 cents were given for stutter-free speech and a loss of the same amount for each disfluent event. Study 2: Money was contingent only for fluent speech.	Fluency increased in both studies, and the authors concluded that enhanced self-observation was more potent than the actual financial values of rewards/penalties.
Manning et al	1976	3 children who stutter (6-9 years)	Compared the effectiveness of reinforcing fluent intervals with verbal and tangible rewards chosen by the participants.	Verbal and tangible reinforcements were equally effective in increasing fluency, and participation in reward selection and subjects' awareness were also decisive factors in improving fluency.
Daly and Kimbarow	1978	18 AWS and 18 Adults who Do not Stutter (8-18 years)	Presented 3 types of verbal stimuli contingently after each disfluency (Right, wrong, tree).	Stuttering was reduced contingent on the presentation of all 3 types of verbal stimuli.
Starkweather and Lucker	1978	4 Adolescents with Stuttering	Applied redeemable tokens contingent on stuttering to identify the role of counter-conditioning in reducing stuttering.	Stuttering decreased in 3 out of 4 participants, as positive tokens helped reduce fear and aversiveness associated with stuttering (counter-conditioning), and 1 subject showed an increase in stuttering as the tokens acted as a reinforcement of the therapeutic history of faked/voluntary stuttering.

Punishment-Based Approaches for Stuttering

According to the review by Nittrouer and Cheney (1984), operant methods may effectively reduce stuttering behaviours, with the results of punishing disfluencies being more significant than those of reinforcement. The punishment principle has been examined in considerably greater detail in the context of stuttering.. Numerous studies have presented aversive stimuli, such as loud noises or electric shocks, during episodes of stuttering Table 2.2 presents a summary of punishment studies with respect to stuttering.

Table 2.2

Studies on the presentation of aversive stimuli in relation to stuttering

Author	Year	Participants	Method	Findings
Flanagan et al	1958	3 male AWS	Using an ABA design, a reading task with two contingent schedules was conducted. *Aversive period:* A 6kHz tone at 105dB was presented contingently on stuttering. *Escape period:* A continuous tone of 105 dB turned off for 5 seconds after each moment of stuttering	Stuttering decreased during the aversive period and increased during the escape period, indicating its operant nature.
Martin and Siegel	1966	3 AWS	Presented shocks contingent on stuttering	Decrease in stuttering during response-contingent shock presentations
Daly and Cooper	1967	18 AWS (18-32 years)	Participants read 3 different passages for 5 consecutive times in the control, and 2 experimental conditions where electric shock was contingent on stuttering and immediately following each stuttered word.	Fewer disfluencies were observed in the experimental condition, with no significant differences in adaptation rate across the 3 conditions.
Biggs and Sheehan	1969	6 AWS (18-28 years)	ABA design with 3 experimental conditions: aversive, escape, and random periods using a 4kHz tone at 108 dB.	No significant reduction in stuttering suppression was observed across the 3 conditions, and it was concluded that the decrease in stuttering is primarily due to distraction effects.

Table 2.2 *(Continued)*

Author	Year	Participants	Method	Findings
Hegde	1971	5 AWS (18-23 years)	Shock was presented contingently on stuttering during the reading task.	Stuttering increased during response-contingent shock presentation, and it was concluded that this triggered stuttering by creating overarousal and anxiety.
William and Martin	1974	12 young AWS	Participants read a list of 50 sentences in 5 consecutive times in 3 conditions: contingent shock presentations, non-contingent, and control conditions.	No significant difference between the 2 experimental conditions, but fewer disfluencies were observed in the experimental condition than in the control. Adaptation occurred in all 3 conditions.

A highly reliable and successful strategy for reducing stuttering frequency is punishment by contingent withdrawal. Response cost involves removing an earned reinforcer contingent on a stuttering event and also promotes fluent speech by providing tokens that can be exchanged for a preselected reinforcer (Hegde, 1985). Halvorson (1971) demonstrated that response cost can reduce stuttering frequency in adults, but pairing it with subsequent fluency reinforcement can create discriminative properties for the punishing stimulus that may signal the reinforcement rather than suppress stuttering behaviour. Seth and Maruthy (2020) demonstrated a significant reduction in stuttering frequency and improvement in speech naturalness with Kannada-speaking preschool children using response cost. Therefore, by using these techniques, clinicians can promote fluent speech production without giving explicit instructions such as "speak smoothly" or "speak slowly," which can reduce speech naturalness.

Furthermore, time-out from positive reinforcement has been the most studied form of punishment (Costello & Ingham, 1984). According to Azrin and Holz (1966), time out (TO) functions as a punisher. The contingent withdrawal of positive stimulation reduces stuttering, even though it is yet unclear exactly how TO works. A minimum of two components make up the complex stimulus known as TO: speech interruption and an imposed time of silence. While the second might involve introducing an unpleasant stimulus, the first could be viewed as the removal of positive reinforcement. It is not always certain which of these elements of TO reduces the disfluent behavior (Leitenberg, 1965). Various studies have examined the effects of punishment through contingent withdrawal, and the first such study was conducted by Haroldson et al. (1968). The subsequent findings are summarised as follows:

Table 2.3

Studies on the effects of punishment by contingent withdrawal

Author	Year	Participants	Method	Findings
Haroldson et al.	1968	4 male AWS	sed an ABAB design, for every instance of stuttering, a red light was illuminated for 10 seconds, and the subject had to stop talking during that time.	A significant reduction in the percentage of words stuttered for all particiapants was reported (at least 88%)
Martin and Haroldson	1969	2 groups of 10 AWS	Compared the effectiveness of Time Out (signalled by a red light) with Information attitude therapy	Stuttering reduced in the TO group, whereas it remained unchanged in the other group; however, the gains did not carry over significantly when TO was withdrawn.
Curlee and Perkins	1969	15 individuals with stuttering	Conversational rate control therapy was used, where fluency was established using DAF and TO (30-second light-out period on instances of stuttering)	Stuttering instances decreased for 10 participants It was concluded that fluency was first established by DAF and strengthened with TO.
Martin and Berndt	1970	12-year-old AWS	Indicated TO by the illumination of red light	Stuttering was eliminated, but a slight increase was observed when TO was withdrawn.
Martin and Haroldson	1971	4 AWS	Condition 1: Peer-imposed TO signalled by a red light Condition 2: Experimenter-imposed TO	Stuttering was significantly reduced in condition 2, and there was very little change in condition 1.
Egolf et al	1971	10 AWS	During conversational interactions, participants were allowed to continue speaking until they stutter and change their turn after stuttering.	Stuttering reduced in 8 of 10 subjects, with a 73% increase in the number of words spoken per turn.

Table 2.3 *(Continued)*

Author	Year	Participants	Method	Findings
Adams and Popelka	1971	8 AWS (18-27 years)	Participants read 300-word passages in control and experimental conditions. In the control condition, the passages were read for 5 consecutive times without TO, and in the experimental condition, TO was signalled by a comfortably loud 1kHz tone for 10 seconds	Stuttering was reduced in both conditions, but more rapidly and to a greater extent in the experimental condition. The study also concluded that TO is not a punishing stimulus for all AWS.
Martin et al	1972	2 preschool CWS	Participants engaged in conversation with a "talking" puppet during which TO was implemented on stuttering contingencies for 10 seconds; during the TO, the puppet did not speak, and the lights were turned off.	Stuttering disappeared to 0% with maintenance for a year.
James and Ingham	1974	14 male AWS	Using an ABAB experimental design, the researcher compared TO (signalled by a 10-second flash of a red light) with enhanced expectancies and TO with allayed expectancies.	Stuttering was reduced in both conditions, indicating that TO's stuttering reduction capacities were not due to the subject's expectation. Out of 14 participants, 6 considered TO as an aversive stimulus, 5 as a time to think, and some considered it as a neutral stimulus.
James	1976	45 adolescents and AWS in a group of 5	Compared the effects of different durations of time-outs (1,5,10, and 30 seconds) signalled by a 290 Hz tone at 65dB.	All TO groups showed a significant reduction in stuttering, except for 2 subjects, and the researchers concluded that the punishing effects of TO are due to its contingent interruption of speaking, whereas the period of silence was uncritical.
Martin and Haroldson	1979	20 AWS (19-46 years)	Compared the effectiveness of 5 procedures: TO (Sounding of chime and illumination of red light), DAF, Noise, metronome, and the word 'wrong' contingent on each stuttering.	The most significant reductions in the percentage of stuttering and the average decrease per subject were greater in the TO condition than in the others.

Table 2.3 *(Continued)*

Author	Year	Participants	Method	Findings
James	1981b	36 AWS assigned to 4 groups	Contingent TO from speaking(signalled by a 290 Hz tone at 65 dB), non-contingent TO from speaking, Contingent tone presentation without cessation of speech, and non-contingent tone presentation.	All contingent TO participants demonstrated a decrease in stuttering compared to non-contingent ones and concluded that a reduction in stuttering frequency occurred only for contingent stimuli and for signalled time-out from speaking.
Martin and Haroldson	1982	30 AWS	Compared the effectiveness of self-administered time out and experimenter-administered time out, where a chime and a flashing red light signalled time out.	Both methods were equally effective in reducing stuttering, with greater generalisation for self-administered time-out.
James et al.,	1989	20 AWS (19-50 years)	Participants were categorised based on their baseline reaction to time-out into 'high' and 'low' responders, signalled by a tone and a light stimulus lasting 2 seconds. They attended a 32-hour fluency training program.	%SS decreased in both conversation and monologue, along with an increase in speaking rate. Both groups responded equally well to time-out at the 6-month follow-up, although they responded differently during the baseline measurement phase.
Onslow et al.,	1997	3 children with stuttering	Analysed the effectiveness of the TO signalled by a red light for 5 seconds contingent on stuttering using ABA design, along with the acoustic analysis of speech (VOT, Vowel duration, Intervocalic interval).	Two children showed a reduction in disfluencies with natural-sounding speech, and acoustic analysis of fluent speech samples revealed an overall decrease in vowel-duration variability in spontaneous speech.
Franklin et al.,	2008	60 AWS	Participants were categorised into a control and an experimental group, in which they were exposed to a 5-second TO signalled by a red light during two 20-minute talking periods.	Experimental group showed decrease in stuttering with enhanced speaking rate . Also, individuals with severe stuttering responded better to the TO condition.

Response Contingent Time Out (RCTO)

An operant method in which the clinician provides reinforcement in the form of attention and eye contact during fluent speech, but briefly removes eye contact contingent upon stuttering, is known as Response Contingent Time Out (RCTO). After a brief pause, the clinician re-establishes eye contact. This withdrawal of reinforcement reduces the frequency of stuttering, while maintaining eye contact during conversation, may reciprocally increase fluent speech. Costello (1975) demonstrated the efficacy of response-contingent time-out using an ABA design in 3 adolescents and adults who stutter, in which speaking briefly paused and the clinician withdrew eye contact for 10 seconds contingent on stuttering. Results showed a significant reduction in stuttering frequency across conversation, monologue, and reading tasks without decreasing overall speaking rate. Costello and Hurst (1981) used an ABAB design with 3 native English-speaking adults who stuttered to investigate whether different topographies of disfluent behaviour (different core features of stuttering) constitute a single response class. Specific disfluencies were punished using a time-out (withdrawal of eye contact for 10 seconds) or a 90 dB 4kHz tone-burst contingency. Results indicated a direct behavioural covariation in all subjects, in which untreated disfluencies decreased along with the treated behaviour, and concluded that different forms of stuttering are not independent but are organised into a single response class. A study by Wagaman et al. (1993) examined the effects of time-outs combined with awareness training and a breathing technique based on stuttering episodes in eight children who stutter. After treatment, stuttering decreased by an average of 89%, and this change was maintained for the next three years.

Twenty-two adults and adolescents participated in a study by Hewat et al. (2006) examining the influence of self-imposed time-out on speech disfluency. By the end of the trial, almost half of the individuals had reduced their stuttered-syllable percentage by more than 50%. Individual differences in treatment responsiveness were observed, wherein participants

with severe stuttering responded positively to the treatment programme. Using a modified pretest–posttest design, Veerabhadrappa (2021) examined the effectiveness of the Pause and Talk (PT) and Prolonged Speech (PS) approaches in 30 Kannada-speaking school-age children (ages 6–12) who stutter. Both treatments produced natural-sounding, fluent speech that was maintained for three months post-therapy, and there were no discernible differences between the two methods. The results showed a significant reduction in anxiety, negative attitudes, and the severity of stuttering. A recent investigation by Einarsdóttir et al. (2025) evaluated the effectiveness of a home-based operant treatment program, Stuttering Treatment for Older Children (STOC), that combined time-outs with performance-based criteria. Seven participants aged 9-13 years were involved in a single-case experimental design with multiple baselines, of whom 4 fully completed the program. The participants' stuttering frequency decreased by an average of 72%, with substantial improvements in quality of life and speech naturalness. Additionally, the study included a follow-up phase in which samples were collected 9 months after the intervention ended, once a month for 3 months, and again 6 months later. After the program, individuals reported being able to talk most or all the time without thinking about changing or controlling their speech, and these improvements persisted throughout the follow-up period.

Acoustic Analysis as an Outcome Measure in Stuttering Treatment

While perceptual measures are often used to assess the effectiveness of an approach, it may also be valuable to consider acoustic measures in understanding the effects of behavioral interventions. Particularly, acoustic measures will help the researchers understand how the behavioural treatment re-organize temporal and spectral aspects of speech. Onslow et al. (1992) analysed acoustic changes in 10 children aged 10 to 14 years after prolonged speech therapy. Acoustic parameters considered were Interphonatory Interval (IPI), Vowel Duration (VD), Voiceless Voice Onset Time (-ve VOT), Voiced Voice Onset Time (+ve VOT), and Articulation

Rate (AR). Results revealed no significant changes in the duration of the measured acoustic parameters in post-therapy. However, an overall reduction in variability was observed for vowel duration and articulation rate.

Packman et al.(1994) analysed speech pattern changes following prolonged speech treatment in 4 AWS; both perceptual and acoustic measures were analyzed. Acoustic measures like vowel duration (VD), intervocalic intervals (IVI), voiceless voice-onset times (-VOT), and articulation rates (AR) were analysed, and no consistent trend was observed across the acoustic measures. Reduction in the variability of vowel duration was observed in 3 participants, whereas it got increased in one of the participants. No consistent trend was observed in the measure of VOT. Metz et al.(1990) compared the speech of 20 AWS (aged 9-20 years) who attended a 5-week residential program involving prolonged speech with that of 20 age- and gender-matched AWNS. The study concluded that prolonged VOT and increased sentence duration may be the strongest factors contributing to the perceived unnaturalness of speech in AWS compared to AWNS. Tasko et al.(2007), evaluated the Walter Reed Stuttering Treatment Program using the speech restructuring approach, observed a reduction in syllable rate without corresponding changes in vocal intensity in fluent speech samples of 35 adults with stuttering.

Santhosh (2006) evaluated a non-programmed prolonged-speech technique in 30 Kannada-speaking individuals who stutter (15–38 years), grouped into 15–24 and 25–38year age groups. Samples included 300 words of spontaneous speech, a reading passage, and 16 bisyllabic words with voiced/voiceless plosives. Temporal (e.g., VOT, vowel duration, closure duration, total duration, voicing, F2 transition duration) and spectral (F2 transition extent, speed, type, formants) measures were analysed across pre, post, and 6-month follow-up. Post-therapy results showed significantly increased vowel duration, total duration, VOT, and voicing duration. F2 transition durations were more prolonged in disfluent pre-therapy speech than in post-therapy and follow-up samples. Increased speed of F2 transitions was observed in pre-

therapy and follow-up compared with the immediate post-therapy assessment. The increased speed during pre-therapy was attributed to trigger dysfluencies. Suchitha (1991) analysed acoustic and temporal speech parameters in persons with stuttering across pre- and post-therapy conditions, and compared with a typical group. The study used a Kannada reading passage, four syllables (/pa/, /ṭa/, /ta/, /ka/), and words beginning with unvoiced stops to measure VOT, speech initiation and termination times, speech rate, and fundamental frequency. Compared to AWS, AWNS demonstrated lower voice onset time (VOT) values and shorter initiation times. Following therapy, AWS exhibited reduced initiation times and decreased VOT. Although speech termination time increased in AWS after therapy, the group differences in speech termination time that were evident prior to therapy were no longer observed post-treatment.In contrast to speech restructuring approaches, relatively few studies have examined acoustic parameters in operant treatment methods, particularly response-contingent time-out (RCTO). Onslow et al. (1997) investigated this by analysing 12-second segments of stutter-free speech before and after the time-out procedure in three school-aged children, using an ABA single-subject design. Acoustic parameters considered were unvoiced voice onset time (VOT), intervocalic interval, and vowel duration across baseline and time-out sessions in which the lowest stuttering levels occurred. Two of the three participants demonstrated clear reductions in stuttering frequency following the intervention. Acoustic parameters, such as VOT and the intervocalic interval, showed no significant changes, but one of the two participants showed a reduction in vowel duration variability. These results suggest that operant methods such as Response Contingent Time-Out may reduce disfluency rates, but further research integrating behavioural and acoustic outcomes is needed to clarify the mechanisms underlying RCTO-induced fluency.

Chapter 3

Method

Participants

A total of 4 male adolescents, aged 10-19 years, participated in the study. All were native Kannada speakers who were diagnosed with developmental speech fluency disorder by a qualified Speech Language Pathologist (SLP) using Stuttering Severity Instrument–Fourth Edition (SSI-4; Riley, 2009).

