STUTTER-FREE SPEECH FOLLOWING RESPONSE-CONTINGENT TIME-OUT FROM SPEAKING IN YOUNG CHILDREN WHO STUTTER

by

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A Dissertation Submitted to the Faculty of the

DEPARTMENT OF SPEECH, LANGUAGE, AND HEARING SCIENCES

In Partial Fulfillment of the Requirements
For the Degree of

DOCTOR OF PHILOSOPHY

In the Graduate College

THE UNIVERSITY OF ARIZONA

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THE UNIVERSITY OF ARIZONA
GRADUATE COLLEGE

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ABSTRACT

Purpose: The purpose of this study was two-fold: 1) to determine if response-contingent time-out from speaking (RCTO) could effectively reduce stuttering frequency in young children, and 2) to determine if differences in participant awareness, emotional state, speech timing, and utterance length could be detected following RCTO.

Background: RCTO is a fundamental component of operant treatments used for stuttering. RCTO requires the individual to pause from speaking immediately after a stuttering behavior has occurred. Well-controlled experimental investigations over the past 30 years have consistently demonstrated the robust and immediate effects of RCTO on stuttering (Prins & Hubbard, 1988), but few studies have examined the possible mechanism(s) responsible for these effects. At present, the processes mediating reductions in stuttering following RCTO are unknown. Factors such as cognitive processes, changes in affect, and modification of speech production systems have been implicated as underlying mechanisms, but findings have been inconsistent and inconclusive (Prins & Hubbard, 1988).

Method: A time-series single-subject A_1BA_2 experiment was conducted on each of 5 children between the ages of 4 and 7 years while they engaged in several different linguistic tasks. Stuttering frequency was measured to determine the effectiveness of RCTO. Articulation rate and mean length of utterance were calculated from stutter-free speech samples obtained from all phases of the experiment (baseline, treatment, extinction). Reports were also obtained from the children after completion of the experiment regarding their awareness and feelings towards the RCTO stimulus used in the investigation.

Results: RCTO effectively reduced stuttering frequency; however, positive results differed across linguistic tasks and were dependent on the child's compliance with the procedure. Explicit awareness was not required for RCTO to work effectively and the time-out response stimulus did not result in adverse emotional consequences. Changes observed for articulation rate and mean length of utterance were task dependent and differed for each child.

Conclusions: The factors examined in the present investigation did not adequately account for the positive effects of RCTO on reductions in stuttering frequency. Theoretical considerations potentially underlying the positive effects of RCTO are discussed.

INTRODUCTION

Overview of Stuttering

Stuttering is a complex, multidimensional disorder (Conture, 1990) that interferes with the smooth, effortless flow of spoken communication (Ramig & Shames, 2002). In the International Classification of Diseases, stuttering is defined as "disorders in the rhythm of speech, in which the individual knows precisely what he wishes to say, but at the time is unable to say it because of an involuntary, repetitive prolongation or cessation of a sound" (World Health Organization 1977, p. 202).

The incidence of stuttering, or the number of adults who have reported stuttering at some point during their lives, is 5% (Andrews et al., 1983). The prevalence of stuttering in the population, however, is only 1% at any given time (Conture, 1996; Yairi & Ambrose, 1992a), which demonstrates the high rate of recovery from stuttering. Despite this seemingly low prevalence rate, stuttering affects over 2 million children and adults in the United States (Ramig & Shames, 2002) and negatively affects the quality of life for these individuals (Boyle, Decoufle, & Yeargin-Allsopp, 1994; Yaruss, 2001).

About 85% of cases of stuttering have their onset in early childhood, typically between the ages of 2 and 5 years of age (Andrews & Harris, 1964). Preschool boys outnumber girls who stutter by 2:1. If stuttering persists into adulthood, the ratio of males to females who stutter increases to about a 4:1 (Ramig & Shames, 2002).

Substantial reduction in stuttering occurs during the first year or two post-onset, with spontaneous recovery occurring in about 80% of preschool-aged children (Andrews & Harris, 1964). In a large scale, longitudinal study of 84 children between the ages of

29 and 59 months (M = 39.81 months) who stutter, Yairi and Ambrose (1999) reported an overall spontaneous recovery rate of 74% at 48 months post-onset. The authors stated that this was an underestimation based on the stringent criteria used to define "recovery" from stuttering. Recovery occurred at different times over the 48-month period. For most children, stuttering duration was 6 to 35 months, but for some, the duration was as long as 36 to 48 months. Females tended to recover at an earlier age, typically between 12 and 30 months following stuttering onset, whereas males who recovered did so between 24 and 36 months of age post-stuttering onset. Also, females recovered in greater proportions than males in this investigation, supporting a genetic basis for stuttering (Yairi & Ambrose, 1999).

Despite the high rate of natural recovery for the majority of young children who stutter, 20% continue to stutter. At present, there is no way to accurately predict who will recover naturally and who will not. Although numerous studies have attempted to provide insight on this issue (e.g., Hall, Amir, & Yairi, 1999; Subramanian, Yairi, & Amir, 2003), most of the evidence to date is inconclusive and conflicting. Because it cannot be determined with any degree of certainty if and when a child will recover naturally, and because stuttering is more difficult to manage and often has a negative impact on other aspects of development (e.g., social, emotional, academic) as children get older, early intervention for stuttering is strongly recommended (Onslow, 1992).

Treatment for Stuttering

Many early intervention approaches for young children who stutter involve "indirect" methods to try to reduce and eliminate stuttering. The indirect approach is based on Starkweather's Demands and Capacities Model of stuttering, which purports that stuttering occurs in the young child when the demands on fluency exceed the child's capacities for fluency (Franken, Kielstre-Van der Schalk, & Boelens, 2005; Starkweather, 1987, 1997; Starkweather, Gottwald, & Halfond, 1990). Therefore, this treatment approach stresses reduction of the cognitive-linguistic, motoric, social, and emotional demands related to speaking in the child's environment (Starkweather et al., 1990). This approach employs techniques such as using a slower speech rate when conversing with the child, using modeling and self-talk rather than demanding speech, reducing the number of questions to the child, and providing the child with daily special interaction time with the parents' or clinicians' undivided attention (Conture, 1990; Franken et al., 2005).

Proponents of the indirect approach to stuttering treatment of young children who stutter strongly admonish calling attention to the young child's stuttering. The popularity of this approach is the result of Wendell Johnson's highly influential "Diagnosogenic Theory" (1944), which postulates that when parents react negatively to their child's normal disfluencies, such as by telling the child to slow down and to stop stuttering, the child subsequently becomes fearful and anxious about speaking. He then responds by attempting to avoid these normal disfluencies, which causes further hesitations and struggle behaviors (Johnson, 1944).