Inclusion Criteria

- Native Kannada-speaking adolescents in the age range of 10 to 19 years.
- Diagnosed with developmental speech fluency disorder.
- No history of speech restructuring or stuttering modification in the past six months.
- Adolescents who stutter with normal intellectual functioning
- Adolescents with age-appropriate language and articulation skills
- Adolescents with a mild to a very severe degree of stuttering as per SSI-4 (Riley, 2009)

Exclusion Criteria

- Adolescents who stutter as a result of brain injury or due to psychological overlays.
- Adolescents who are under medications for psychological issues.

The language screening was conducted for all the participants using the Linguistic Profile Test (Suchithra & Karanth, 2007). Kannada Diagnostic Photo Articulation Test (KDPAT) (Deepa & Savitri, 2010) and Montreal Cognitive Assessment (MoCA; Kaul et al., 2022) were used to screen the articulation and cognitive abilities, respectively. Using SSI-4 (Riley, 2009), the investigator in the present study confirmed the presence of Developmental Speech Fluency Disorder, and participants with very mild stuttering were excluded.

Table 3.1

Demographic details of participants in the study

Participants	Age/Gender	Age of Onset (As per parent's report)	Severity of Stuttering	Family History of Stuttering	SSI Score	Previous Treatment and Duration
P1	13.4 years/Male	7 years	Mild	No	18	At 12.3 years of age for 10 days
P2	14.5 years/ Male	3 years	Very severe	No	36	At 4 years of age for 2 months
P3	10.4 years/ Male	7 years	Moderate	Yes	26	No previous treatment
P4	11.8 years/ Male	3 years	Severe	No	29	At 7 years of age for 3 months

By conducting a parental interview, participants' demographic information and a brief history of the speech disfluency was gathered. Data were collected on the age of stuttering onset, handedness, severity, and prior medical and intervention history. Information from the interview confirmed that the age of onset of stuttering was at or before 7 years for all participants, and all were right-handed individuals with age-appropriate articulation and language skills. Table 3.1 presents the comprehensive details of all participants included in the study.

Written informed consent from the parents/legal guardians and an assent form from the participants were obtained before enrolling them into the study. The study was conducted at AIISH, Mysuru, after obtaining ethical clearance from the AIISH ethics committee, and was carried out in accordance with the "Ethical Guidelines of Behavioural Research involving Human Subjects" (Basavaraj & Venkatesh, 2009) of AIISH, Mysuru.

Research Design

The study was conducted based on a pre-experimental AB design.

Procedure and Treatment Regimen

Step 1: Assessing the Responsiveness to Response Contingent Time-Out (RCTO)

As there is high variability in the treatment responsiveness to RCTO, each participant was tested for their stuttering reduction before enrolling them into the study. Initially, participants were asked to read Kannada passages for grades 5, 6 and 7 (Mahesh, 2018) for 2 minutes without any interruption from the clinician (baseline). Following this, the clinician imposed RCTO, during which the clinician said "stop" during dysfluencies and withdrew eye contact for 5 seconds for a 2-minute reading sample. The same procedure was repeated a third time without the clinician imposing RCTO. A similar procedure was also repeated for the conversation task. Participants who exhibited at least a 10% relative reduction in stuttering disfluencies from their baseline across any of these speaking tasks were considered responsive to RCTO and enrolled into the study. This was an adapted version of responsiveness testing to RCTO from a previous study (Einarsdottir et al., 2025).

Step 2: Applying the RCTO on Adolescents Who Stutter

Only those participants who responded positively in the responsiveness testing were included in this stage. A baseline of 300-350 syllables was measured over 2 sessions until the participant's stuttering dysfluencies became stable (2-5% variation across the baseline sessions) in their narration, conversation, and reading samples. The audio and video recordings were orthographically transcribed to measure the percentage of syllables stuttered, along with clinician- and self-rated stuttering severity. A Samsung S23 FE mobile phone was used to record the speech samples that were used to calculated %SS, speaking rate, and naturalness.

The treatment procedure remained similar to the responsiveness testing, in which the

clinician immediately identified the clinical signs of stuttering disfluencies and instructed the patient to 'stop' talking while briefly breaking eye contact (3–5 seconds) with a neutral facial expression, then resumed talking after the brief time-out. Positive reinforcement came from the clinician's attention to the participant rather than from explicit and targeted reinforcement of fluent utterances (Hegde, 2006). At later stages of therapy, when the participant exhibited a reduction in dysfluencies, the clinician predominantly employed nonverbal strategies—such as gestures and facial expressions—to indicate whether the participant should pause or continue speaking, thereby facilitating the transition toward stutter-free speech. In contrast to most other stuttering management techniques (such as Prolonged Speech), the clinician did not model the fluent utterances for the participant. Additionally, during the intervention program, the clinician trained the participant to use self-initiated time-out, which encouraged the participant to use the treatment regimen beyond the clinical setting.

Every treatment session comprised three tasks: reading aloud, conversation, and monologue, each carried out by the investigator of this study for 10-15 minutes. Once the participant demonstrated greater fluency (>97%), the clinician introduced generalization to more natural, unstructured speaking situations. Natural situations used for the generalization tasks were talking with a stranger and telephonic conversations.

Step 3: Maintenance of fluency

The participant was put into the maintenance phase when (1) the participant attained ≥ 98% fluency in the clinical situation and (2) when the clinician assigned a severity level of 0 to 2 on a 10-point scale (where 0 indicates 'no stuttering', 1 indicates 'extremely mild stuttering' and 9 indicates 'extremely severe stuttering'), which was adopted from the Lidcombe Program (Jones et al., 2005). During the maintenance phase, parents were asked to maintain a fluency logbook (daily logs), in which they were asked to record the practice of the treatment at home

as well as other speaking situations based on 3 tasks like reading, narration and conversation, along with the overall severity using the severity rating scale adopted from the Lidcombe Program (Jones et al., 2005). The clinician counselled the participant to follow the treatment practice of at least 10 minutes per day under the parent/legal guardian's supervision. The log book included the type of activity (reading, conversation, narration, etc.) and the severity rating provided by the parents. The maintenance data were shared with the investigator by the parents every 3 days. After a month, the participants were asked to provide follow-up speech sample recordings.

Measurement of Outcome Variables

A. *Perceptual Speech Outcome Measures*

Outcome variables, including the percentage of syllables stuttered (%SS), speech rate in Syllables Per Minute (SPM), Speech Naturalness rating, and Stuttering Severity Rating, were measured at baseline, at the end of treatment, and during the one-month follow-up period.

1. Percentage of syllables stuttered (%SS).

Analysis was carried out by the investigator after listening to the recorded sample and transcribing it into IPA. A total of 350 syllables from each task of the recorded conversation, narration, and reading samples of the participants were IPA-transcribed, of which 300 syllables (after deleting the first and last 25 syllables) were analyzed to identify disfluencies (Riley, 1972). Stuttering-like disfluencies (SLDs) that include single-syllable whole-word repetitions, part-word repetitions, and dysrhythmic phonation involving blocks and prolongations were identified by the investigator of this study (Yairi & Ambrose, 2005). The following formula was used to determine the %SS:

% SS = Total syllables stuttered/ total syllables uttered * 100

2. Speech Rate in Syllables Per Minute (SPM).

SPM is a commonly used clinical measure of speech rate. It indicates how many syllables, both fluent and disfluent, adolescents who stutter have uttered in a minute, including pauses. In this study, speech rate, expressed as syllables per minute (SPM), was determined by dividing the total number of syllables (300) by the time taken to produce them. These syllables were obtained from the speech samples used to analyse the percentage of syllables stuttered (%SS) across three tasks: conversation, reading, and narration.. The following formula was used for estimating SPM:

Syllables per minute (SPM) = Total number of syllables uttered /Total time in minutes
Here,
Syllables per minute (SPM) = 300 syllables /Total time in minutes

3. Speech Naturalness rating (NAT).

A nine-point speech naturalness scale from SSI-4 was used to evaluate the naturalness of the speech, with 1 representing extremely natural- sounding speech and 9 representing extremely unnatural-sounding speech. Researchers have widely recognized and utilized this scale, such as in SSI-4 (Riley, 2009). A 3-minute audio sample from the % SS data was extracted from the conversation task to measure the Speech Naturalness.

4. Clinician and Self-Rated Stuttering Severity.

Both the clinician and the adolescent rated the severity of stuttering at 3 time points: pre-therapy, post-therapy, and follow-up. The clinician rated stuttering severity using a 10-point scale (0 = ‘no stuttering’, 1 = ‘extremely mild stuttering’, 9 = ‘extremely severe stuttering’) (see Appendix B), was selected from the Lidcombe Program (Jones et al., 2005). Adolescents who stutter rated their own stuttering using Question 1 of the self-rating measure

developed by Riley et al. (2004), a 9-point scale (1 = ‘relatively fluent’; 9 = ‘severe stuttering’) (see Appendix A).

B. Acoustic Outcome Measures

Stimuli.

Eight meaningful trisyllabic words in Kannada containing voiced and unvoiced plosives (retroflex, velar, dental, bilabial) in word-initial position, followed by vowel /a/ were selected. These words were used to measure the acoustic data, like VOT (Voice Onset Time) and second formant transition duration (F2 TD). Table 3.2 presents the lists of these words.

Table 3.2

Words Selected for the Acoustic Analysis.

Sl. No.	Unvoiced Plosives	Voiced Plosives
1.	/pajana/	/ba:gilu/
2.	/ʈamaʈe/	/ɖamaru/
3.	/kaʈʈari/	/gala:ʈe/
4.	/ʈagaɖu/	/ɖavaɖe/

The selected words were read by the participants of this study three times into a dynamic microphone held at 10 cm from the mouth, and the recordings were made using CSL 4500b at a sampling rate of 44,100 during pre-, post-, and 1-month follow-up. From the recorded words, perceptually stutter-free words were selected for acoustic analysis using Praat software (Boersma & Weenink, 2025; version 6.4.42). The following acoustic parameters were measured:

a) ***Vowel duration.***

The distance between the peaks of the first and last periods that displays the distinctive waveform shape for that vowel is known as the vowel duration, i.e., the interval of time between the vowel's onset and offset and this was measured in milliseconds. Vowel duration was analysed at the level of narration wherethe duration of the first 10 occurrences of the following vowels /a/, /i/, /u/ was calculated.

b) ***Voice Onset Time (VOT).***

VOT, measured as the time between the articulatory release/stop burst, and the onset of glottal activity for the following vowel, as indicated by the voice bars on the spectrograms that was measured in milliseconds. This is measured only in the syllable initial positions for the above listed words for the targeted unvoiced syllables of /pa/, /t̪a/, /ka/ and /ʈ̪a/ and voiced syllables of /ba/, /d̪a/, /ga/ and /ɖ̪a/.

c) ***F2 Transition Duration.***

The duration, measured in milliseconds, from the onset of the F2 locus frequency (influenced by the preceding consonant) to the point at which the formant reaches the steady-state frequency for the following vowel. This was also measured only in the syllable initial positions for the above listed words for the targeted unvoiced syllables of /pa/, /t̪a/, /ka/ and /ʈ̪a/ and voiced syllables of /ba/, /d̪a/, /ga/ and /da/.

Statistical analysis

As this study used a pre-experimental single-subject design, no inferential measures were used to analyze the results. Instead, descriptive statistical measures such as mean and standard deviation were computed across the treatment points for the selected behavioral and acoustic measures.

Chapter 4

Results

This study employed a pre-experimental AB design, which meant that no inferential statistical measures were used to analyze the calculated fluency parameters. The normality of the data was not assessed, as the results were discussed according to the conventions of single-subject experimental design. This section presents descriptive statistics for the fluency measures analyzed across all four participants. For each participant, the following measures were reported: percentage of stuttered syllables (% SS), speaking rate (in syllables per minute), self- and clinician-rated stuttering severity, naturalness, and acoustic measures.

Participant 1

History

ABC is a 13-year-old adolescent diagnosed with a mild developmental speech fluency disorder, with an SSI-4 score of 18 and a percentile rank of 24 - 40. The participant attended 10 days of therapy one year prior to the study, utilizing the fluency shaping procedure. During the first contact with the patient, stuttering like disfluencies (SLDs), such as syllable repetitions and blocks, in word-initial positions, with very minimal physical concomitants, such as distracting sounds (e.g., clicking) and head and extremity movements were observed.

Responsiveness Testing

Before enrolling the participant into the RCTO treatment, responsiveness to the treatment was assessed using a 2-min reading and conversation sample. This procedure was adapted from a previous study that reported the long-term effects of RCTO in adolescents (Einarsdóttir et al., 2025). A 2-minute reading sample was recorded without treatment, followed by a clinician-imposed time-out and a self-imposed time-out reading trials for 2 minutes. To assess responsiveness, the percentage of syllables stuttered was calculated during the initial 2-minute trial without treatment and compared with the self-initiated time-out trial.

Similar procedure was repeated for the conversation task. After introducing RCTO, the percentage of syllables stuttered decreased from 4.33% to 1.64% in the conversation sample and from 7% to 2.38% in the reading task. The participant showed a 62.1% reduction in SLDs during conversation and a 66.0% reduction during reading relative to baseline, exceeding the predefined responsiveness criterion of a 10% reduction. Hence, the participant was enrolled into the RCTO treatment as there was a consistent reduction in %SS during the responsiveness testing.

Baseline Assessment

Baseline assessment included the measurement of percentage of syllable stuttered (%SS) and speech rate in syllables per minute (SPM) across reading, narration and conversation; naturalness assessment using (SSI-4), patient self-rated stuttering severity (9-point scale, Riley et al., 2004) and clinician-rated overall severity of Stuttering using the Lidcombe scale (Jones et al., 2005). Table 4.1 and Table 4.3 show the results of these baseline assessments.

Table 4.1

Baseline Fluency Measures Prior to Intervention for Participant 1

% SS						Naturalness Rating	Patient Self-Rated Stuttering Severity	Clinician Rated Severity of Stuttering
Reading		Narration		Conversation				
B1	B2	B1	B2	B1	B2			
6.33	8	5.33	4.67	3.33	4.33	3	4	4

Note. %SS = Percentage of syllables stuttered; B1 = 1st Baseline; B2 = 2nd Baseline.

RCTO Treatment and Outcomes

a) Behavioral Outcomes: Establishment phase.

In the establishment phase, RCTO was delivered by the investigator of this study as per the protocol described in the method section of this study. This was continued until a noticeable decrease in disfluency was perceived. The clinician perceived a considerable reduction in

disfluencies following 10 RCTO sessions. The behavioral outcome measures, such as %SS, SPM, naturalness, severity rating by clinician and the self-rated stuttering severity of the patient were documented immediately after these 10 sessions. With regard to the percentage of syllables stuttered (%SS) and the speaking rate measurement in syllables per minute (SPM), along with the absolute change, a percentage change was also computed using the below formula:

$$Percentage\ Change = \frac{Post\ Treatment\ Score - Baseline\ Mean}{Baseline\ Mean} \times 100$$

Following 10 sessions of treatment, a score of 1 was obtained in the perceptual measures of fluency, such as naturalness, clinician and client rated severity of stuttering. Figure 4.1 shows a ≤ 2% in %SS in the immediate post-therapy measurement across the three tasks. An increase in speaking rate was observed across all the speaking tasks (as in Table 4.3). In conversational speech, SPM increased by 30.19% immediately after therapy and by 37.05% at follow-up, indicating continued improvement in the speaking rate of spontaneous speech production. Narration showed relatively smaller gains, with a 7.07% increase post-therapy and a 16.74% increase at follow-up. Reading tasks showed a 6.08% increase immediately after therapy, followed by a noticeable improvement of 43.66% at the 1-month follow-up, suggesting continued enhancement in speaking rate over time. Overall, the findings indicate that therapy was associated with progressive improvement in speech rate across all speaking contexts, with the largest short-term gain observed in reading and conversation tasks.

The percentage of syllables stuttered showed a substantial reduction during post-therapy and was maintained through the 1-month follow-up across all tasks (as shown in Table 4.2). %SS showed a percentage decrease of 82.51% in the post therapy for conversational speech and demonstrated a robust maintenance of 91.38% at 1-month follow-up. A stable 80% reduction in %SS was observed in the narration task at post-therapy and at 1-month follow-up.

Reading tasks showed a 72.07% reduction immediately after therapy, which further improved to 86.03% at follow-up. There were a continuous reduction and maintenance of %SS from post therapy to 1 month follow up.

b) Behavioral outcomes: Generalization phase.

Post therapy assessment revealed an absolute increase in fluency. After post-therapy assessment, generalization sessions were carried out where the participant was made to a) talk with strangers (face to face) and also had b) a telephonic conversation. A total of 5 generalization sessions were carried out, after which the percentage of syllables stuttered were calculated. It was observed that the participant had a %SS of 0.5% while talking with a stranger and 1.5% during a telephonic conversation for a 200-syllable speech sample.