Johnson's theory on stuttering has never been verified. In fact, evidence exists to contradict many of its basic premises (McDearmon, 1968). Despite this evidence, parents and clinicians continue to be somewhat fearful about calling attention to stuttering in the young child. As a result, the indirect approach to treatment of young children who stutter continues to be strongly advocated (Conture, 1990) and although it has some evidence to suggest it is effective for incipient stuttering, it consists of many components and requires a great deal of parental compliance (Franken et al., 2005).

Unlike the indirect approach to stuttering treatment, direct approaches require that the parent and clinician call attention to the child's stuttering (e.g., Lidcombe program), and might involve having the child alter his speech to achieve fluency (i.e., prolonged speech treatment or continuous phonation). Direct interventions for young children who stutter have been shown to have no aversive psychological consequences on children (Woods, Shearsby, Onslow, & Burnham, 2002) and have proven highly effective in reducing or eliminating stuttering in treatment outcome trials (Lincoln & Onslow, 1997; Onslow, Packman, & Harrison, 2002).

Response-Contingent Time-out from Speaking

One direct treatment approach that has proven highly successful in reducing or eliminating stuttering in adults and children is response-contingent time-out from speaking (RCTO). RCTO is a behavioral approach that requires the individual to pause briefly from speaking immediately after a stuttering event has occurred (Prins & Hubbard, 1988). This is its only treatment component, and therefore, would appear relatively easy for parents and clinicians to administer.

Numerous studies, particularly by James (1976, 1981a, 1981b, 1981c, 1983), have demonstrated the robust effect RCTO has on reducing stuttering in adults. RCTO continues to be used as a treatment for stuttering in adults and adolescents (Hewat, O’Brian, Onslow, & Packman, 2001; Hewat, Onslow, Packman, & O’Brian, 2006); however, the mechanism underlying its success is still unknown.

What is known about RCTO is that its ameliorative effects on stuttering are dependent on several variables. These include: (a) a definition of the target behavior that is to be eliminated and reduced, (b) a time-out correction stimulus, and (c) and administration of the correction stimulus contingent on the target behavior. For RCTO to be effective, a clear definition of the behavior to be corrected is needed (Ingham, 1984). This is especially important in determining the relation of a response stimulus to its corresponding change in behavior (Prins & Hubbard, 1988). Because stuttering is the target behavior to be corrected, a “stutter” behavior must be clearly defined for RCTO to be effective in reducing or eliminating its occurrence.

The manner in which stuttering is identified and defined continues to be debated, however. Some researchers are of the opinion that stuttering should be viewed in terms of specific types of speech disfluencies (Adams, 1976; Wingate, 1977). They contend that determination of stuttering frequency in terms of these specific behaviors would serve to reduce disagreement among listeners in stuttering identification, thus increasing interobserver reliability (Wingate, 1977). By contrast, others have argued that stuttering is perhaps a threshold phenomenon and may be more accurately identified when viewed as a “moment” or “instance” of stuttering, rather than as a group of specific behaviors (Martin & Haroldson, 1981). Martin and Haroldson (1981) demonstrated that listeners were more reliable when identifying stuttering behaviors in this way rather than adhering to a standard definition of stuttering.

Next, for RCTO to be effective, the correction stimulus must involve cessation (time-out) of speaking and be contingent on stuttering, meaning that it must occur immediately after a moment of stuttering. In 1981, James directly investigated the issue of time-out versus simply signaling stuttering, as well as contingency versus non-contingency of the correction stimulus. In his investigation, 36 adults who stutter were assigned to one of four groups which involved presentation of a 290-Hz tone signal at 65 dB SPL and time-out from speaking signaled by presentation of the same tone signal contingent or non-contingent on stuttering. The four conditions were as follows: time-out from speaking contingent on stuttering, non-contingent time-out from speaking, tone signal without cessation of speech contingent on stuttering, and non-contingent tone.

Results revealed a significant reduction in the frequency of stuttering only for participants who were required to cease speaking in the presence of the tone signal contingent on each instance of stuttering. In other words, administration of the response stimulus had to occur immediately after an instance of stuttering, and the participant had to cease speaking once the stimulus was delivered for RCTO to effectively reduce and eliminate the frequency of stuttering. Furthermore, administration of the response stimulus was determined by James to be "contingent" when it occurred no more than 1 second after an instance of stuttering.

In summary, RCTO is an effective approach for reducing the frequency of stuttering when the target behavior (stuttering) is clearly defined, the correction stimulus is a time-out requiring the individual to cease speaking, and the time-out correction stimulus immediately (no more than 1 second) follows an instance of stuttering. The success of RCTO has driven several researchers to investigate potential hypotheses about how RCTO actually works to reduce or eliminate stuttering.

Factors Responsible for the Effects of RCTO

Participant Awareness and Expectancy

The role of participant awareness and "knowledge of results" in RCTO has been of interest to investigators for over 30 years (see Prins & Hubbard, 1988 for a review of the literature). On the one hand, it has been suggested that individuals who stutter can be induced to stop just by calling attention to their stuttering (Wingate, 1959, 1976). This "attention effect" was examined in a study by Cooper, Cady, and Robbins (1970) in which they concluded that any stimulus that calls attention to stuttering will result in its reduction.

Similarly, Siegel and Martin (1966) reported a significant decrease in the disfluencies of 10 normal speakers after the participants were told that while reading, they produced several disfluencies. Participants were instructed to re-read the passage without producing any disfluencies. This resulted in a 50% decrease in disfluencies, supporting the hypothesis that drawing attention to a particular behavior, such as disfluency, will result in the reduction of that behavior.

On the other hand, the study by James (1981b) discussed previously provided contradictory evidence for the importance of participant awareness and the "attention effect." One of the four conditions of the James (1981b) investigation involved presentation of a tone signal (without time-out) contingent on stuttering. This would in effect serve to draw attention to stuttering, yet it did not result in any marked reduction in stuttering. This finding raises the question of whether a participant's awareness of his stuttering is relevant to its subsequent reduction following RCTO (James, 1981b).

Several researchers have argued that verbal conditioning, for which RCTO is one form, is only effective when the participant knows what is expected of him (Siegel, 1970; Spielberger, 1962; Spielberger & DeNike, 1966). This notion of participant expectancy was directly investigated by James and Ingham (1974). In their investigation, one group of adults who stuttered was informed that a time-out procedure would successfully reduce their stuttering while the other group was informed that time-out would have no effect. Regardless of the information provided to participants (whether or not time-out was beneficial), stuttering frequency decreased and the magnitude of reduction was not significantly different. Therefore, participant expectancy of results had no influence on the effects of RCTO.

Changes in Emotional State

It is clear at this point that participant awareness and expectation do not adequately explain the positive effects observed with RCTO, and that other factors must be at work. One suggestion is that the therapeutic effects of RCTO are the result of alterations in the speaker's emotional state (Prins & Hubbard, 1988). Participants in Adams' and Popelka's (1971) study reported that time-out from speaking gave them time to relax. Another study by Yonovitz and Shephard (1977) measured heart rate and galvanic skin response (GSR) or palmer sweat in 8 stutterers and 8 non-stutterers to infer anxiety level during time-out from speaking. Heart rate and GSR were both found to decrease in the participants who stuttered during the time-out procedure, but increased in participants who did not stutter. It was suggested that the participants who stuttered felt more relaxed during the time-out period. In addition, participants who did not stutter reported feeling annoyed by the intrusive pause from speaking. Participants who stuttered were unable to adequately describe their subjective feelings about the procedure. Similar but inconsistent results were obtained for GSR measures by Reed and Lingwall (1976) during response-contingent stimulation procedures.

Changes in Speech Timing

Another factor that has been speculated to contribute to significant reductions in stuttering following RCTO is that of speech production modification (Prins & Hubbard, 1988). Specifically, certain aspects of stutter-free speech pertaining primarily to speech timing parameters may be altered following RCTO. Though evidence for this assumption in individuals who stutter is limited and inconclusive (Andrews, Howie, Dozsa, & Guitar, 1982), changes in speech timing (e.g., rate) and other suprasegmental speech parameters (e.g., loudness, stress) have been observed in normal speakers who underwent RCTO (Newman, 1987).

In an attempt to determine if changes in speech timing occurred following RCTO, Onslow, Packman, Stocker, van Doorn, and Siegel (1997) conducted acoustic analyses of perceptually stutter-free speech samples obtained before intervention, and those obtained after RCTO intervention in three school-age children (ages 10 years: 6 months, 10 years: 6 months, and 11 years: 1 month). Four acoustic measures were analyzed: (a) vowel duration (VD), defined as the interval between the peaks of the first and last periods with a characteristic shape of the waveform for that vowel; (b) intervocalic interval (IVI), measured where vowels were separated by voiceless consonants and defined as the interval between the peaks of the last characteristic period of one vowel and the first characteristic period of the following vowel; (c) voiceless voice onset time (VOT), defined as the interval between the onset of the plosive burst and the peak of the first discernible period of subsequent vocal fold activity; and (d) articulation rate (AR), measured in syllables per second (pauses deleted).

Although a slight but inconsistent decrease in IVI was observed for one participant, and a slight increase in articulation rate consistent with the slight decrease in the means of VD, IVI, and VOT was observed for another participant, none of these differences were found to be statistically significant. Only the variability of the vowel duration measure was significantly different before and after RCTO (it decreased), and only in one participant. Nevertheless, it is difficult to draw any definitive conclusions about speech timing and RCTO from this investigation due to the limited number of participants, the age of participants (10:6, 10:6, 11:1 years: months), and the lack of success with RCTO in one of the three participants.

Limitations of Studying Adults and Older Children

The studies just described attempted to determine possible factors (awareness, change in emotional state, and changes in speech timing) that might account for the effectiveness of RCTO using either adults or older children who stutter. The problem with studying adults is that they have likely developed compensatory speech behaviors and avoidance strategies as a result of stuttering over a long period of time, or perhaps have psychological issues due to their stuttering (i.e., anxiety about speaking) (Andrews et al., 1983) .

Take, for example, the studies that explicitly attempted to determine the participant's awareness of the RCTO procedure. The inherent difficulty in interpreting these studies is that adults involved in speech experiments are most likely aware on some level that the experiment involves his or her stuttering (Prins & Hubbard, 1988). The studies that investigated changes in emotional state and also revealed decreased anxiety levels following RCTO are problematic as well, given that adults who stutter have been found to have heart rate and GSR base-rates that are already higher than those of normally fluent speakers (Yonovitz & Shephard, 1977). Furthermore, adults who stutter have most likely developed high anxiety levels about their stuttering over the years (Messenger, Onslow, Packman, & Menzies, 2004) making it difficult to discern if their anxiety levels changed in response to treatment or other factors.

Speech timing measures pre-/post-RCTO are also difficult to interpret because adults who stutter have been shown as a group to produce slower speech movements, and thus slower rates than their fluent counterparts (Max, 2004). For example, individuals who stutter tend to produce slower bilabial closing movements (Max, Caruso, & Gracco, 2003a) while fluent speakers tend to produce these same movements with shorter durations and at greater velocities when compared to opening movements (Gracco, 1994). The production of slower speech movement sequences is believed to be a compensation for impaired sensory feedback monitoring, particularly auditory feedback monitoring, or an over-reliance on feedback control due to weakened feedforward control mechanisms (Civier & Guenther, 2005; Max, Guenther, Gracco, Ghosh, & Wallace, 2004). In fact, computer simulation models of speech production, particularly modeling of speech movements in the directions into velocities of articulators (DIVA) model (e.g., Guenther, 1995; 2003; Guenther, Ghosh, & Tourville, 2006), simulated speech patterns similar to stuttering. This was accomplished by programming the articulatory synthesizer with dominant feedback control projections and weakened feedfoward command projections during speech production. The dominance of feedback control (over-reliance on auditory or orosensory feedback signals) during speech production simulation is associated with long time delays that render the system unstable. The instability caused by the slow-acting feedback controller during the rapid process of speech production resulted in increased disfluent output by the articulatory synthesizer. This output resembled patterns of stuttering. Furthermore, when the synthesizer's speech rate was reduced, instances of fluent output were increased (Civier & Guenther, 2005). The slow rate of speech in this case served to accommodate the long time delays associated with the dominant feedback control mechanism, which in turn, reduced instances of stuttering.