Figure 4.1

Percentage of Syllables Stuttered (%SS) Across Treatment Time Points and Speech Tasks for Participant 1

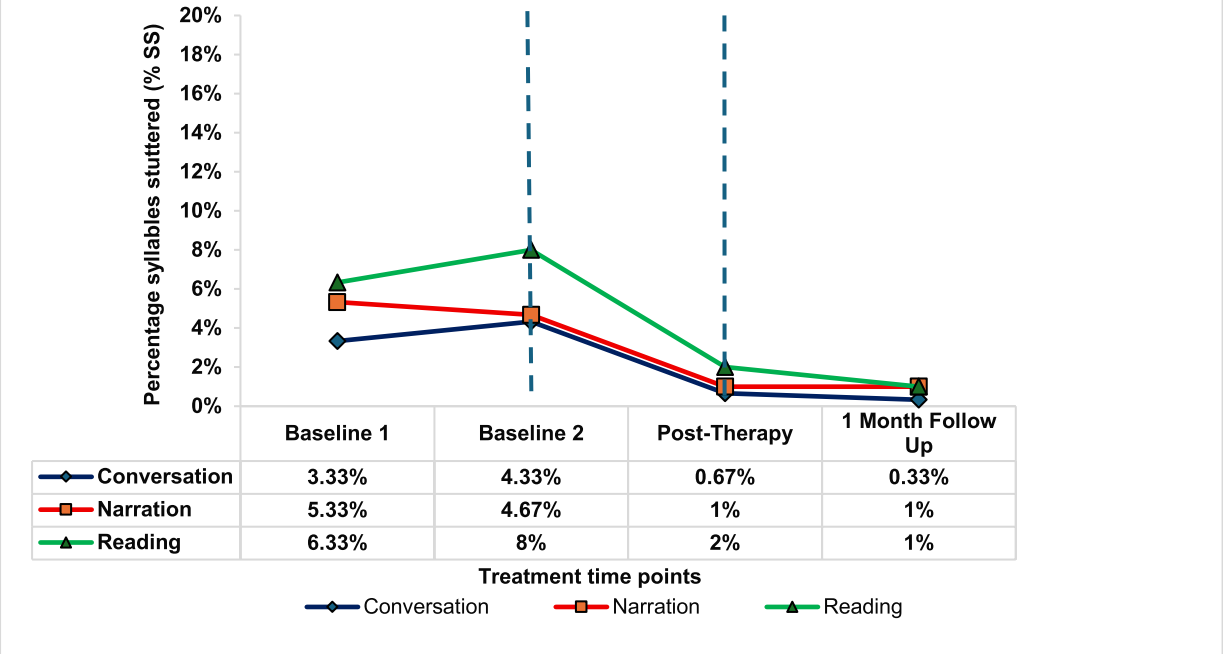


Table 4.2

Percentage Change in %SS Across Treatment Time Points in Speech Tasks for Participant 1

Percentage of Syllables Stuttered (%SS)	% Change (Baseline to post-therapy)	% Change (Baseline to 1-Month Follow-up)
Conversation	- 82.51%	- 91.38%
Narration	- 80%	- 80%
Reading	- 72.07%	- 86.03%

Table 4.3

Rate of Speech (in syllables per minute) and Percentage Change Across Treatment Time Points for Speech Tasks for Participant 1

Rate of Speech (in SPM)	Baseline 1	Baseline 2	Post therapy	1-month follow-up	% Change (Baseline to post-therapy)	% Change (Baseline to 1-Month Follow-up)
Conversation	169.87	196.12	238.25	250.8	30.19%	37.05%
Narration	195.4	192.84	207.85	226.61	7.07%	16.74%
Reading	149.5	112.21	138.81	187.99	6.08%	43.66%

SPM = Syllables per minute

c) Behavioral outcomes: One Month Post Treatment Follow Up.

After generalization, fluency maintenance was monitored through parent-rated severity scores over the course of one month. This assessment included various tasks, such as conversation, narration, and reading, as well as an overall severity rating. The ratings utilized a 10-point ordinal scale from the Lidcombe Program (Jones et al., 2005).

Initially, parent-rated severity scores were 3 for narration and reading, whereas a score of 2 was given for conversation and overall severity. By day 19, a stable plateau rating of 1 was achieved for all tasks and maintained throughout the monitoring period. These changes are

documented in Figure 4.2, which shows the parent-rated stuttering severity for participant 1 for a duration of 1 month following post-therapy. Figure 4.3 shows the overall severity noted by the parent during the post-therapy one-month follow-up.

Parent rated severity scores were further supported by a one-month follow-up assessment (Figure 4.1), which revealed sustained fluency, with a percentage of syllables stuttered reaching it's lowest point of 0.33% in conversation. Naturalness and severity ratings consistently remained at 1, indicating that the behavioral gains were both perceptually natural and clinically significant.

Figure 4.2

Parent-Rated Severity Scores Across Speech Tasks During the 1-Month Post-Treatment Period for Participant 1

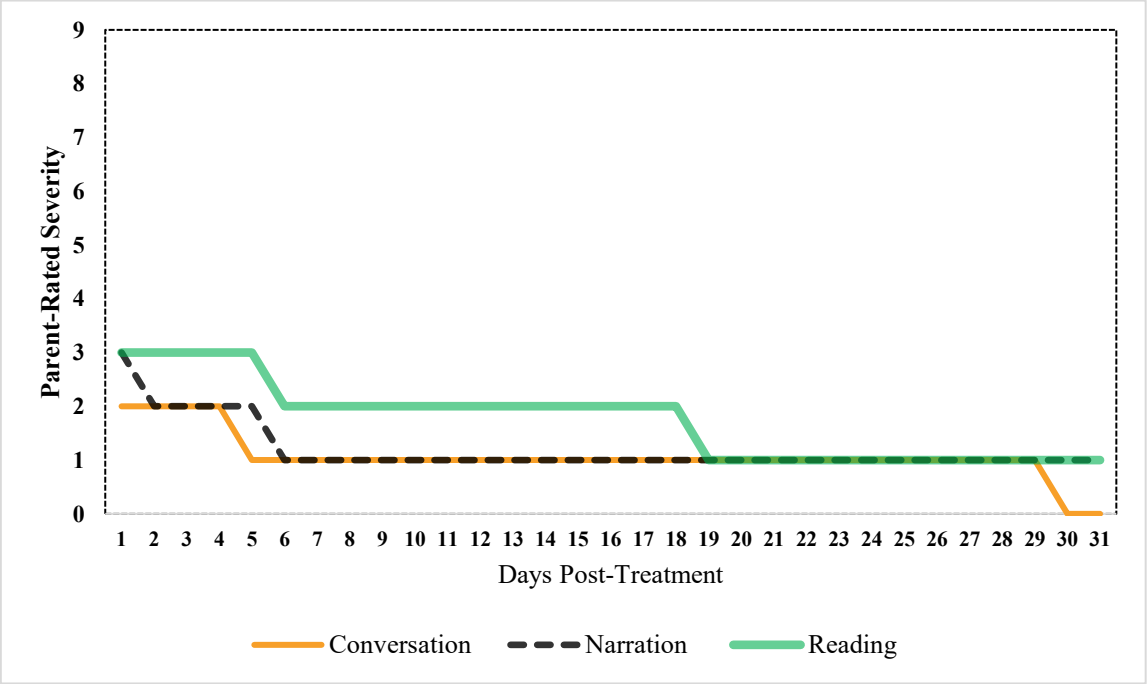
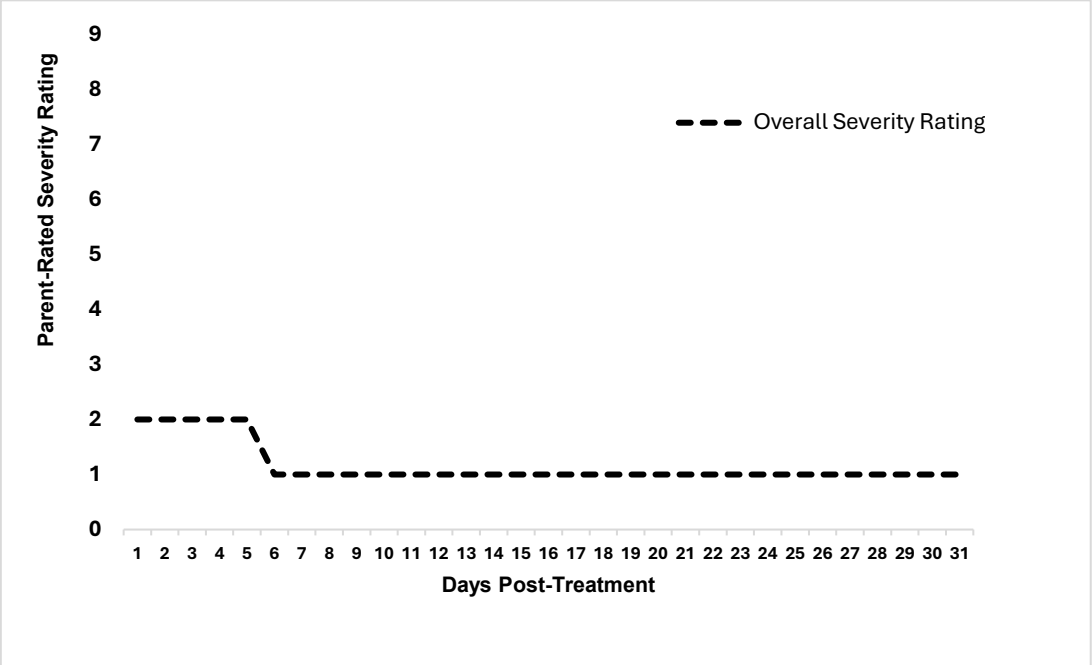


Figure 4.3

Overall Parent Rated Severity During the 1-Month Post-Treatment Period for Participant 1



Acoustic Outcomes

Acoustic analysis was carried out to understand the post therapy changes following RCTO treatment. This involved the measurement and comparison of parameters such as *Voice Onset Time (VOT), F2 Transition Duration, and Vowel Duration* for each participant following RCTO treatment.

A. Vowel Duration for Narration

Vowel duration was measured using the narration sample of the participant. To measure vowel duration from the narration sample, the first 10 instances of the vowels /a/, /i/ and /u/ were selected. Mean vowel durations of /a/ and /i/were reduced following intervention with a percentage of 15.04% and 31.13%, respectively. This was further maintained during the 1-month post treatment follow up. On contrary, the duration of the vowel /u/ increased from baseline to follow-up with a percentage increase of 56.57% and this increase was accompanied by a reduction in overall standard deviation plausibly supporting fluent speech production.

Table 4.4 shows the mean vowel duration and the percentage change in vowel duration during narration following RCTO treatment in participant 1.

Table 4.4

Mean Vowel Duration and Percentage Change in Vowel Duration Across Treatment Time Points During Narration in Participant 1

Target Vowels	Pre-Therapy (in ms) Mean (SD)	Post-Therapy (in ms) Mean (SD)	1-Month Follow-Up (in ms) Mean (SD)	% Change (Baseline to post-therapy)	% Change (Baseline to 1-Month Follow-up)
/a/	80.31 (41.66)	68.23 (17.96)	69.43 (9.90)	-15.04%*	−13.55%
/i/	97.44 (61.82)	67.11 (23.29)	76.98 (19.31)	−31.13%	−21.00%
/u/	76.58 (54.88)	96.06 (32.60)	119.90 (38.13)	+25.44%#	+56.57%

* = reduction in vowel duration; # = increase in vowel duration.

B. Voice Onset Time (VOT)

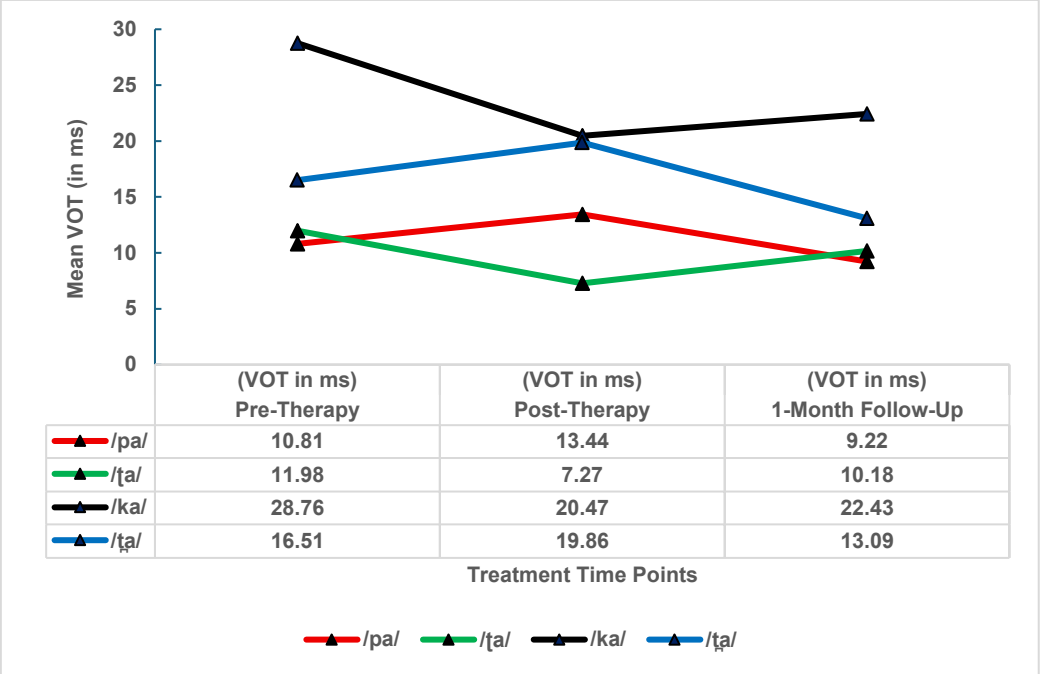
The VOT was analyzed only at syllable-initial position at the pre-, post-, and 1-month follow-ups for voiced and unvoiced plosive consonants in a word context, using 8 stimulus words representing 8 target consonants, in fluent utterances.

a) Unvoiced Plosives

For unvoiced plosives, there was a general trend of decrease in overall mean VOT values in 1-month post-treatment follow-up, and there was a slight increase in VOT post-treatment for /pa/ and /t̪a/ stimuli, as in Figure 4.4.

Figure 4.4

Mean Voice Onset Time (VOT) in 4 Target Words with Unvoiced Plosives Across Treatment Time Points for Participant 1

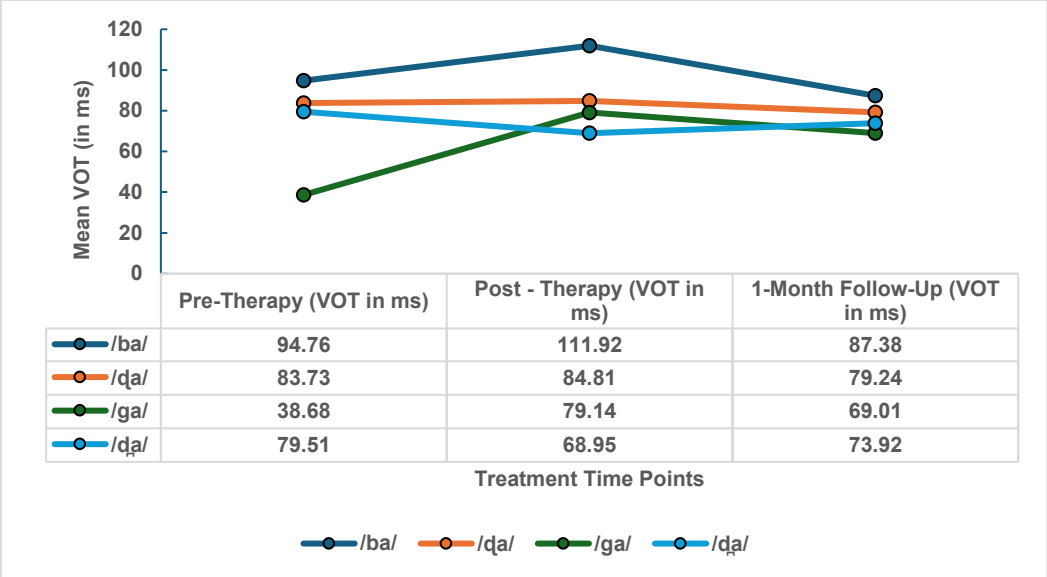


b) Voiced Plosives

Voiced plosives showed a comparatively higher and wider range of baseline values. Also, there was a general trend of decreased mean VOT values for all plosives except /ga/, which increased from 38.68 ms to 79.14 ms from baseline to post-therapy and reached 69.01 ms during follow-up. Also, a slight increase in VOT for /ba/was observed from baseline to post-treatment, which decreased to 87.38 ms during the follow-up, as in Figure 4.5.

Figure 4.5

Mean Voice Onset Time (VOT) in 4 Target Words with Voiced Plosives Across Treatment Time Points for Participant 1



C. F2 Transition Duration

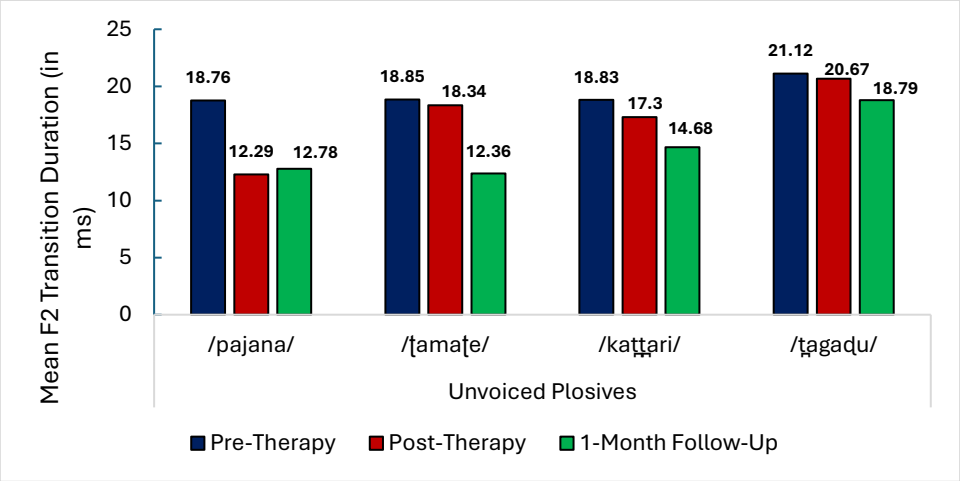
In a word context, F2 TD was analysed at the syllable-initial position for voiced and unvoiced plosives at 3 time points: pre-therapy, post-therapy, and follow-up for fluent utterances.

a) Unvoiced plosives

The mean F2 transition duration values decreased from baseline to follow-up for all unvoiced plosives, as shown in Figure 4.6.

Figure 4.6

Mean F2 Transition Duration (F2 TD) in 4 Target Words with Unvoiced Plosives Across Treatment Time Points for Participant 1

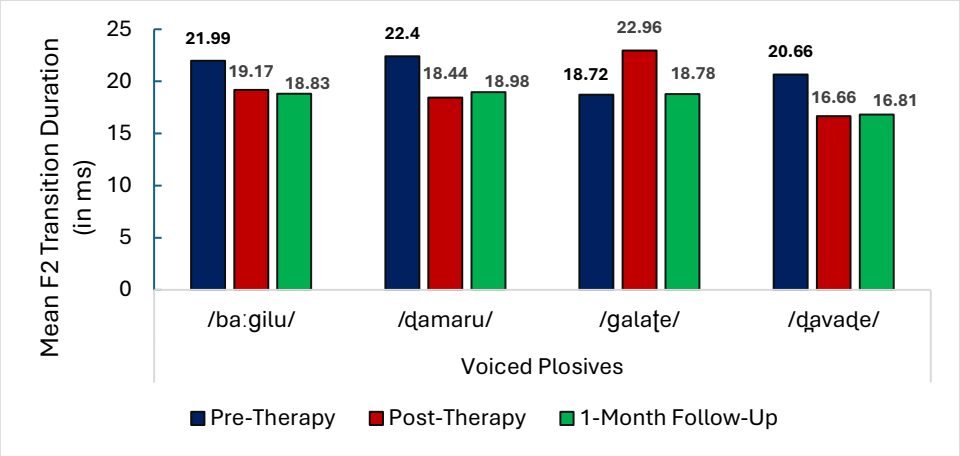


b) Voiced Plosives

All the voiced plosives except for /ga/ demonstrated a decrease in transition duration from baseline to post-therapy, and the reduction was either continuing or stabilising at 1-month follow-up. For /ga/ F2 TD increased from 18.72 ms to 22.96 ms during post-therapy, which almost returned to the baseline value at 1-month follow-up.

Figure 4.7

Mean F2 Transition Duration (F2 TD) in 4 Target Words with Voiced Plosives Across Treatment Time Points for Participant 1



Overall, participant 1 demonstrated shifts in behavioral and acoustic outcomes following RCTO. Behaviorally, the participant achieved a significant reduction in the percentage of syllables stuttered with an increase in speaking rate, which was maintained during the 1-month follow-up period. Furthermore, these fluency gains were transferred to functional communication tasks, such as telephonic conversations and conversations with strangers during the generalization phase, with well-maintained home training. Acoustically, the participant demonstrated a clear reduction in vowel duration variability and showed reduction in VOT and F2 transition duration from pre-therapy to follow-up for both voiced and unvoiced plosives.

Participant 2

History

XYZ is an adolescent aged 14.5 years diagnosed with very severe developmental speech fluency disorder, indicated by an SSI-4 score of 36 and a percentile rank of 96-99. At the age of 4, the participant was diagnosed with mild stuttering and had attended 2 months of

therapy for the same. However, the details of the treatment taken could not be remembered by the patient or his family. The current baseline assessment revealed a high frequency of SLDs, such as syllable repetitions and blocks, localized in word-initial positions, and Other Disfluencies (ODs), such as interjections, phrase repetitions, and revisions. The participant also exhibited physical concomitants such as movements of the extremities, head movements, lip pressing and poor eye contact. The duration of individual stuttering events was highly variable, reaching up to 30 seconds at times.

Responsiveness Testing

Responsiveness to RCTO was assessed through a 2-minute conversation and a reading sample. The percentage of syllables stuttered for 2-minute trials without RCTO were compared with 2-minute trials with self-imposed time-out. Results revealed a decrease in the percentage of syllables stuttered from 24% to 6.25% (73.96% relative reduction in %SS) for conversation and 17.42% to 10.32% in reading (40.76% relative reduction in %SS), indicating that the participant is responsive to RCTO. Hence, the participant was enrolled on the study.

Baseline Assessment

Behavioral measures such as the percentage of syllables stuttered (%SS) and speaking rate in syllables per minute across conversation, narration, and reading tasks; naturalness score; clinician-rated severity of stuttering; and patient self-rated stuttering severity were collected. Table 4.5 and Table 4.7 present the results of these baseline assessments.

Table 4.5

Baseline Fluency Measures Prior to Intervention for Participant 2

% SS						Naturalness Rating	Patient Self-Rated Stuttering Severity	Clinician-Rated Severity of Stuttering
Reading		Narration		Conversation				
B1	B2	B1	B2	B1	B2			
8.33	13	12.67	16.33	10.33	11.67	7	7	8

Note. %SS = Percentage of syllables stuttered; B1 = 1st Baseline; B2 = 2nd Baseline

RCTO Treatment and Outcomes

a) Behavioral Outcomes: Establishment phase

The investigator delivered RCTO for *13 sessions*, after which an absolute disfluency rate of < 2% was documented (98% of fluency was therefore observed), along with clinician and self-rated severity scores of 1 and naturalness rating of 2. Figure 4.8 shows the %SS across various time points of the RCTO treatment.

As shown in Table 4.6, the percentage of syllables stuttered dropped substantially from baseline to post-therapy and was maintained during the 1-month follow-up period across all tasks. Compared with the other tasks, a marked reduction in the relative disfluency percentage was seen in the reading task, with a 96.90% reduction immediately after therapy and 90.62% at follow-up. Nonetheless, conversation and narration tasks also exhibited reductions of 90.91% and 88.48%, respectively, which were preserved successfully at the follow up period.

Across all tasks, speaking rate increased from baseline to follow-up (as in Table 4.7). The most prominent change was in the conversation task, where the rate almost tripled from baseline to follow-up, resulting in a 206.88% increase. Narration also showed an increase in rate with a percentage of 160.45% immediately after therapy and 172.08% at 1 month follow-up. A modest increase in speaking rate was seen in reading with an increase of 112.04% immediately after therapy and 93.89% at 1 month follow-up, respectively.

b) Behavioral outcomes: Generalization phase.

The number of generalization sessions to transfer the learnt fluency skills for two speaking situations of talking to strangers (face to face) and telephonic conversation with them took nearly 10 sessions. The %SS reduced to 0.5% in both situations for a 200-syllable speech sample.

Figure 4.8

Percentage of Syllables Stuttered (%SS) Across Treatment Time Points and Speech Tasks for Participant 2

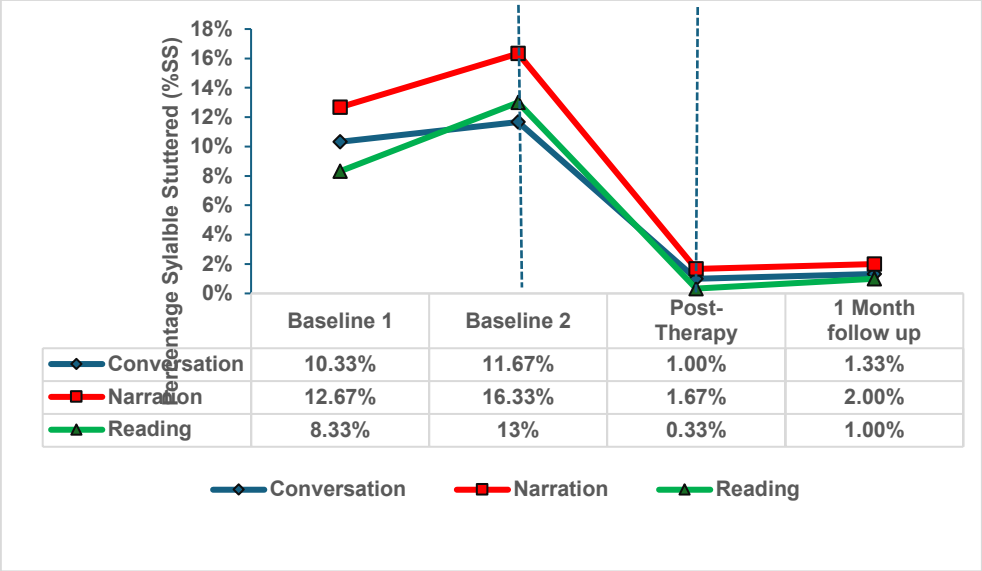


Table 4.6

Percentage Change in %SS Across Treatment Time Points in Speech Tasks for Participant 2

Percentage of Syllables Stuttered (%SS)	% Change (Baseline to post-therapy)	% Change (Baseline to 1-Month Follow-up)
Conversation	- 90.91%	- 87.91%
Narration	- 88.48%	- 86.21%
Reading	- 96.90%	- 90.62%

Table 4.7

Rate of Speech (in syllables per minute) and Percentage Change across Treatment Time Points for Speech Tasks for Participant 2

Rate of Speech (in SPM)	Baseline 1	Baseline 2	Post therapy	1-month follow-up	% Change (Baseline to post-therapy)	% Change (Baseline to 1-Month Follow-up)
Conversation	89.37	70.72	230.33	245.63	187.77%	206.88%
Narration	91.77	65.05	204.22	213.34	160.45%	172.08%
Reading	141.20	94.86	250.28	228.86	112.04%	93.89%

SPM = Syllables per minute

c) Behavioral outcomes: One Month Post Treatment Follow Up.

After generalisation, parent-rated severity scores across tasks and overall severity were measured, with scores of 2 for narration and conversation and 1 for reading on day 1. Compared to conversation and reading, the parent rated severity for narration was 2 until day 7. After which the parent rated severity was reduced to 1 (from day 7 to 18) both conversation and narration. Reading showed a consistent reduction after day 3 and was scored as 0 indicating near normal fluency in this task. From days 19 to 29, minor fluctuations between 2 and 3 were noted for narration, whereas it was 2 for conversation. These changes in %SS across the speaking tasks were documented in Figure 4.9, and Figure 4.10 depicts the overall severity rating during the one-month follow-up period.

These parental ratings were substantiated by a one-month follow-up assessment (Figure 4.8). During this assessment, the percentage of syllables stuttered remained at or below 2% across all tasks. Both clinician and self-rated severity ratings, along with naturalness, shifted to a score of 2 in the one-month follow-up. This indicates a clinically minimal increase in the percentage of syllables stuttered (%SS), which falls within the accepted limit of a 3% absolute disfluency rate.

Figure 4.9

Parent-Rated Severity Scores Across Speech Tasks During the 1-Month Post-Treatment Period for Participant 2

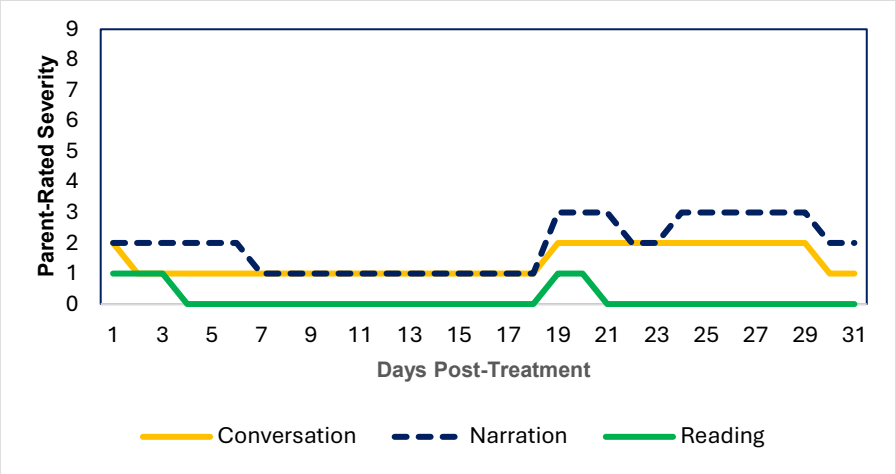
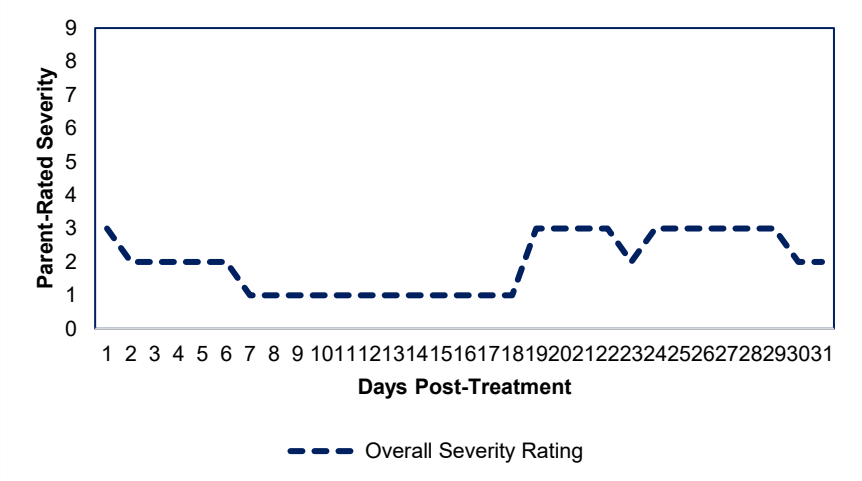


Figure 4.10

Overall Parent Rated Severity During the 1-Month Post-Treatment Period for Participant 2



Acoustic Outcomes

A. Vowel Duration for Narration

Vowel duration of vowels /i/ and /u/ reduced following the treatment, with a percentage decrease of 22.49% and 11.22% immediately after the therapy (as shown in Table 4.8). This

was further reduced during a 1-month follow-up assessment, with percentages of 25.95% and 45.48% for /i/ and /u/, respectively. On the contrary, the duration of /a/ increased by 42.80% immediately after therapy, then slightly decreased but still maintained an increasing trend from baseline, with a 20.31% increase during follow-up.

Table 4.8

Mean Vowel Duration and Percentage Change in Vowel Duration Across Treatment Time Points During Narration in Participant 2

Target Vowels	Pre-Therapy (in ms) Mean (SD)	Post-Therapy (in ms) Mean (SD)	1-Month Follow-Up (in ms) Mean (SD)	% Change (Baseline to post-therapy)	% Change (Baseline to 1-Month Follow-up)
/a/	68.65 (23.98)	98.03 (22.00)	82.59 (20.48)	+42.80%	+20.31%
/i/	98.37 (27.06)	76.25 (26.27)	72.84(25.29)	−22.49%	−25.95%
/u/	145.64 (68.30)	129.30(54.22)	79.40 (21.78)	-11.22%	-45.48%

ms = milliseconds

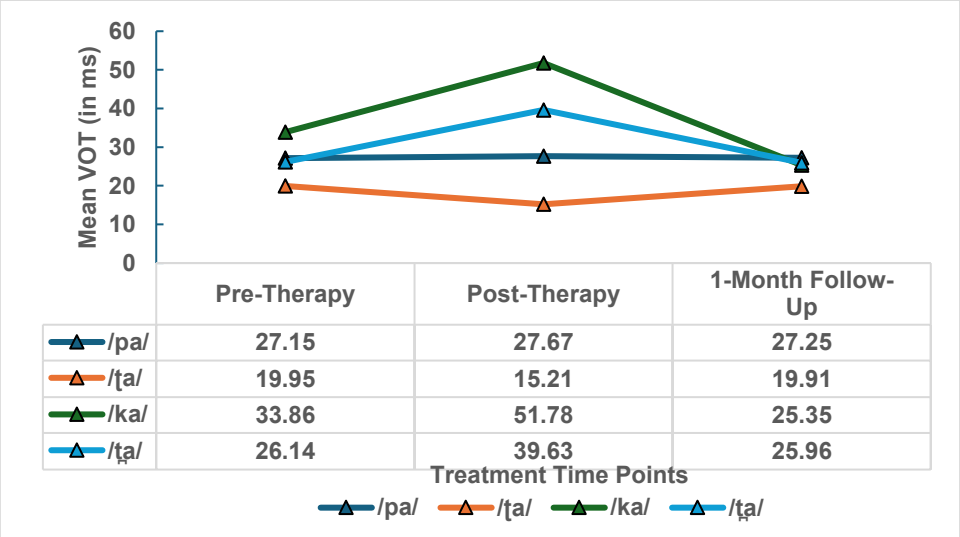
B. Voice Onset Time (VOT)

a) Unvoiced Plosives.