Use of these compensatory speech behaviors, such as a slow speech rate, would make it difficult to determine with any certainty the speech timing factors that might underlie RCTO, and those associated with the use of compensatory strategies in adults following the treatment. Unfortunately, studying older children involves the same difficulties as that of studying adults who stutter as discussed previously. Given that stuttering onset may occur as early as 18 months of age, but is usually not reported until somewhere between 2 and 5 years of age (Bloodstein, 2006), the school-aged children in the Onslow et al. (1997) study had been stuttering for a minimum of 5 years, if not more, prior to their participation in the study. Research has shown that school-age children as young as 7 years of age present with significantly more negative attitudes toward their speech than their non-stuttering peers, with speech-related attitudes about stuttering becoming more negative with increasing age (DeNil & Brutten, 1991). Such negative attitudes about speech might interfere with not only the success of a treatment program for stuttering, but might also cause older children to adopt various speaking or non-speaking-type strategies to deal with their stuttering.

For the same reasons discussed earlier, it is plausible that older children have learned to reduce their speech rate in the same fashion as adults, either consciously or unconsciously, to achieve more instances of stutter-free speech productions, and may have done so in the Onslow et al. (1997) experiment. Use of compensatory speech strategies could potentially mask changes in speech behavior that might result from a treatment program for stuttering. Given the fact that one participant in the Onslow et al. (1997) investigation showed a continued decrease in his levels of stuttering during the extinction phase suggests that other factors were responsible for the positive effects of RCTO during administration of the treatment. This might explain why speech articulation rate pre/post-RCTO showed minimal to no change in this participant. Perhaps changes in speech timing would have been observed following RCTO if younger children were investigated because compensatory speech behaviors are not likely to be used by young children (Chang, Ohde, & Conture, 2002).

RCTO and Young Children

RCTO as a treatment for young children who stutter was investigated by Martin, Kuhl, and Haroldson (1972). In their investigation, two children (3.5 and 4.5 years of age) received weekly 20-minute sessions, which involved conversing with a "talking" puppet. The puppet (Suzybelle) was mounted inside a stage-box decorated as a house and was operated by two investigators out of view from the child. One investigator (female) simultaneously talked while moving the puppet's jaw and the second investigator controlled a footswitch which turned the lights inside the stage-box on and off.

During initial treatment sessions, the child was allowed to talk with Suzybelle. Time-out from speaking was initiated after the first 10 minutes of the fourth session. When the child stuttered, the second investigator depressed the footswitch on the puppet apparatus, turning the lights off in the stage-box. Suzybelle went silent during this time, and remained so until the lights came on again. Time-out lasted 10 seconds. The child was given no instruction prior to administration of time-out, and no information was provided regarding the child's behavior, speech or otherwise, during those 10 seconds.

Results for both children revealed a substantial reduction in stuttering to near zero levels. This reduction was maintained throughout the 10 extinction sessions, as well as at the follow-up session approximately 1 year after the treatment sessions. Because RCTO was conducted as a treatment, with maintenance of stuttering reduction during extinction sessions and generalization of results 1 year post-treatment, it can be argued that other factors may have played a role in stuttering reduction other than the RCTO (e.g., natural recovery). The authors suggest that the sudden reduction in stuttering observed immediately after initiation of RCTO at the very least, helps rule out natural recovery (Martin et al., 1972); however, no other variables were examined that potentially may have contributed to the success of the procedure.

RCTO and Linguistic Factors

Influence of Language on Stuttering

There is evidence to suggest that language skills of young children who stutter resemble those of their normally fluent peers, and in some cases, even exceed average norms (Watkins & Johnson, 2004). There is also evidence that young children who stutter present with delayed or disordered language skills (Anderson & Conture, 2000; Bloodstein, 2002; 2006). Regardless of which body of evidence is correct, language skills clearly play a role in stuttering.

It is well-documented in the literature that stuttering varies as a function of language factors (Andrews et al., 1983). For example, in English speakers, more than 90% of stuttering occurs on the initial syllable of an utterance (Hahn, 1942; Johnson & Brown, 1935). Stuttering is also more likely to occur on content words, longer words, words beginning with consonants, and on words with increased linguistic stress (Bloodstein, 2006).

Utterance length and complexity have also been shown to be associated with stuttering, in that longer, more complex utterances increase the likelihood that stuttering will occur (e.g., Bernstein Ratner & Sih, 1987; Muma, 1971; Weiss & Zebrowski, 1992). A relatively recent study by Zackheim and Conture (2003) indicated that children between the ages of 3 years, 1 month and 5 years, 11 months who do and do not stutter (6 in each group) were more likely to be disfluent when utterances were produced with a mean length of utterance (MLU) that was higher relative to the child's overall MLU during conversational speech production. The authors went on to predict that communicative situations that directly or indirectly encourage children to produce utterances above their MLU will likely result in production of more disfluencies (Zackheim & Conture, 2003).

Influence of Stuttering Treatment on Language

Language abilities of young children appear to be affected by treatment for stuttering. In an attempt to determine the underlying mechanism responsible for success of the Lidcombe program, a successful direct behavioral (operant) treatment for young children who stutter, Bonelli, Dixon, Bernstein Ratner, and Onslow (2000) analyzed various aspects of young children's language function pre/post-treatment. Of particular interest was MLU and developmental sentence scoring (DSS), which were used to assess length and complexity of child syntax, respectively. Pre-treatment MLU and DSS values were found to exceed the mean expectation for the child participants' ages. Following treatment, a decrease in both measures was observed, indicating that the children did not meet developmental expectancies in language growth following the Lidcombe Program (language scores were lower at the conclusion of treatment based on predicted modeling growth curves); however, the children's pretreatment scores were already higher than their age expectancies. After the treatment, their MLU values were more on par with their age.

This finding not only supports the prediction put forth by Zackheim and Conture (2003), but also reveals that decreases in stuttering rate resulting from direct treatment for stuttering impact on the length and complexity of a child's language skills (Bonelli et al., 2000). This provides a clear rationale for testing this hypothesis in young children following RCTO.

Potential Questions about RCTO

The RCTO literature on children opened the door to several interesting research questions. First, in Martin and colleague's (1972) "puppet" investigation, the authors never discussed how the two children behaved during the 10 seconds of time-out. There is no mention of whether or not the children actually stopped talking during this time, a variable thought to be critical for RCTO to be effective as an intervention for stuttering (James, 1981b). It has also been suggested that removal of the opportunity to talk may be more important than the presentation of silence. In other words, speaking is "self-reinforcing" (Haroldson, Martin, & Starr, 1968). Therefore, it is of interest to know whether the consequence for stuttering (silencing of the puppet), the child's behavior (e.g., pause from speaking) during the procedure, or both were contributing factor(s) in the success of RCTO.

Second, one of the children remarked, "Hey Suzybelle, how come you turn out when I'm stuttering, how come?" This is of interest because of the speculation that awareness during RCTO may be a primary contributor to its success as discussed earlier in this paper, despite the mixed and inconclusive evidence (Biggs & Sheehan, 1969; James & Ingham, 1974; Siegel & Martin, 1966). The question then, is what role did participant awareness play in the success of RCTO in reducing stuttering in these children?

Finally, if speech timing or MLU had been assessed in the Martin et al., (1972) investigation following RCTO, would changes in these variables been observed? Unlike the older children employed in the Onslow et al. (1997) investigation, the speech behaviors of young children are relatively free of treatment influences and of learned or habituated speech patterns (Chang et al., 2002; Yaruss, LaSalle, & Conture, 1998). The two preschool children in the Martin et al. (1972) investigation might have been able to shed some light on the issue of underlying factors responsible for the effects of RCTO. To date, this has never been investigated in young children.

Purpose

The purpose of the present investigation was two-fold. The first was to determine if RCTO is an effective means of decreasing stuttering frequency in young children who stutter in a one-time experimental paradigm. Although the success of RCTO as a treatment for young children has already been demonstrated (Martin et al., 1972), their experiment was conducted over approximately 11 months. Although the authors presented a solid argument for the positive treatment results not being attributed to maturation or spontaneous recovery, their argument is tenuous and requires further investigation.

The second purpose of the investigation was to determine if differences in (a) speech timing, (b) utterance length, (c) participant awareness, and (d) emotional state could be detected following the RCTO procedure. Investigating potential changes in these variables prior to and immediately following RCTO might determine their contribution (if any) to the positive effects of RCTO on stuttering. The important differences between this study and that of Onslow and colleagues (1997) is that young children were studied instead of school-age children over 10 years of age, more subjects were studied, and a measure of language skill was included.

METHOD

Participant Recruitment and Selection

Children between 3 and 7 years of age who stuttered were recruited to participate in this study. Participants were recruited from public and private preschool and school programs, or daycare programs in the greater Tucson Community. Copies of recruitment materials are provided in Appendix A. A child was considered to stutter if he or she produced three or more within-word disfluencies (sound/syllable repetitions, sound prolongations, or monosyllabic whole-word repetitions) per 100 words of conversational speech and if he or she has at least one adult expressing concern about the child's speech fluency skills (Chang et al., 2002). Inclusion in this study required that participants (a) spoke American English as their first-language, (b) had hearing sensitivity within normal limits as determined by pure-tone audiometric screening procedures, (c) were not currently enrolled in speech-language therapy for stuttering, (d) had not received prior direct treatment for stuttering in the past 2 years, and (e) had no history of neurological injury, disease, or handicapping condition other than stuttering based on parental report. A copy of the parent questionnaire used to gather this information is located in Appendix B.

Participants

Nine children met the criterion for study participation. Three children were unable to participate because of scheduling conflicts and one child was dismissed because he was unable to comply with experimental procedures. Five children ranging in age from 4:5 to 7:0 (years:months) participated in the investigation. Three of the children were bilingual (Participants 1, 2, and 4) and presented with several speech and language errors that may have been related to the simultaneous learning of two languages. Spanish was the second language for all three participants. Other errors were determined to be associated with a speech and language delay (Participants 2 and 4). Two of the children (Participants 3 and 5) were diagnosed with a speech and language disorder prior to their participation in the study. One was currently enrolled in services for a mild receptive and expressive language delay (Participant 5) and the other had received speech therapy in the past but was not enrolled in any services at the time of the investigation (Participant 3). Participant 3 also received therapy for stuttering 2 years earlier from a community based program in Tucson.

The speech and language skills (other than stuttering) were not part of the inclusion or exclusion criteria because speech and language impairments (e.g., phonological disorders) have been shown to occur concomitantly with stuttering (Paden & Yairi, 1996). Children who were bilingual were also not excluded as long as their *primary* language was English. It is not surprising that three of the participants were bilingual given that stuttering is more prevalent in individuals who are bilingual, particularly in young children learning two languages simultaneously (Van Borsel, Maes, & Foulon, 2001), and that this investigation was conducted in Tucson, AZ where approximately 36% of the population is Hispanic (www.fedstats.gov).

Informal Speech and Language Assessments

Informal assessments were completed by the principal investigator, a clinically certified speech-language pathologist, during the experimental procedure, and again following transcription of all language samples obtained during verbal interactions between the child and research assistant. It was noted if a child had any other speech and language difficulty in addition to stuttering. If this was case, it was brought to the parents' attention so that they might pursue further evaluation of their child.

Participant 1 (P1)

P1 was a 4 year, 5-month old Hispanic boy. He spoke both English and Spanish at home. According to his mother, he "repeated himself" on a daily basis but had no apparent awareness of his disfluencies. P1's mother also reported that her older son, who was 12 years of age, stuttered severely and had difficulty with verbal expression. Based on informal observation, speech and language skills for P1 were judged to be within normal limits. Stuttering behaviors were characterized by part- and whole-word repetitions, sound- and syllable prolongations (of minimal duration), and articulatory posturing. These posturing behaviors were often very subtle. On occasion, P1 was able to stop himself from stuttering by terminating production of the desired word and replacing it with another word. P1 also demonstrated two instances of "linguistic code switching" in which he produced a word within an utterance in Spanish (i.e., "huevos" for "eggs").

Participant 2 (P2)

P2 was a 6 year, 5 month-old African-American girl who spoke both English and Spanish in the home. Her mother stated that because P2 had difficulty rolling her "r" sounds, she did not speak Spanish very much but understood both Spanish and English very well. P2's mother also reported that P2 expressed herself very well, talked non-stop, told stories, and asked many questions. She reported that P2 repeated her words multiple times particularly at the beginning of sentences, and at times, no sound came out at all. She also stated that P2 was aware of her stuttering and sometimes pointed it out. Sometimes P2 became very frustrated by her stuttering where "the veins in her neck popped out." P2's mother stated that to reduce the frequency of P2's stuttering, she spoke more quietly and asked P2 to take a breath and relax. She also allowed her to finish her conversation on her own.

Participant 3 (P3)

P3 was a 7 year-old Hispanic and Asian boy. His only language was English. His mother reported that P3 was very quiet at times, particularly when feeling self-conscious, which made it difficult for her to hear and understand him at times. She also reported that his stuttering frequency used to be much worse in the past, and that it was addressed through counseling and awareness. To address his stuttering at home, P3's mother reported that she would tell P3 to calm down or think first before trying to speak. She also reported that she would repeat his phrases back to him fluently.