As depicted in Figure 4.11, the mean VOT for most of the unvoiced plosives remained relatively stable between the pre-therapy baseline and the follow-up assessments, except for the token /ka/. For /ka/ and /ʈa/, the VOT increased immediately after therapy, and then reduced during follow-up. For the retroflex /ʈa/, a slight reduction in its VOT was observed following treatment. This reduction increased after the 1-month follow-up, reaching levels comparable to the pretreatment baseline.

Figure 4.11

Mean Voice Onset Time (VOT) in 4 Target Words with Unvoiced Plosives Across Treatment Time Points for Participant 2

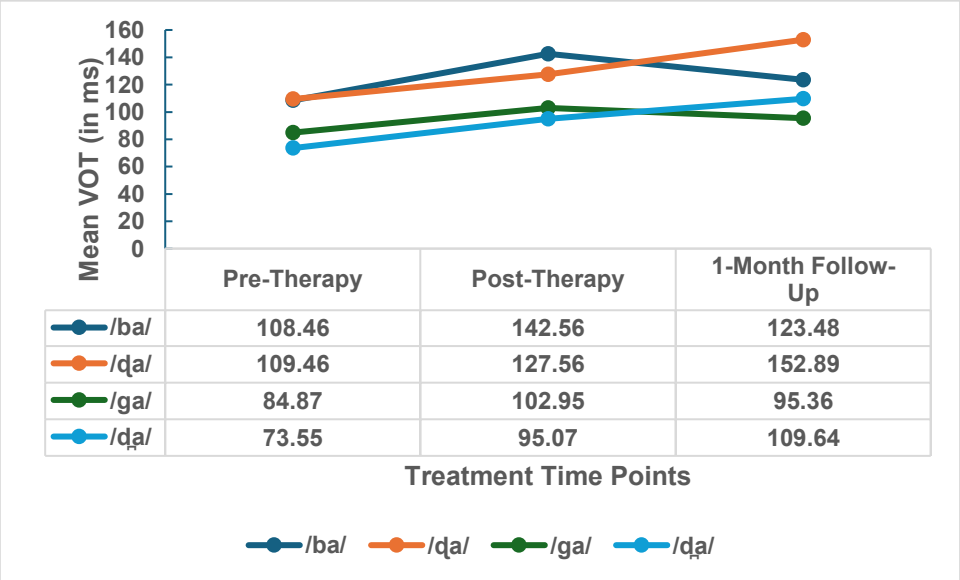


b) Voiced Plosives.

For all voiced plosives, mean VOT increased from pre-therapy to follow-up assessments (as shown in Figure 4.12).

Figure 4.12

Mean Voice Onset Time (VOT) in 4 Target Words with Voiced Plosives Across Treatment Time Points for Participant 2



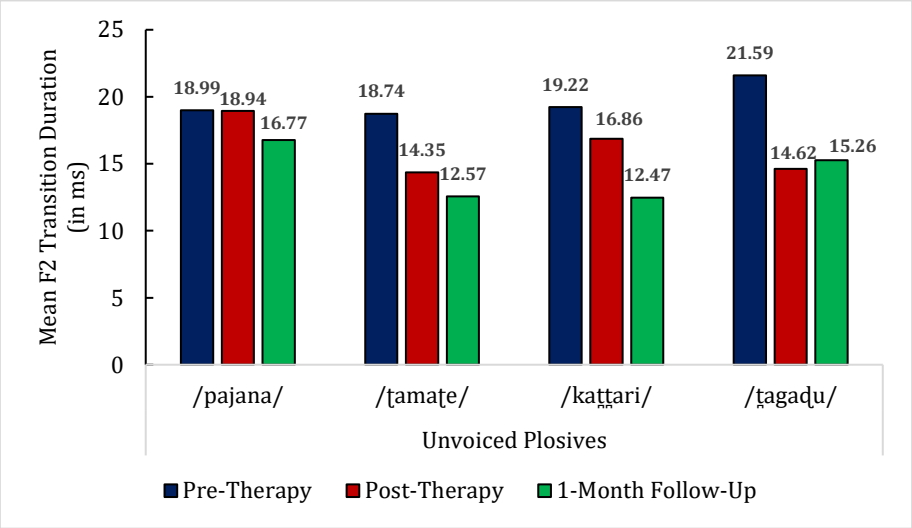
C. F2 Transition Duration

a) Unvoiced plosives.

For all the unvoiced plosives, a decreasing trend of F2 transition duration was observed from baseline to follow-up, as shown in Figure 4.13.

Figure 4.13

Mean F2 Transition Duration (F2 TD) in 4 Target Words with Unvoiced Plosives Across Treatment Time Points for Participant 2

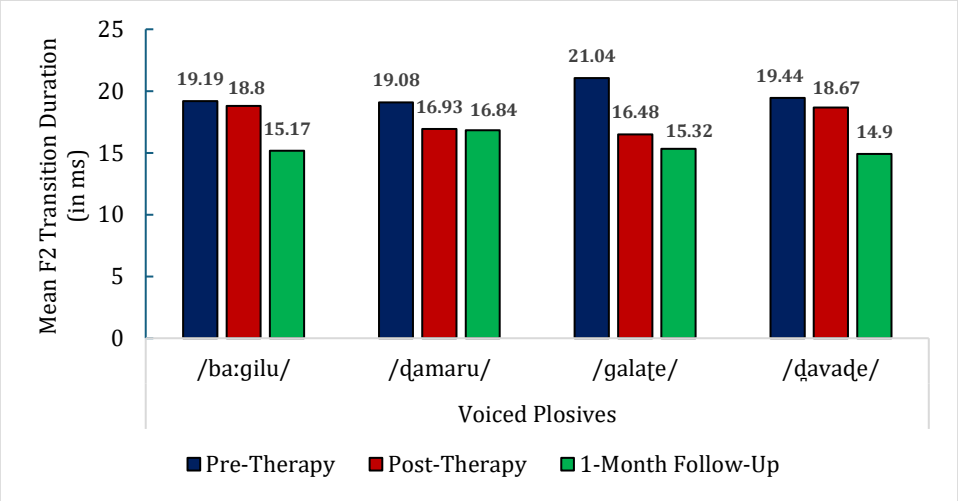


b) Voiced Plosives.

Similar to unvoiced plosives, voiced plosives also exhibited a gradual decrease in F2 transition duration from baseline to follow-up, as in Figure 4.14.

Figure 4.14

Mean F2 Transition Duration (F2 TD) in 4 Target Words with Voiced Plosives Across Treatment Time Points for Participant 2



In summary, participant 2 showed positive outcomes across all behavioral parameters. The percentage of syllables stuttered decreased to ≤ 2% at all time points across all tasks, with good generalization across conditions. This change was also accompanied by an increase in the rate of speech across all tasks, without affecting speech naturalness. Acoustically, the participant exhibited a reduction in the variability of vowel duration (as indicated by the reduction in the SD of vowel duration) and F2 transition durations for all the voiced and unvoiced plosives. However, a trend of increased voice onset time (VOT) was observed for voiced plosives following treatment and throughout the 1-month follow-up period, while the VOT for unvoiced plosives remained stable.

Participant 3

History

The third participant**,** PQR, was a 10.4-year-old adolescent diagnosed with moderate developmental speech fluency disorder. Baseline assessment yielded an SSI-4 score of 26 with a percentile rank of 24-26. The participant's speech predominantly included Stuttering-Like

Disfluencies (SLDs), such as blocks and syllable repetitions in initial positions, as well as occasional prolongations. Other Disfluencies (ODs), like phrase repetitions and interjections, were also present, accompanied by clear instances of word avoidance. Additionally, the participant exhibited physical concomitants, such as head movements (turning away, looking around), extremity movements, and facial grimaces, manifested as lip pressing and tensing of the jaw muscles. The participant had no prior history of undergoing any intervention before enrolling into the current study.

Responsiveness Testing

To assess treatment suitability, responsiveness was tested on reading and conversational trials. In the absence of RCTO, the percentage of syllables stuttered was 4.7% in reading and 4.6% in conversation; with self-imposed RCTO, it reduced to 4% and 3.7% in reading and conversation, respectively. This shows a relative reduction of 14.89% for reading and 19.56% for conversation. The participant was enrolled in the study because he exhibited observable, though clinically minimal, reductions in both contexts.

Baseline Assessment

Two baseline assessments were conducted to establish the initial behavioural profiles, and the outcomes are presented in Table 4.9 and Table 4.11.

Table 4.9

Baseline Fluency Measures Prior to Intervention for Participant 3

% SS						Naturalness Rating	Patient Self-Rated Stuttering Severity	Clinician-Rated Severity of Stuttering
Reading		Narration		Conversation				
B1	B2	B1	B2	B1	B2			
7.00	5.00	4.33	5.33	3.00	5.67	5	5	5

Note. %SS = Percentage of syllables stuttered; B1 = 1st Baseline; B2 = 2nd Baseline

RCTO Treatment and Outcomes

a) Behavioral Outcomes: Establishment phase

After 9 investigator-delivered RCTO sessions, the disfluency rate dropped to ≤ 1% across all speaking tasks (as shown in Figure 4.15). Also, post-therapy perceptual ratings of clinician-rated and self-rated severity, along with speech naturalness, improved to a score of 1 immediately after the intervention.

The speaking rate increased immediately following the intervention across all three tasks, as shown in Table 4.11. The speech rate increase was highest for reading (59.31%), followed by conversation (58.61%), whereas narrative speech showed a relatively lower increase of 34.33% immediately after the therapy.

With regard to %SS, a substantial reduction was observed across all three speaking tasks (as in Table 4.10) during the immediate post-therapy assessment, with considerable decrease in disfluencies in the conversation task at 92.40%. Besides, both reading and narration tasks exhibited reduction in disfluencies, with 83.33% and 86.13%, respectively, during the immediate post-therapy assessment.

b) Behavioral outcomes: Generalization phase

Five post-treatment generalisation sessions were conducted to address situational variations in stuttering. During these trials, %SS was reduced to 1.5% while talking to strangers and 1.0% in telephonic conversations for a 200-syllable speech sample.

Figure 4.15

Percentage of Syllables Stuttered (%SS) Across Treatment Time Points and Speech Tasks for Participant 3

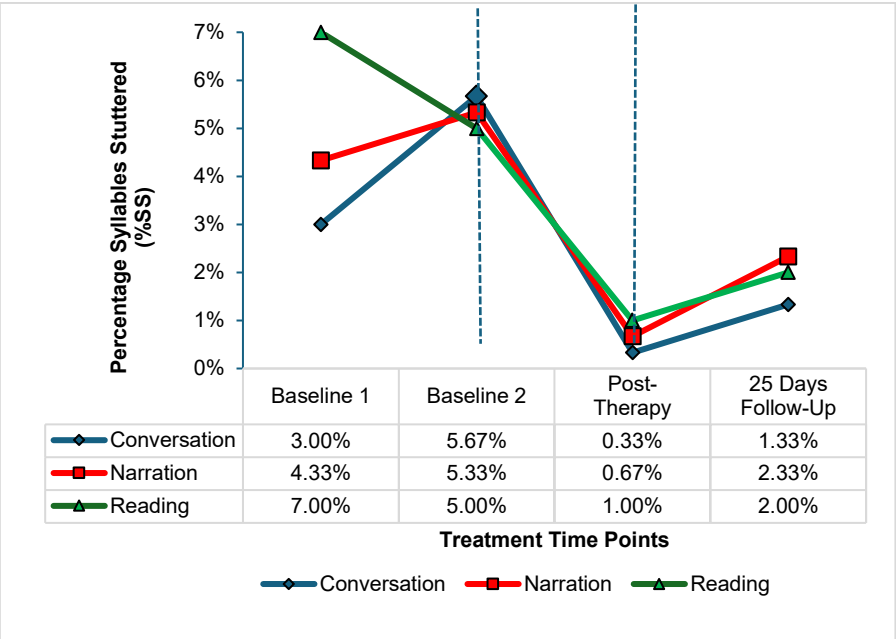


Table 4.10

Percentage Change in %SS Across Treatment Time Points in Speech Tasks for Participant 3

Percentage of Syllables Stuttered (%SS)	% Change (Baseline to post-therapy)	% Change (Baseline to 25 Days Follow-Up)
Conversation	- 92.40%	- 69.35%
Narration	- 86.13%	- 51.76%
Reading	- 83.33%	- 66.67%

Table 4.11

Rate of Speech (in syllables per minute) and Percentage Change Across Treatment Time Points for Speech Tasks for Participant 3

Rate of Speech (in SPM)	Baseline 1	Baseline 2	Post therapy	25 days Follow-Up	% Change (Baseline to post-therapy)	% Change (Baseline to 25 Days Follow-Up)
Conversation	207.99	112.86	254.45	236.75	58.61%	47.58%
Narration	206.21	157.12	244.03	188.36	34.33%	3.69%
Reading	107.25	115.59	177.50	126.24	59.31%	13.30%

SPM = Syllables per minute

c) Behavioral outcomes: 25 Days Post Treatment Follow Up.

After generalisation sessions, parent-rated severity scores were collected over 25 days across all tasks, along with the overall severity score. The reading and narration scores began and concluded at 2, with temporary reduction to a score of 1 during distinct periods of follow-up, whereas the conversation scores remained at 1 throughout the follow-up period. Figure 4.16 and 4.17 indicates these changes observed during the 25-day follow-up period.

The follow-up assessment conducted 25 days after the generalisation session supported parents' ratings, showing a minimal increase in disfluencies across all speaking tasks (Figure 4.15). There was a slight regression in fluency gains, with the %SS reductions shrinking to 69.35%, 51.76%, and 66.67% for conversation, narration, and reading tasks, respectively (as in Table 4.10), even though disfluencies were well below the baseline data. Also, speaking rate decreased from the immediate post-therapy assessment (as shown in Table 4.11) across all tasks. This change was more prominent in reading and narration tasks, where the increase in speech rate dropped to 13.30% and 3.69%, respectively, from the baseline assessment, plausibly due to the slight increase in disfluencies. However, conversational speech rate

remained relatively stable, preserving the net increase of 47.58% over baseline performance. All these changes also led to a shift in perceptual scores, such as naturalness, clinician-rated severity, and self-rated severity, to 2 during follow-up assessment.

Figure 4.16

Parent-Rated Severity Scores Across Speech Tasks During the 25 Days Post-Treatment Period for Participant 3

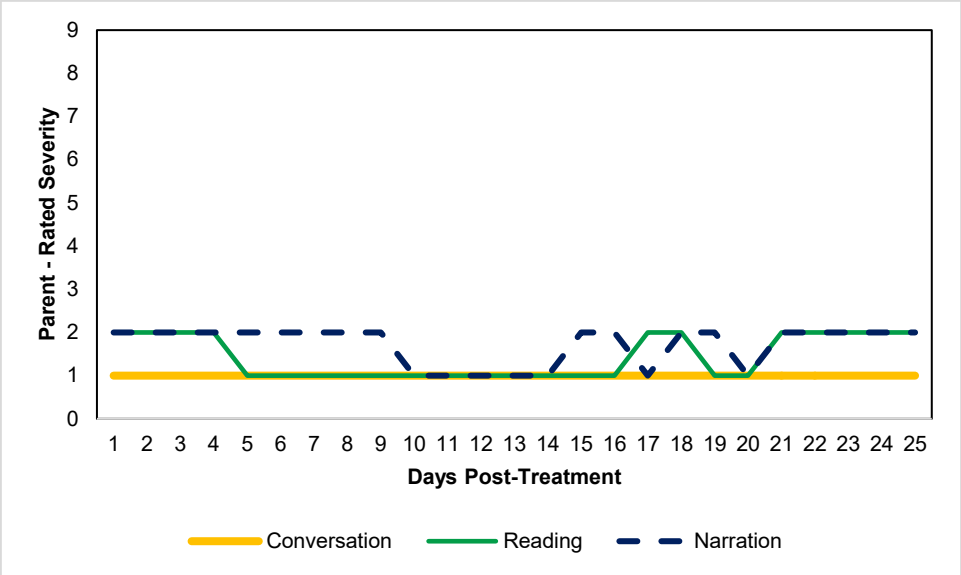
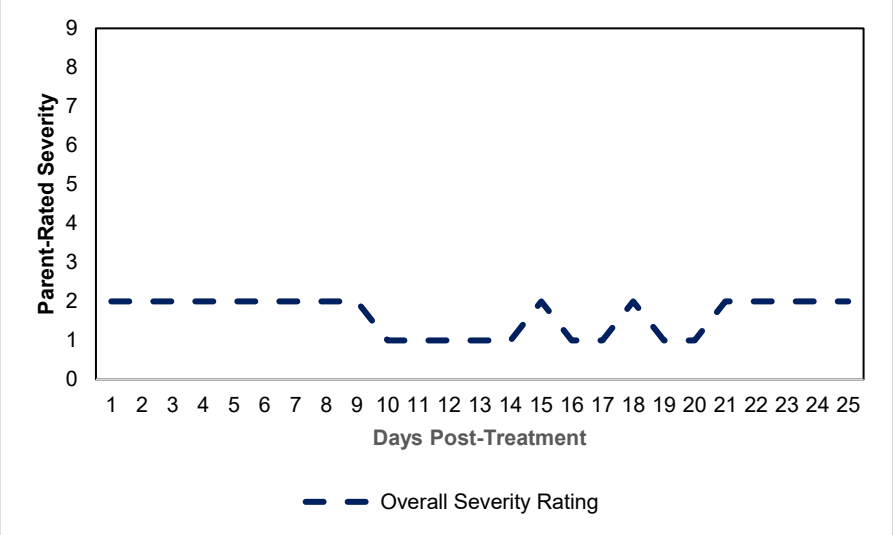


Figure 4.17

Overall Parent-Rated Severity During the 25 Days Post-Treatment Period for Participant 3



Acoustic Outcomes

A. Vowel Duration for Narration

Analysis of the mean vowel duration of participant 3 across treatment points revealed a decreasing trend for /a/ and /u/ with 19.38% and 23.44% reduction, respectively, from baseline to follow-up (as in Table 4.12). However, for /i/, an increase in duration of 15.79% was noted at the follow-up, even though there was a minimal decrease of 3.84% immediately after therapy. All these changes were accompanied by a reduction in standard deviation, most likely indicating a decrease in speech production variability.