P3's other caregiver reported that he received direct treatment for his stuttering through a Tucson community based program. This treatment involved having everyone in the child's environment speak with a slow rate of speech. This slow rate of speech, called "turtle talk", was modeled for the child and he was verbally reinforced for using a slow rate. When use of the slow speech rate resulted in stutter-free speech productions, P3 was verbally reinforced as well. When use of a faster speech rate contributed to stuttered utterances, he was informed that his speech was "bumpy". Though this treatment approach was successful in reducing P3's stuttering frequency, it did not eliminate it. Thus, P3's other caregiver continued to have concern about his stuttering.

P3's articulation and expressive language skills were judged to be within normal limits; however, P3 presented with word-finding problems which resulted in long pauses during conversational speech production. He had a difficult time remembering past experiences which also contributed to long pause times. P3 occasionally had difficulty with comprehension of "wh" questions and responded incorrectly during question-answer interactions.

P3's stuttering was difficult to detect initially, particularly during more verbally structured activities (e.g., picture description, book labeling). As a result, only the question-answer task was used throughout the experiment. P3's stuttering frequency increased when he was excited. This was often the case when he was sharing personal experiences with the research assistant interacting with him; therefore, the question-answer interaction was most appropriate for speech and language elicitation.

P3's stuttering was characterized by sound/syllable prolongations, part/whole-word repetitions, and abnormal pausing. P3 also used a self time-out strategy when he was about to produce an instance of stuttering. Other times he would stop himself from stuttering by interjecting a filler word such as "like". These compensatory speech strategies have important implications for the analysis and interpretation of P3's experimental data.

Participant 4 (P4)

P4 was a 5 year, 7-month old Hispanic girl. She spoke both English and Spanish at home and participated in a bilingual English/Spanish program at school. According to her mother, P4 had difficulty with verbal expression, and frequently demonstrated stuttering behaviors (e.g., repetition of sounds or words and prolongation of sounds or words) on a daily basis. P4's mother also indicated that P4's speech was more difficult to understand when she stuttered, and that her stuttering was worse when she was upset. She also stated that P4 got frustrated during instances of stuttering and, also when she was unable to produce words correctly following a parent model.

Patterns of articulation errors (phonological processes) for P4 noted included: assimilation (e.g., "lellow" for "yellow"; "play-loh" or "play-doh"), labialization- substitution of /f/ for "th" (i.e., "baf" for "bath"), prevocalic voicing- production of /d/ for "th" (i.e., "de" for "the"), gliding for liquids (i.e., "wing" for "ring"; "wight" for "right"), and consonant cluster reduction (i.e., "twee" for "three"). P4 consistently distorted the /r/ sound in all positions of single words and substituted /w/ for /r/ in the initial position. She also substituted /s/ for "sh" and distorted /s/ sounds in the initial and final positions of words. Speech comprehensibility was judged to be fair when the context was known and poor when the context was not known.

Receptively, P4 only had difficulty following the direction involving the concept "between". She correctly and sufficiently answered all "wh" questions throughout the experiment and provided the correct steps to sequencing events (e.g., tell me all the things I need to do to bake a cake).

Expressively, P4 had difficulty with subject, object, and possessive pronoun usage. She consistently confused he and she and substituted him and her for the subject pronoun, and substituted him and her for the possessive pronouns his and hers. She also consistently omitted possessive /s/ (i.e., “Dora house” for “Dora’s house”) and the verb copula “be” (e.g., “that a baby”). P4 frequently demonstrated “linguistic code switching” in which she produced certain words within an utterance in Spanish (e.g., “how about balloones”). She presented with vocabulary difficulties throughout the session (e.g., “circle” for “cheese”; “blow” for “dough”). It is uncertain if these difficulties were the result of dual language learning.

P4’s stuttering behaviors included sound prolongations (e.g., “m---y” for “my”), part-word repetitions (e.g., “bu-bu-but”), monosyllabic word repetitions (e.g., I-I-I-I), hesitations, and frequent use of fillers (e.g., “uh”; sssssssss--) prior to production of the desired utterance. She also prolonged the /s/ sound of all utterance productions that ended in word final /s/ (“yesssssssssss”).

Participant 5 (P5)

P5 was a 4 year, 7-month old Caucasian boy. His only language was English. His mother indicated that P5 may have had some knowledge about his stuttering. She also reported that he tended to be socially withdrawn in larger group settings, perhaps because of his stuttering. Patterns of errors (phonological processes) noted for P5 included: prevocalic voicing - production of /d/ for “th” (i.e., “dat” for “that”), devoicing - production of a voiceless sound for a voiced sound (e.g., “pecause” for “because”), deaffrication - substitution of /t/ for “ch”, velar assimilation (i.e., “kake” for “take”), and gliding for liquids (i.e., “wing” for “ring”; “wight” for “right”). P5 substituted /s/ for “sh” and /d/ for “j” (i.e., “dump” for “jump”). He also presented with inconsistent consonant cluster reduction (i.e., “bake” for “break”). Speech comprehensibility was judged to be good in conversational speech.

P5’s expressive and receptive language skills were formally assessed by a certified speech-language pathologist in Tucson several months prior to his participation in the investigation. Results revealed a mild-moderate delay of both expressive and receptive language skills.

Informal assessment during the investigation revealed that P5 had difficulty with subject, object, and possessive pronoun usage. He consistently substituted him for he and substituted them for they, and substituted him or her for the possessive pronouns his or hers. He inconsistently substituted me for I as well.

P5’s stuttering behaviors included part-word repetitions (e.g., “tur-tur-tur-turtle” for “turtle”), whole-word repetitions (e.g., “mouse-mouse-mouse-mouse”), and monosyllabic word repetitions (e.g., I-I-I-I). Although P5 demonstrated a high frequency of stuttering, he did not exhibit any hesitations, blocks or secondary behaviors (e.g., eye blinking). Speech naturalness was judged to be acceptable.

General Design

A time-series single-subject, withdrawal design (A_1BA_2) was employed. This involved determination of baseline percent syllables stuttered (%SS) (A_1 phase), administration of RCTO (B phase), and extinction of the time-out sessions to determine if treatment effects were attributed to the treatment, or to other factors (A_2). Participant awareness and emotional state were assessed using a post-experiment questionnaire (Kazdin, 1974). Participants were not informed by their parents or by the investigators the reason for participation in this investigation. They were only informed that they were going to play with the research assistant while their voice was recorded. It was assumed then, that participants were initially unaware of the nature and purpose of the experiment.

Differences in speech timing were assessed via articulation rate in syllables per second and utterance length was determined by calculation of mean length of utterance (MLU). The manner in which these calculations were made is discussed later in this section.