Table 4.12

Mean Vowel Duration and Percentage Change in Vowel Duration Across Treatment Time Points During Narration in Participant 3

Target Vowels	Pre-Therapy (in ms) Mean (SD)	Post-Therapy (in ms) Mean (SD)	25 Days Follow-Up (in ms) Mean (SD)	% Change (Baseline to post-therapy)	% Change (Baseline to 25 Days Follow-up)
/a/	121.23(69.70)	107.70(27.71)	97.74 (19.84)	- 11.16%	-19.38%
/i/	101.94 (39.61)	98.03 (31.60)	118.04(28.95)	-3.84%	+15.79%
/u/	165.20 (53.80)	113.36(42.30)	126.47 (28.34)	-31.38%	-23.44%

ms = milliseconds

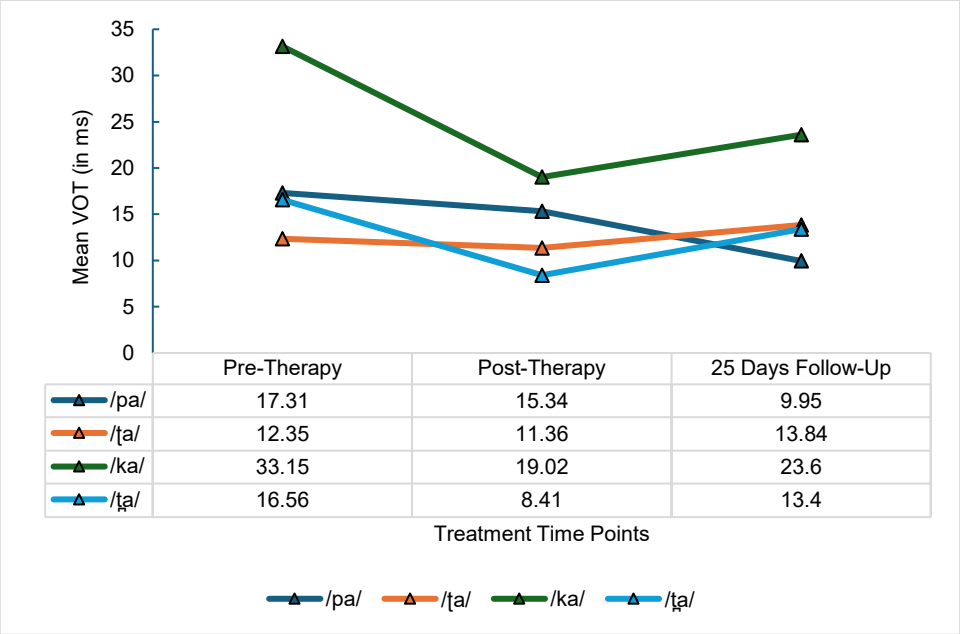
B. Voice Onset Time (VOT)

a). Unvoiced Plosives.

Analysis of mean VOT revealed a generalized trend of reduction immediately following the intervention for all unvoiced plosives, as in Figure 4.18, followed by divergent patterns during follow-up. During follow-up, VOT values marginally raised for all unvoiced plosives compared with the immediate post-therapy assessment except for /pa/ that continued to show a reduction.

Figure 4.18

Mean Voice Onset Time (VOT) in 4 Target Words with Unvoiced Plosives Across Treatment Time Points for Participant 3

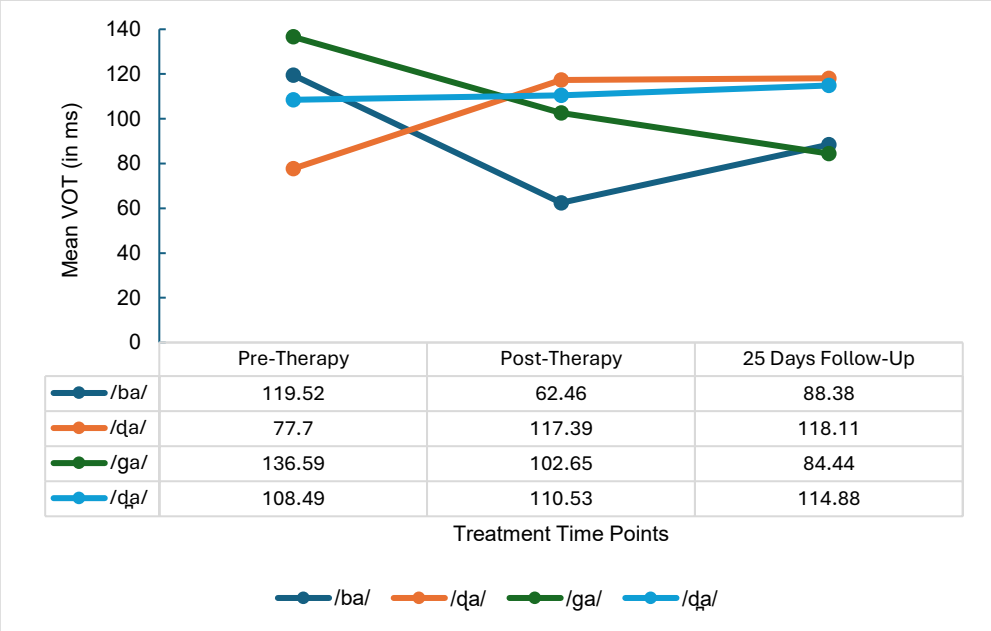


c) Voiced Plosives.

For voiced plosives, analysis of mean VOT values showed highly non-uniform variations across the treatment time points. For /ba/ and /ga/, a reduction in VOT was noted immediately after the intervention (as in Figure 4.19), which was continued for /ga/ during follow-up, whereas /ba/ showed a rebound to 88.38 ms during follow-up. In contrast, /ɖa/ showed an increase in VOT during the immediate post-therapy assessment, which stabilised at 118.11 ms during follow-up, whereas /ɖa/ remained relatively stable during the entire period.

Figure 4.19

Mean Voice Onset Time (VOT) in 4 Target Words with Voiced Plosives Across Treatment Time Points for Participant 3



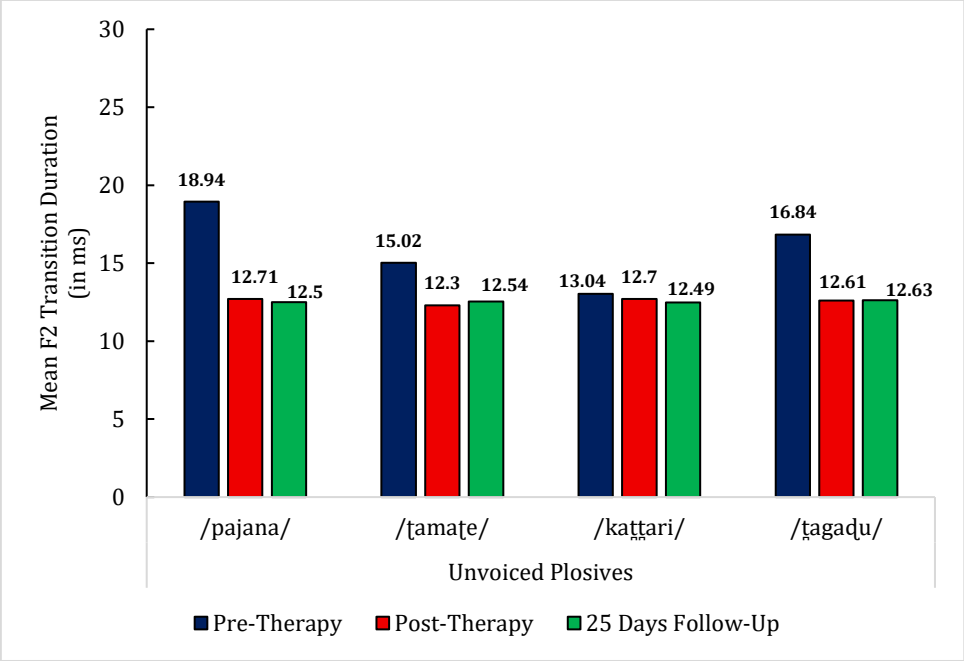
C. F2 Transition Duration

a) Unvoiced plosives.

The mean F2 transition duration for all unvoiced plosives showed a general trend of reduction immediately after the RCTO intervention, as in Figure 4.20, and remained at nearly an identical level during the follow-up assessment.

Figure 4.20

Mean F2 Transition Duration (F2 TD) in 4 Target Words with Unvoiced Plosives Across Treatment Time Points for Participant 3

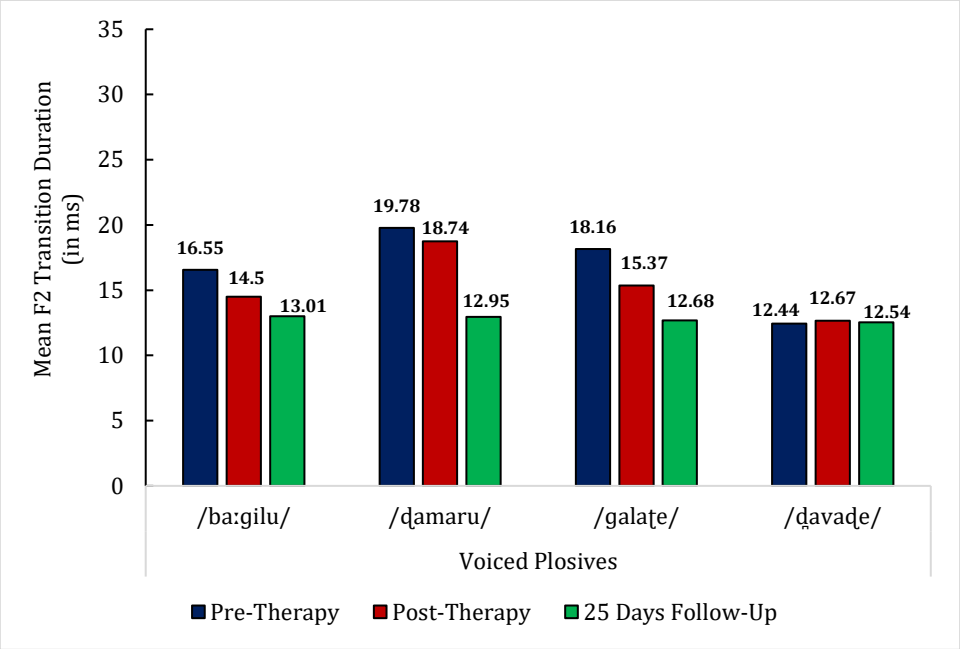


b) Voiced Plosives.

For all voiced plosives, except /ɖa/, there was a generalised trend of progressive reduction in mean F2 transition duration from baseline to follow-up, whereas in /ɖa/ it remained relatively stable, with negligible variations across the entire experimental timeline (as shown in Figure 4.21).

Figure 4.21

Mean F2 Transition Duration (F2 TD) in 4 Target Words with Voiced Plosives Across Treatment Time Points for Participant 3



Overall, participant 3 showed a remarkable reduction in the percentage of syllables stuttered across all the tasks, along with an increase in speech rate immediately post-intervention with moderate maintenance over a 25-day follow-up. Acoustically, the participant exhibited a generalised reduction in F2 transition duration and variability of vowel duration, whereas VOT exhibited a non-uniform pattern across both plosive classes.

Participant 4

History

MNO was an 11.8-year-old adolescent diagnosed with severe developmental speech fluency disorder, with an SSI-4 score of 29 and percentile rank of 78-88. The participant's speech characterised SLDs, such as part-word repetitions, prolongations, and blocks in word-initial positions, as well as Other Disfluencies (ODs), such as revisions, interjections, and phrase repetitions. Physical concomitants exhibited by the participant included avoidance of eye contact, head and extremity movements (e.g., hand over the face, foot tapping), and facial

grimaces, such as jaw muscle tensing and lip pressing. The participant had attended 3 months of therapy at the age of 7.3 years, utilising fluency-shaping procedures.

Responsiveness Testing

To determine treatment suitability, responsiveness to RCTO was assessed. The percentage of syllables stuttered was 11.63% in reading and 10.28% in conversation for a 2-minute sample without RCTO, which reduced to 4.39% in reading and 6.00 % in conversation with self-initiated RCTO. This indicates a relative reduction of 62.25% in reading and 41.63% in the conversation task. Hence, the participant was responsive to RCTO and was therefore enrolled in the current study.

Baseline Assessment

Baseline fluency measures were calculated for %SS across 3 speaking tasks, along naturalness rating, patient self-rated stuttering severity and clinician rated severity of stuttering. Tables 4.13 and 4.15 represent the behavioural outcomes of 2 baseline assessments for participant 4.

Table 4.13

Baseline Fluency Measures Prior to Intervention for Participant 4

% SS						Naturalness Rating	Patient Self-Rated Stuttering Severity	Clinician-Rated Severity of Stuttering
Reading		Narration		Conversation				
B1	B2	B1	B2	B1	B2			
10	10	13.33	11	11.33	11	6	5	6

Note. %SS = Percentage of syllables stuttered; B1 = 1st Baseline; B2 = 2nd Baseline

RCTO Treatment and Outcomes

A. Behavioural Outcomes: Establishment phase

The investigator delivered 9 sessions of RCTO, after which the %SS decreased to < 2% across all tasks during the immediate post-therapy assessment (as in Figure 4.22). As detailed in Table 4.14, substantial %SS reductions of 91.78% and 90.00% were achieved in the narration and reading tasks, respectively, and 85.04% in the conversation task during the

immediate post-therapy assessment. These improvements were further reflected in perceptual measures, with both clinician-rated and self-rated severity scores decreasing to 1, and speech naturalness improving to a rating of 2.

The participant also exhibited a substantial increase in speech rate following the intervention (as shown in Table 4.15). The increase was most pronounced in the reading task followed by conversation and narration respectively.

B. Behavioral outcomes: Generalization phase

To stabilise fluency gains across various situations, generalisation sessions were conducted. By the end of 5th session, participant's %SS reduced to 1.5% in telephonic conversations and 0.5% while talking to strangers for a 200-syllable speech sample.

Figure 4.22

Percentage of Syllables Stuttered (%SS) Across Treatment Time Points and Speech Tasks for Participant 4

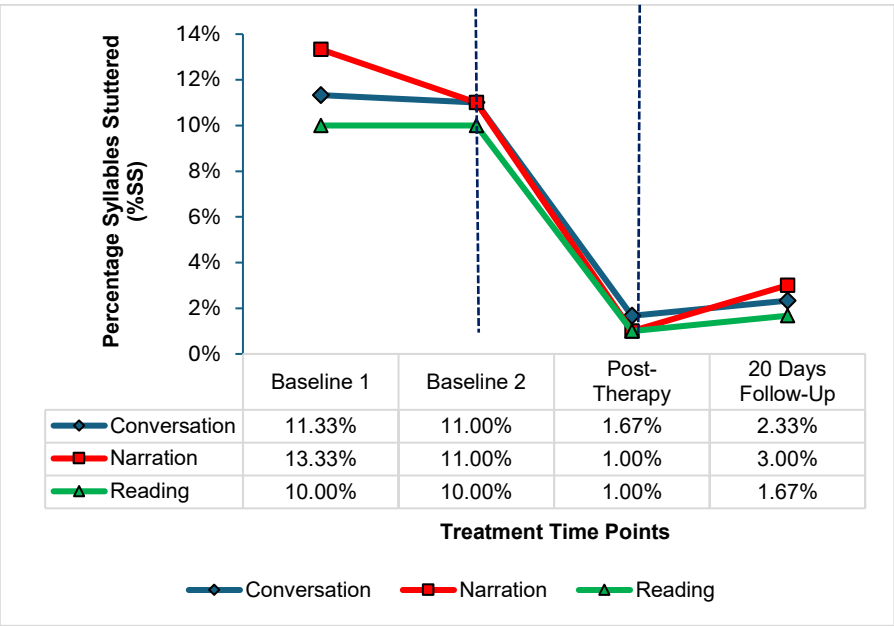


Table 4.14

Percentage Change in %SS Across Treatment Time Points in Speech Tasks for Participant 4

Percentage of Syllables Stuttered (%SS)	% Change (Baseline to post-therapy)	% Change (Baseline to 20 Days Follow-up)
Conversation	- 85.04%	- 79.12%
Narration	- 91.78%	- 75.33%
Reading	- 90.00%	- 83.30%

Table 4.15

Rate of Speech (in syllables per minute) and percentage change across Treatment Time Points and Speech Tasks for Participant 4

Rate of Speech (in SPM)	Baseline 1	Baseline 2	Post therapy	20 Days follow-up	% Change (Baseline to post-therapy)	% Change (Baseline to 20 Days Follow-up)
Conversation	120.61	125.32	187.44	199.87	52.44%	62.55%
Narration	135.38	124.52	177.43	173.98	36.54%	33.88%
Reading	89.18	69.63	138.06	150.70	73.88%	89.80%

SPM = Syllables per minute

C. Behavioural outcomes: 20 Days Post-Treatment Follow-Up.

Following generalisation, the investigator collected severity scores rated by parents over 20 days across all the tasks, along with the overall severity rating as shown in Figures 4.23 and 4.24, respectively. The severity scores for narration were 2 during the initial 6 days, after which they fluctuated between 1 and 2 before concluding at 2. Also, the reading scores fluctuated between 1 and 2 during the first week, stabilised at 2 from day 7 to 11, and ended at 2 after minor subsequent variability. However, the conversation scores remained at 1 for almost all 20 days, except on the 12th day indicating stable fluency in general conversation tasks. Follow-up assessment conducted 20 days after generalisation sessions revealed a minimal

increase in %SS compared with the immediate post-therapy assessment, as shown in Figure 4.22. Due to a slight relapse in disfluencies, the overall percentage decrease in syllables stuttered changed to 79.12% in conversation, 75.33% in narration, and 83.30% in reading, even though fluency maintained was relatively high compared to baseline measures. These changes also reflected in the clinician and self-rated severity fluency measures shown where the clinician-rated severity and self-rated severity shifted to 2, and the naturalness score to 3.