Procedures

Laboratory, Equipment, and Set-up

The laboratory consisted of two rooms separated by a one-way mirror. Participants interacted with a research assistant on the side of the laboratory that was set up as a playroom. The principal investigator and other research assistants remained on the other side of the one-way mirror and observed the experiment through the window. Audio signals could be heard through headphones connected to the digital video-recorder (Sony, Model VCT-D680RM) via a 30 ft. cable, and through headphones connected to either the digital audio tape (DAT) (TASCAM, Model DA-P1) or compact disk (CD) recorder (Marantz, Model CDR 300).

Participants wore a lapel microphone (Audio-Technica, Model AT803b) connected to DAT or CD recorder via a 25-foot cable throughout the recording session. The DAT or CD recorder was behind the one-way mirror and was operated by the principal investigator. Each child's speaking samples were recorded onto either DAT (Participants 1 and 2) or CD (Participants 3-5) and digital videotape.

The research assistant interacting with the child wore a 2-way radio with an earpiece (Radio Shack, Model 21-914) so that the principal investigator and research assistants behind the one-way mirror could communicate with her. The digital video-recorder was in the room with the child and was operated by another research assistant. The child's caregiver was present at all times, but either stood behind the one-way mirror and watched the session, or sat at the table in the recording room and interacted minimally with the child during the experiment.

Interacting Research Assistants

Two research assistants were responsible for interacting with the participants. One was the primary research assistant (RA1) who interacted with 4 of the 5 participants. The other was a substitute (RA2) when the primary research assistant was not available. This second research assistant only participated in the experiment with one child (Participant 3); however, she was present during each experiment and operated the digital-video recorder. Both research assistants were undergraduate senior students in the Department of Speech, Language, and Hearing Sciences at the University of Arizona. The primary research assistant had extensive experience interacting with young children with disabilities. Neither research assistant had experience working with children who stuttered though both had completed coursework in stuttering.

Speech and Language Elicitation Tasks

Spontaneous speech and language samples were elicited by having the child engage in different speaking tasks that included pictures, picture books without words, and toys. For older subjects (e.g., 5 years or older), a question-answer interaction also occurred in which no other stimulus was present during elicitation of spontaneous speech. The purpose of having several different means to elicit speech was primarily to maintain the child's attention and motivation during the course of the investigation (2-3 hours). As discussed previously, stuttering levels vary depending on the linguistic task (Zackheim & Conture, 2003). The speech and language elicitation tasks used in this investigation required different demands on language formulation relative to the child's language proficiency and experience. Therefore, it was deemed necessary to analyze speech and language elicited from each task (picture description, picture book without words, self-selected toy, and question-answer) separately.

During each task, the child was encouraged to do most of the talking. A hierarchy of verbal prompts was used by the interacting RA to elicit speech and language. Verbal prompts used with each speech and language elicitation task are provided in Table 1 in order of increasing linguistic demand.

Colorful, age-appropriate pictures were used for the picture description task (Super Duper, 2004). Books used in the investigation are listed in Appendix C. These books were chosen because they either (a) had no words but consisted of normal pictures that could be readily described, or (b) contained pictures with familiar child vocabulary words (e.g., dog, boy, mouse, car), and therefore, were easily described by the participants regardless of language skill. All of the books were age-appropriate, contained brightly colored pictures, and were intrinsically motivating to the participants.

Table 1. Verbal prompts for each speech and language elicitation task.

	Picture Description	Book	Toy
Verbal Prompt #1	"Tell me everything you see"	"Tell me everything you see"	"Tell me everything you're doing"
Verbal Prompt #2	"Tell me what you think is happening"	"Tell me what you think is happening"	"Tell me everything you need to make ______."
Verbal Prompt #3	"Have you ever seen/done _____?" If so, explain.	"What do you think will happen next?"	"Have you ever seen/done _____?" If so, explain.

Toys that the child could choose from included Mr. Potato Head, Legos, Dora's Clubhouse, cars/blocks, play-doh, cooking, art supplies, and several different games. Games included Spiderman Memory, I Spy Memory, and basketball. The question-answer interaction involved asking the child a series of questions that were formulated apriori by the principal investigator. The list of questions is provided in Appendix D. This task was only used with older participants (over 5 years of age) because it required the greatest amount of linguistic demand. This task required the child to discuss an event that was not in the here and now, and often involved using narrative language structure. Narrative language tasks require several utterances per speaking event, and usually involve use of complex sentence structure and vocabulary. These skills often not developed until 5 years of age (Miller et al., 2005); therefore, this task was not considered appropriate for children younger than 5 years of age.

When the list of questions was exhausted, questions about the child's personal experiences were asked. These questions were derived from the parent/guardian who was standing with the research investigators behind the one-way mirror. The questions were more related to the child's own personal experiences and therefore, were different for every child but required a similar demand on language formulation.

If the child did not produce enough speech to establish percent syllables stuttered during each speaking session, the RA interacting with the child provided more specific verbal prompting related to each task, such as "What do you think the woman is going to make?" while pointing to the picture in the book, or "Can you tell me what the mouse is doing" while pointing to the mouse in the book.

Recording Session

Each experiment was conducted over several hours on one day. All three phases were administered in one recording session. Each phase was expected to last approximately 30-40 minutes (Onslow et al., 1997); however, because younger children were employed in this investigation, baseline and treatment phases were often 60 minutes in duration. The extinction phase ranged from 15-60 minutes depending on the child's compliance. Breaks were provided upon request or when deemed necessary.

At the start of the investigation, the RA interacted with the child informally so that a rapport could be established. The child was then given the following instruction by the RA: "Sometimes I need to take a break and put my head down, and when I take a break and put my head down, you take a break and put your head down too." Next, the child was asked to select the order of activities he/she was to engage in during the experiment. Four digital photographs or black and white line drawings depicting each activity were placed face down in a decorative box. These denoted the (a) picture description task, (b) book task (c) toy, and in some cases (d) question-answer interaction. Only one toy photo was placed in the box at a time. The child, one at a time, randomly selected a photo or line drawing. These were placed on a "schedule board" either on the wall or on the felt board near the RA in the order they were selected. After completion of all speaking tasks, the photos/drawings were placed back into the box and the child was again asked to randomly select, one at a time, a new order of tasks. A new toy was also used each time.

For each phase of the experiment, speech samples were recorded in 60-90 second speaking sessions depending on the age, attention skills, and language abilities of the child, as well as his or her compliance with the speaking task. After each 60-90 second speaking session, percent syllables stuttered was determined by a trained RA behind the one-way mirror. These values were plotted on graph paper and visual trends were determined by the principal investigator. These trends determined when a phase shift occurred.