Figure 4.23

Parent-Rated Severity Scores Across Speech Tasks During the 20 Days Post-Treatment Period for Participant 4

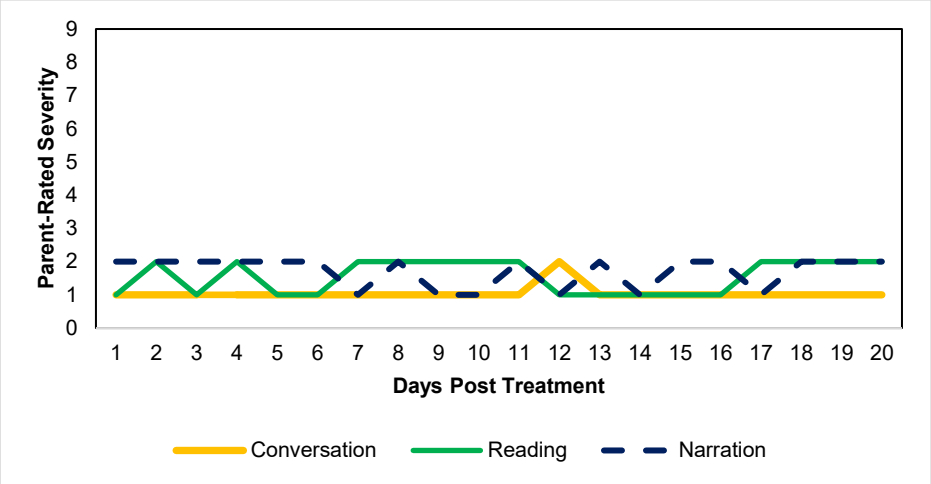
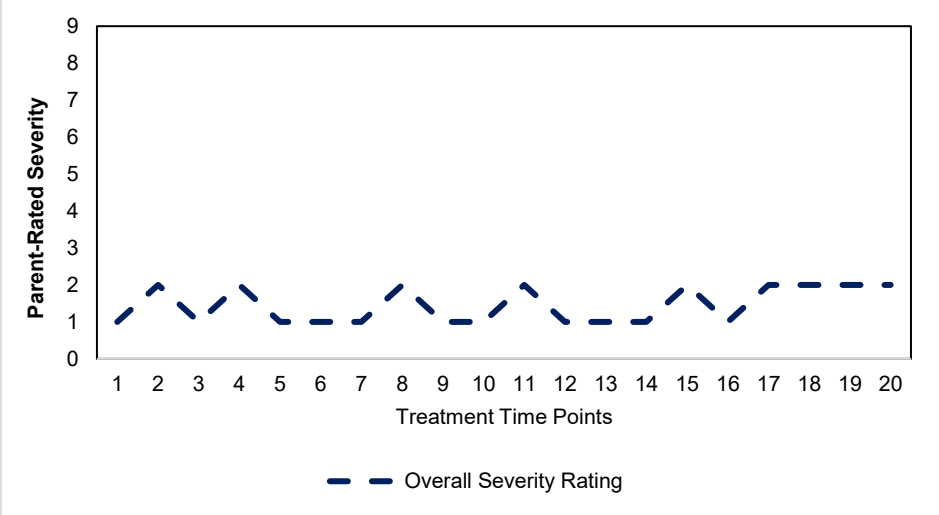


Figure 4.24

Overall Parent-Rated Severity During the 20 Days Post-Treatment Period for Participant 4



Acoustic Outcomes

A. Vowel Duration for Narration

Duration of /a/ remained relatively stable during the entire treatment period for participant 4, with a general trend of gradual reduction from baseline to follow-up, with a percentage reduction of 6.56% at follow-up. Similarly, a trend of reduction in vowel duration was also found for /u/ from baseline to follow-up, with a reduction percentage of 16.18% during follow-up. For /i/, the duration reduced by 11.32% at the immediate post-therapy assessment, which later stabilised to baseline during follow-up. Along with these changes, a reduction in standard deviation from baseline to follow-up was observed, indicating a decrease in vowel production variability (as shown in Table 4.16).

Table 4.16

Mean Vowel Duration and Percentage Change in Vowel Duration Across Treatment Time Points During Narration in Participant 4

Target Vowels	Pre-Therapy (in ms) Mean (SD)	Post-Therapy (in ms) Mean (SD)	20-Days Follow-Up (in ms) Mean (SD)	% Change (Baseline to post-therapy)	% Change (Baseline to 20 Days Follow-up)
/a/	109.72(48.88)	106.05(19.27)	102.52 (19.82)	- 3.34%	-6.56%
/i/	116.84 (27.46)	103.61 (28.51)	117.37(19.62)	-11.32%	+0.45%
/u/	145.89 (47.20)	111.31(33.08)	122.29 (15.86)	-23.70%	-16.18%

ms = milliseconds

B. Voice Onset Time (VOT)

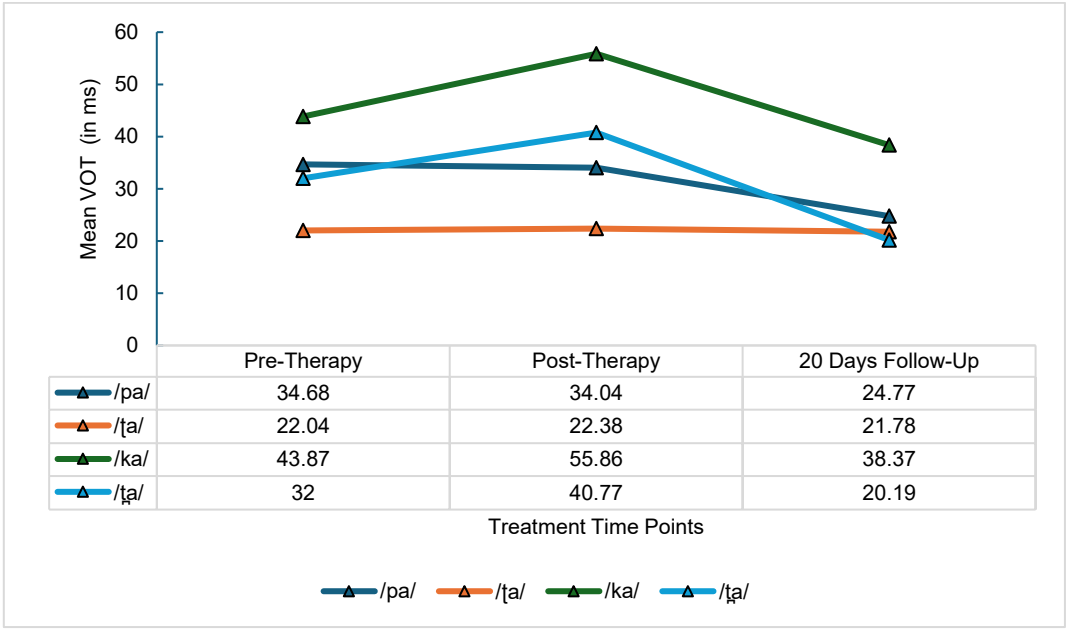
a) Unvoiced Plosives.

For unvoiced plosives like /ka/ and /t̪a/, mean VOT increased during the immediate post-therapy assessment, then decreased to below baseline levels during the follow-up

assessment. For /pa/, it exhibited steady values around 34ms during baseline and post-therapy assessments, and later decreased to 24.77ms during follow-up. On the other hand, it remained relatively stable for /ta/, hovering around 21ms and 22ms (as in Figure 4.25).

Figure 4.25

Mean Voice Onset Time (VOT) in 4 Target Words with Unvoiced Plosives Across Treatment Time Points for Participant 4

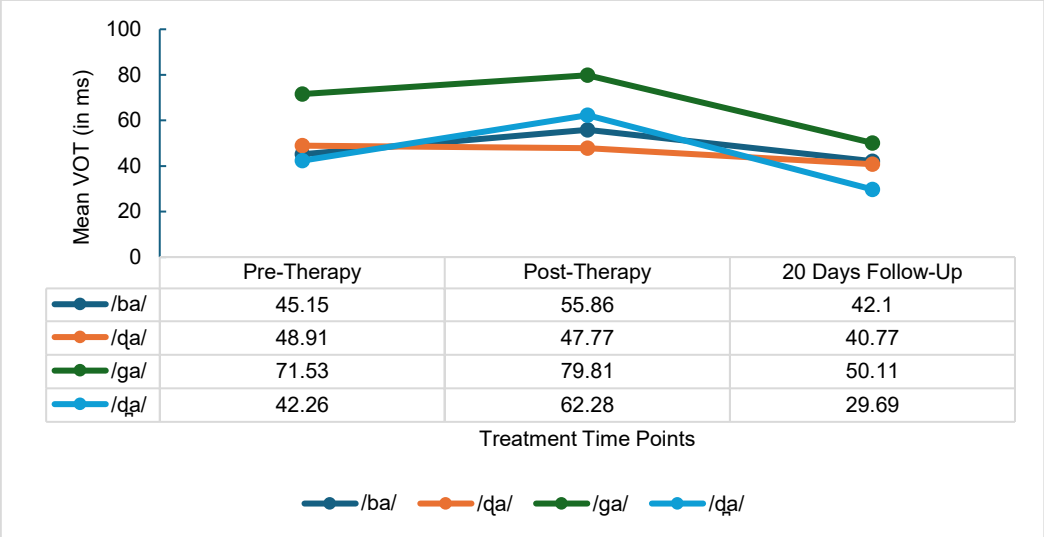


b) Voiced Plosives.

For all the voiced plosives, except /da/, mean VOT values increased during the immediate post-therapy assessment, but decreased in comparison to baseline during the follow-up assessment (as in Figure 4.26). For retroflex sound /ɖa/, a gradual and steady reduction from 48.91ms at baseline to 47.77ms at post-therapy and 40.77ms at follow-up was observed. However, even for the syllable /ɖa/, the follow-up assessment indicated a decrease in the mean VOT duration.

Figure 4.26

Mean Voice Onset Time (VOT) in 4 Target Words with Voiced Plosives Across Treatment Time Points for Participant 4



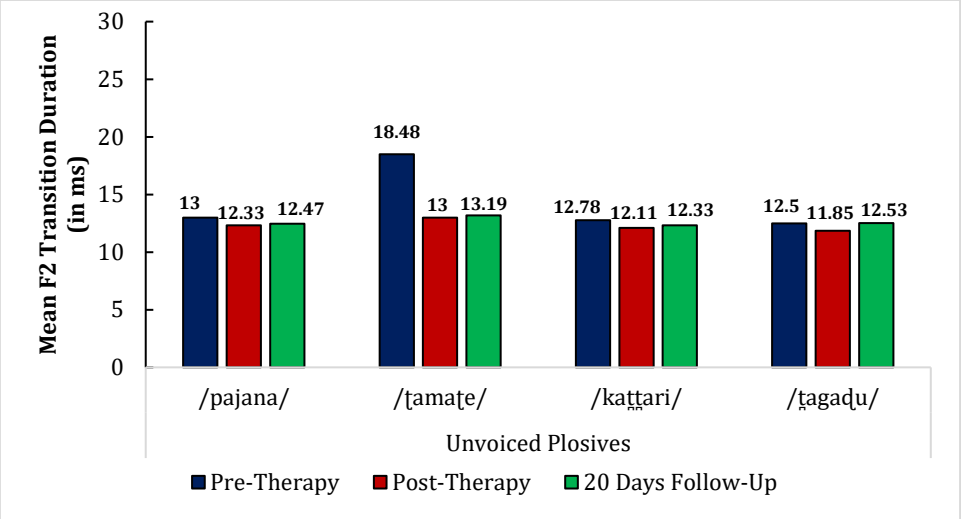
C. F2 Transition Duration

a) Unvoiced plosives.

Mean F2 TD remained relatively stable throughout the treatment period for all unvoiced plosives except /ʈa/, which decreased from 18.48ms at baseline to 13ms post-therapy and remained stable at 13.19ms during follow-up (as in Figure 4.27).

Figure 4.27

Mean F2 Transition Duration (F2 TD) in 4 Target Words with Unvoiced Plosives Across Treatment Time Points for Participant 4

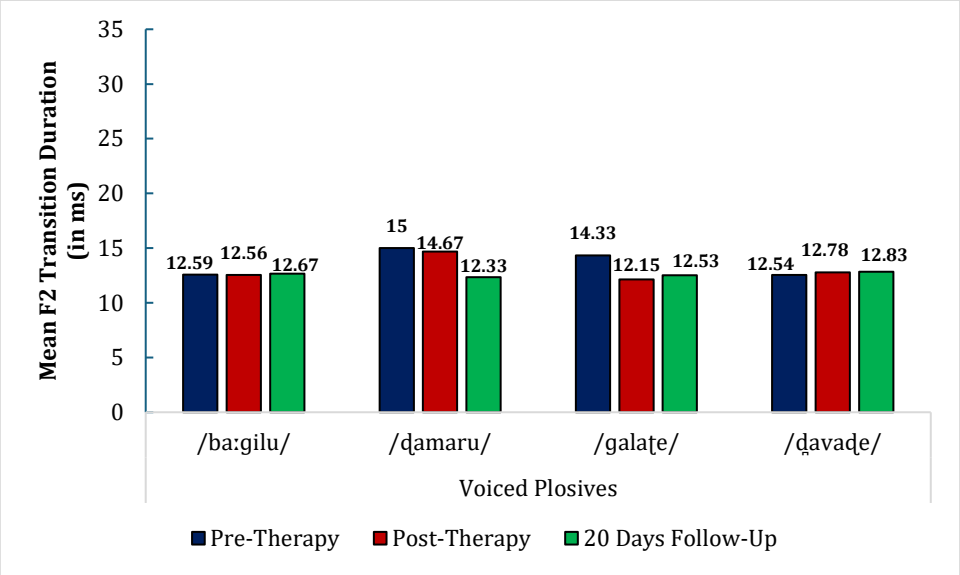


a) Voiced Plosives

Mean F2 TD of voiced plosives like /ba/ and /ɖa/ remained relatively stable throughout the treatment for participant 4, whereas it showed gradual and minimal reductions from baseline to follow-up for /ɖa/ and /ga/ (as in Figure 4.28).

Figure 4.28

Mean F2 Transition Duration (F2 TD) in 4 Target Words with Voiced Plosives Across Treatment Time Points for Participant 4



To summarise, there was a substantial reduction in %SS for Participant 4, along with an increase in speech rate and improved naturalness compared to baseline values. Acoustically, a reduction in variability of vowel duration alongside post-treatment stabilisation was noted. Furthermore, F2 TD remained remarkably stable for both voiced and unvoiced plosives throughout the treatment period. The trends in the mean Voice Onset Time (VOT) from pre-treatment to immediate post-treatment were inconsistent. However, there was a clear reduction in the mean VOT from post-treatment to the follow-up assessments

Table 4.17

A Summary Table of Behavioral and Acoustic Changes Observed Across Treatment Time Points for All Four Participants

Participants	Phase	%SS			Rate of Speech (in SPM)			NAT	S-SSR	C-SSR	VOT		F2 TD		VD		
		C	N	R	C	N	R				VP	UVP	VP	UVP	/a/	/i/	/u/
P1	PT	D	D	D	I	I	I	E	D	D	V	V	D	D	D	D	I
	FU	D	D	D	I	I	I	E	D	D	V	D	D	D	D	D	I
P2	PT	D	D	D	I	I	I	E	D	D	V	I	D	D	I	D	D
	FU	D	D	D	I	I	I	E	D	D	V	I	D	D	I	D	D
P3	PT	D	D	D	I	I	I	E	D	D	V	D	D	D	D	D	D
	FU	D	D	D	I	I	I	E	D	D	V	D	D	D	D	I	D
P4	PT	D	D	D	I	I	I	E	D	D	V	D	D	D	D	D	I
	FU	D	D	D	I	I	I	E	D	D	V	D	S	D	D	I	I

Note: All Post-Treatment (PT) and Follow Up (FU) values indicate directional changes compared with respect to baseline data. P1= Participant 1;P2= Participant 2;P3= Participant 3;P4= Participant 4; PT = Post-treatment; FU = Follow-up; C = Conversation; N = Narration; R = Reading; I = Increased; D = Decreased; S = Stable; V = Variable; E= Enhanced; %SS = Percentage of Syllables Stuttered; SPM = Syllables Per Minute; NAT= Naturalness rating; S-SSR= Self Stuttering Severity Rating; C-SSR= Clinician Stuttering Severity Rating; VOT = Voice Onset Time; F2 TD = Second Formant Transition Duration; VD = Vowel Duration; VP = Voiced Plosives; UVP = Unvoiced Plosives.

Chapter 5

Discussion

This study has examined the effects of Response Contingent Time Out (RCTO) on various behavioural and acoustic outcome measures in Kannada-speaking adolescents who stutter. RCTO was conducted with adolescents, a population that has received comparatively less attention in the literature of stuttering treatment than adults and preschoolers who stutter (Blomgren, 2013; Brignell et al., 2020).

Responsiveness Testing and RCTO

Most participants in this study responded positively for responsiveness testing for the RCTO treatment. The high responsiveness to responsiveness testing for RCTO exhibited by participant 2, indicated by a relative reduction of 73.95% in %SS during the conversation task with self-imposed time-out, might also be one of the reasons for the marked positive treatment outcome, aligning with the view that assessing responsiveness prior to the intervention is a clinically important procedure (Einarsdóttir et al., 2025). At the same time, participant 3, who showed minimal responsiveness to RCTO during responsiveness testing, with a relative reduction of 14.89% in %SS, in reading, achieved substantial fluency gains across tasks during immediate post-therapy and follow-up assessment. This also supports the view of James (1981a), which states that individual differences exist in responsiveness to TO. This finding also suggests that, although testing responsiveness can serve as a screening tool for treatment, it should not be the sole criterion for selecting candidates for RCTO.

Effect of RCTO on Percentage of Syllables Stuttered (%SS)

The most consistent finding across all four participants was a notable reduction in %SS after intervention, irrespective of stuttering severity. For all participants, immediately after therapy, disfluency rates dropped to ≤ 2% across all tasks, with robust reductions of 72.07%-

96.90% relative to baseline. This reduction was largely maintained during follow-up (20-30 days post-generalisation), with reductions ranging from 51% to 91% without affecting the naturalness of speech.

These reductions in disfluencies were supported by and are consistent with previous studies (Costello, 1975; Einarsdóttir et al., 2025; Hewat et al., 2006; Einarsdóttir et al., 2025; Veerabhadrappa, 2021). A study by Costello (1975) produced similar results, with stuttering reduced to near-zero levels across tasks such as conversation, monologue, and reading during the establishment phase of 9-13 clinical hours, whereas a study by Veerabhadrappa (2021) examined the %SS across the same tasks and also assessed it's maintenance, found highly significant statistical reduction in %SS and stuttering severity scores with no significant regression during 1- and 3-months follow up. In the present study, the establishment phase was achieved by 9-13 sessions across participants, with a mean of 10 sessions. In the study by Einarsdóttir et al. (2025), the stuttering frequency decreased to an average of 72% across the 4 participants who completed the treatment program, with good maintenance of fluency and speech naturalness. In Hewat et al.'s study on the influence of self-imposed time-out on disfluency among 22 adolescents and adults who stuttered, a 50% reduction in % SS was observed in more than half of the participants.

Participant 2 in the present study, with very severe stuttering (SSI-4 score of 36, percentile rank of 96–99), demonstrated the greatest magnitude of change in %SS reduction across all tasks, where the participant was provided with 13 establishment and 10 generalisation sessions. It is important to note that this individual experienced disfluency lasting up to 30 seconds during the baseline phases. The improved fluency in participant 2 is supported by some of the previous studies by Hewat et al. (2006) and Franklin et al. (2008), which found that individuals with more severe stuttering benefit from time-out procedures. This may be due to frequent contingencies or feedback received by a person with severe stuttering, compared to

an individual with mild stuttering, and having a high baseline in stuttering frequency may have provided a wider range for measurable change.

Effect of RCTO on Speaking Rate

All 4 participants exhibited a remarkable increase in speaking rate following the intervention, with maintenance of this increase during follow-up compared with the baseline. Participant 2 showed the most pronounced increase in speech rate, where it almost tripled during a 1-month follow-up, with a percentage increase of 206.88% in the conversation task. This participant also exhibited the lowest baseline speaking rate across the narration and conversation tasks, mainly due to increased stuttering frequency and duration.

An increase in speaking rate following a time-out was supported by previous studies (Einarsdóttir et al., 2025; Franklin et al., 2008; James et al., 1989; Veerabhadrappa, 2021). Onslow (1996) proposed an inverse and direct relationship between speech rate and stuttering. Based on the inverse relationship, as stuttering decreases, speech rate increases; whereas, in the direct relationship, with a reduction in speech rate, stuttering frequency also reduces. In the present study, the increase in speech rate could be attributed to the inverse relationship stated by Onslow (1996). Due to the reduction in stuttering, there was a release of time previously occupied by stuttering events and associated struggles, leading to an increased speech rate without altering the speaking style or it's naturalness. A study conducted by Veerabhadrappa (2021) in school-age children who speak Kannada also reported similar findings.

RCTO and Speech Naturalness

All participants achieved a naturalness score of 1 or 2 following the intervention, reflecting a perceptually natural speech, mirroring the findings by Einarsdóttir et al. (2025). Even though there was a minor increase in disfluencies during follow-up, naturalness scores didn't increase, but were maintained between scores of 1 and 3, suggesting the preservation of

perceptual speech quality. The stable maintenance of speech naturalness contrasts with fluency shaping procedures that are commonly criticized for its post-treatment increase in speech unnaturalness due to prolonged speech (Metz et al., 1990). As we did not change the speaking rate in RCTO, naturalness was relatively preserved for all the participants following treatment. This has immense practical value for adolescents who are more sensitive to peer comparison and social anxiety (Erickson & Block, 2013).

Relationship of RCTO with self-rated and clinician-rated severity scores

Both self-rated and clinician-rated severity scores also attained their lowest values post-intervention for all the 4 participants and demonstrated slight elevations during follow-up. Furthermore, the agreement between clinician-rated and self-rated stuttering severity indicates that the participants also accurately perceived their fluency gains. These scores are highly relevant because self-perception of stuttering severity is associated with communication-related quality of life in people who stutter (Iverach & Rapee, 2014). Consequently, self-rated severity is an essential outcome, along with clinician-rated severity ratings, in a treatment study.

RCTO and Acoustic measures

The analysis of VOT in the present study revealed non-uniform and idiosyncratic patterns of change following RCTO. A general trend of VOT reduction following therapy was observed for unvoiced plosives (seen in 3 out of 4 participants), but this was not uniform across all unvoiced plosives or participants. For voiced plosives, the trend is even more variable, where some participants showed progressive changes, while others showed nonlinear changes across the three treatment timepoints. This variability, or lack of a directional shift, in VOT is uniformly observed across all 4 participants for voiced plosives. These findings are consistent with those of Onslow et al. (1992) and Packman et al. (1994), who studied the effects of

prolonged speech in children and adults with stuttering, respectively, and found no consistent trend in VOT patterns. In the study by Santhosh (2006), a longer VOT than baseline was observed following non-programmed prolonged-speech treatment. A similar finding was reported by Metz et al. (1990), who found that prolonged VOT and increased sentence duration following prolonged speech treatment led to the perception of unnaturalness in speech. Onslow et al. (1997) found no significant differences in VOT following time-out in school-aged children with stuttering, and these results partially align with those of the present study. As RCTO does not involve any alteration of temporal parameters, as in fluency-shaping procedures, this might explain why no specific patterns of VOT shifts are observed in the present study. Additionally, this study also measured the VOT for each syllable type (voiced or unvoiced) in the initial position of only one trisyllabic word; this may not have fully captured the changes in VOT over treatment time points.

The most consistent finding with the analysis of Vowel duration was a reduction in the variability of vowel duration (decreased SD) for all the participants for all the vowels following intervention. However, there was no uniformity in the direction of change of mean vowel duration across participants and across vowels in the present study. For vowel /a/, 3 out of 4 participants showed a reduction in mean vowel duration; for /i/, 2 participants showed an increase in duration during the follow-up phase after a reduction during immediate post-therapy assessment. For /u/, a reduction was observed in 2 participants, and an increase in duration in the other 2. This non-uniform pattern in vowel duration can be due to the different compensatory strategies adopted by the participants for different vowels to maintain a reduction in the variability of speech production, which in turn led to a faster transition (supported by the reduction of F2 TD), resulting in an increase in the rate of speech. A reduction in the variability of vowel duration was also reported in the study of Onslow et al. (1992) following prolongation. An increased vowel duration post-intervention, which normalised

during follow-up, was reported in the study of Santhosh (2006). The findings of Onslow et al. (1997) are consistent with those of the present study. In their study, a reduction in the variability of vowel duration was noted in one of the three participants following a time-out. In contrast, the current study observed this reduction across all participants, although it was not uniform across different vowels. This reduction in variability may be associated with consistent speech motor stability achieved following intervention, suggesting it as a more reliable acoustic parameter rather than changes in mean vowel duration.

F2 transition duration, which indicates the time taken by the articulators to move from one consonant to a steady-state vowel formant, demonstrated a general trend of reduction or stabilisation following intervention for all the voiced and unvoiced plosives. These results support the findings of Santosh (2006), who noted that prolonged F2 transition durations occurred during pre-therapy conditions than during post-therapy or follow-up samples. These reductions in transition duration plausibly indicate the articulatory stability that might have been gained following the intervention, suggesting that the transitions have become faster or more precisely timed. Thus, RCTO has been shown to be an effective method for reducing stuttering frequency without affecting speech naturalness, meeting the needs of adolescent populations.

Chapter 6

Summary and Conclusion

The present study aimed to evaluate the effects of Response Contingent Time Out (RCTO) in Kannada-speaking adolescents who stutter by comparing the changes in behavioural and acoustic outcome measures across pre-, post-therapy and follow-up assessments. Stuttering-related communication difficulties have a serious impact on the lives of adolescents who are in a transitional phase of development, resulting in elevated risk of anxiety, reduced self-esteem, and embarrassment (Iverach & Rapee, 2014). Despite its importance, this population remains comparatively understudied in the stuttering treatment literature. Only a very few studies exist in the adolescent population, particularly regarding the application of operant-based treatment methods (Einarsdóttir et al., 2025; Hewat et al., 2006).

A total of 4 male Kannada-speaking adolescents diagnosed with developmental speech fluency disorder using SSI-4 and ages ranging from 10.4 to 14.5 years, participated in this study. All the participants presented with varying degrees of stuttering, ranging from mild to very severe. The study used a pre-experimental AB design, which involved baseline assessments, responsiveness testing, a treatment phase with establishment, generalisation, and post-generalisation monitoring (20-30 days) by the parents, followed by a follow-up assessment by the clinician. After collecting 2 stable baselines across conversation, narration, and reading tasks, responsiveness testing was conducted. Participants who showed a 10% relative reduction in stuttering from their baseline during responsiveness testing were enrolled in this study. After establishing fluency across tasks such as conversation, reading, and narration, generalisation sessions involving telephonic conversations and interactions with strangers were conducted. Behavioural outcome measures included the percentage of syllables stuttered (%SS), speech rate in syllables per minute (SPM), clinician-rated and self-rated

stuttering severity, and speech naturalness ratings (NAT), and acoustic outcome measures included vowel duration and F2 transition duration. All these parameters were measured at three time points: pre-treatment, immediate post-treatment, and 20–30-day follow-up.

The results obtained are as follows:

- Remarkable reduction in the disfluency rates across all participants, with %SS dropping to ≤ 2% across all tasks, with reductions ranging from 72.07% - 96.90% during immediate post-therapy assessment. This was largely maintained during follow-up, with reductions ranging from 51% to 91%.
- Increase in the speaking rate following intervention for all the participants, along with sustained speech naturalness score from 1-3 throughout follow-up assessments.
- Reduction in the clinician-rated and self-rated severity scores to their lowest values after therapy for all the participants, and the agreement of these scores between clinician and participant indicates accurate perceptions and self-monitoring of fluency gains by all participants.
- Reduction in variability of vowel duration across all participants for all vowels (/a/, /i/, /u/) plausibly suggests stable speech production following intervention. No specific patterns of change for mean vowel durations were observed.
- Non-uniform changes in patterns of VOT were observed following treatment for both unvoiced and voiced plosives, with no consistent directional trends in VOT among participants.
- Reductions or stabilisations of F2 transition durations following RCTO for both voiced and unvoiced plosives, indicating faster transitions of articulators with preserved fluency.

Conclusion

As per the findings of this study, RCTO was found to be effective in treating Kannada – speaking adolescents who stutter. RCTO produced substantial reductions in %SS and an increase in speech rate while preserving speech naturalness. Acoustically, the refinement in F2 transition durations and reduction in variability of vowel duration indicate that operant contingencies promote stability of speech production. Hence, RCTO is a treatment method that could be utilized without altering speaking style, thereby indirectly reducing social stigma commonly observed in this population.

Limitations of the Study

- The follow-up period was 20-30 days post-generalisation, which is a short-term period and is insufficient to assess the treatment's sustainability, as there are high chances of relapse in stuttering.
- All the participants were male, which limits the generalizability to the female adolescent population.
- The study used an AB design, which does not have a treatment withdrawal or reversal phase, hence it poses difficulty in ruling out internal validity threats for the observed treatment effects.
- Acoustic parameters like VOT, F2TD were measured at word-level tokens. It may not reflect the articulatory dynamics occurring in connected speech contexts.
- As it is a single-subject design with a small sample size (n=4), the inferential generality of the behavioural and acoustic findings to a broader adolescent population remains restricted.
- Psycho-social assessments like communication-related anxiety and quality of life were not formally assessed.

Future Directions

To build on the findings of this study, future research can:

- Extend the follow-up window to 3 or 6 months to evaluate the long-term maintenance of fluency gains.
- Consider a larger sample size to validate these findings for a broader adolescent population.
- Include female participants to ensure the generalisation of acoustic and behavioural findings to the entire adolescent population.
- Expand the acoustic analysis to other temporal and spectral parameters for a deeper exploration of underlying speech production mechanisms.
- Include formal tests which measure psychosocial parameters like communication-related anxiety and quality of life, along with objective speech measures.

Implications of the Study

- This study demonstrated the effectiveness of Response-Contingent Time-Out (RCTO) in reducing stuttering disfluencies among Kannada-speaking adolescents who stutter, irrespective of stuttering severity, with maintenance of speech naturalness.
- This study has shown some of the acoustic changes following RCTO, thereby providing hints into the underlying mechanisms of fluency change in this operant treatment method.
- As positive gains were documented and successfully maintained through the follow-up period, future large-scale, randomised group studies are warranted to further evaluate its efficacy and establish its generalizability.

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Appendix A

Subjective Stuttering Severity Rating Scale (Riley et al., 2004)

Question 1 of the 9-point self-rated stuttering severity scale developed by Riley et al. (2004) was used by the participants in the study.

Client _____ Case # _____ Sampled @ _____ Date _____

1. How would you score your fluency during the session today?

   Relatively fluent 1 2 3 4 5 6 7 8 9 Severe stuttering

2. How would you score your speech with the following audiences during the last week?

	Relatively fluent								Severe stuttering
Close friend	1	2	3	4	5	6	7	8	9
Authority figure	1	2	3	4	5	6	7	8	9
Telephone	1	2	3	4	5	6	7	8	9

3. How much time during conversation during the last week did you think about stuttering with the following audiences?

	Never								Constantly
Close friend	1	2	3	4	5	6	7	8	9
Authority figure	1	2	3	4	5	6	7	8	9
Telephone	1	2	3	4	5	6	7	8	9

4. How often did you change words during the last week when you thought you might get stuck, with the following audiences?

	Never								Always
Close friend	1	2	3	4	5	6	7	8	9
Authority figure	1	2	3	4	5	6	7	8	9
Telephone	1	2	3	4	5	6	7	8	9

5. To what extent did you feel internally hurried during conversation this past week with the following audiences?

	Never								Always
Close friend	1	2	3	4	5	6	7	8	9
Authority figure	1	2	3	4	5	6	7	8	9
Telephone	1	2	3	4	5	6	7	8	9

6. How much energy did you expend this week on how you speak rather than on what you wanted to say with the following audiences?

	0%								100%
Close friend	1	2	3	4	5	6	7	8	9
Authority figure	1	2	3	4	5	6	7	8	9
Telephone	1	2	3	4	5	6	7	8	9

7. During the past week how often did you refrain from a conversation because of fear of stuttering with the following audiences?

	Seldom								Frequently
Close friend	1	2	3	4	5	6	7	8	9
Authority figure	1	2	3	4	5	6	7	8	9
Telephone	1	2	3	4	5	6	7	8	9

8. During the past week how much choice did you feel you had to take part in a conversation with the following audiences?

	A great deal								Very little
Close friend	1	2	3	4	5	6	7	8	9
Authority figure	1	2	3	4	5	6	7	8	9
Telephone	1	2	3	4	5	6	7	8	9

Appendix B

Stuttering Severity Rating Scale of Lidcombe Program (Jones et al., 2005)

A 10-point stuttering severity rating scale adapted from the Lidcombe Program was used by parents of the participants in the present study.