Measurement of Stuttering

For all three phases, percent syllables stuttered was measured using a desktop computer (Dell Dimension, Model XPS) and the Stuttering Measurement System (SMS) computer software program (Ingham, Bakker, Moglia, & Kilgo, 1999). This software is designed to measure the number of syllables and stutters produced by the speaker on-line. This involves left-clicking the computer mouse to count syllables, and right-clicking the mouse to count stutters. The computer software was operated by a trained research assistant (RA3). This was an undergraduate senior in the Department of Speech, Language, and Hearing Sciences at the University of Arizona who had participated in the training protocol provided by the developers of the SMS software.

The trained student (RA3) operating the SMS program was instructed to identify instances of stuttering according to her “threshold” (Martin & Haroldson, 1981). No standard definition of stuttering was provided; however, this student had completed undergraduate coursework in stuttering.

Overview of Experimental Procedure

A_1 phase: Measurement of Baseline Percent Syllables Stuttered

The purpose of this first phase was to establish a visually stable baseline of stuttering frequency. A stable baseline is necessary in an ABA withdrawal design to confirm the effectiveness of treatment (McReynolds & Kearns, 1983). Unfortunately, stuttering frequency in young children is highly variable across speaking conditions and time (Ingham & Riley, 1998). A visually stable trend in stuttering was not readily apparent for all child participants. This was likely the result of the different speech and language elicitation tasks used in the investigation. Each task placed a different linguistic demand on the child, thus influencing the frequency of stuttering (Zackheim & Conture, 2003).

Patterns of instability during baseline measures were examined when trends were difficult to identify. This phase was extended as long as necessary to determine the variation in stuttering frequency across each speaking task. As a result, the number of trials in this phase was not pre-determined (Barlow & Herson, 1984; Kadzin, 1982), and each participant had a different number of baseline measures. If a stable baseline could not be achieved, and no pattern of variation was observed, then the baseline phase was terminated when a trend of increasing frequency of stuttering was observed (McReynolds & Kearns, 1983).

B phase: Administration of RCTO

The RA reminded the child of the instruction provided at the beginning of the investigation about taking breaks and again stated to the child, "Sometimes I need to take a break and put my head down, and when I take a break and put my head down you take a break and put your head down too." The RA engaged in the same tasks with the child which were randomly selected and ordered in the same fashion. This time, if the child stuttered, he/she was told to "take a break" and to put his or her head down. Time-out was accomplished by having the RA terminate interaction with the child by putting her head down and telling the child to "take a break." The child was required to cease speaking as well as cease all other activity (e.g., playing), and put his or her head down for the duration of the time-out.

The RA interacting with the child was not responsible for determining whether or not the child stuttered. Only the trained undergraduate senior (RA3) behind the one-way mirror was permitted to make that determination. The 2-way radio was used to notify the RA interacting with the child when a stutter had occurred and when to take a break.

Time-out from speaking involved a 5-second pause from speaking contingent on a moment of stuttering. The duration of the time-out was chosen arbitrarily in that previous studies with children have used 10-seconds in duration without a rationale (Martin et al., 1972). James (1976) investigated duration of time-out on the effects of RCTO and found no statistically significant differences across the 1, 5, 10, and 30-second time-out duration participant groups. In the present investigation, the 5-second duration was selected because it was considered long enough to produce the desired result, and short enough to ensure maintenance of the child's interest or attention to the speaking task.

If the child did not stop talking immediately after instructed to do so, the break continued until the child was compliant. A compliance/contingency index was calculated for each child. That is, the number of seconds that passed before the child actually stopped talking when instructed to do so was determined. This was determined at the conclusion of the investigation for all participants by the principal investigator, and verified by another research assistant naïve to the investigation. The principal investigator and research assistant separately viewed the digital video-tapes and used a stopwatch (Ultrak, Model 340) to determine how many seconds elapsed before the child stopped talking after being instructed take a break. As discussed in detail previously, contingency is thought to be critical for the success of RCTO.

If the child stuttered again, the same procedure was repeated. Every stuttering moment was timed-out except for Participant 5 whose stuttering frequency was so great that he would have remained in time-out for the majority of the recording session if a break occurred on each instance of stuttering. Also, he was non-compliant throughout the investigation and often refused to take a break; therefore, only 61% of his stuttering instances were timed-out.

Speaking sessions continued during this phase until percent syllables stuttered displayed either a stable trend, or a trend of decreasing frequency (McReynolds & Kearns, 1983). In some instances, this was not possible due to the child's lack of compliance (Participant 5). Patterns of variability were examined across the different speech and language elicitation tasks. Again, the number of trials in this phase was not pre-determined (Barlow & Herson, 1984; Kadzin, 1982). As a result, each participant remained in this phase of the experiment for a different length of time.

A2 Phase: Extinction of RCTO

For this final phase, the RA again reminded the child about taking breaks and reiterated the statement, "Remember, sometimes I need to take a break and put my head down and when I take a break and put my head down, you take a break and put your head down too." Then, the RA attempted to repeat the A_1 phase of the experiment but was only minimally successful. At this point in the experiment, participants were exhausted, inattentive, non-compliant, or some combination of these. Unfortunately, many of the same elicitation tasks could not be repeated, or one type of task (e.g., several self-selected toys in a row) was repeated to maintain the child's attention during this phase. Again, the primary purpose of this phase was to extinguish the effects of RCTO. This was usually accomplished by allowing the child more freedom to choose activities he/she wanted to engage in.

Speaking sessions continued until baseline levels of stuttering could be reached, or when a trend of increasing stuttering frequency was observed. In most cases, however, the number of trials was determined by the child's compliance regardless of whether or not a trend was apparent.

Determination of Treatment Effects

At the conclusion of the experiment, data were carefully analyzed again for determination of treatment effects. The effectiveness of treatment was determined according to 3 variables: (a) trend, or direction of frequency of the behavior, (b) slope, or the degree of change in the frequency of the behavior, and (c) level (higher or lower) at which the behavior was occurring (McReynolds & Kearns, 1983). These variables were determined by visual inspection of plotted data relative to baseline levels.

In addition to visual inspection of the above-mentioned variables, determination of whether or not treatment was effective was ultimately based on visual comparison of the level of stuttering frequency at baseline, with the reduced level of stuttering frequency achieved during the treatment phase (McReyolds & Kearns, 1983). If no overlap was observed for baseline and treatment values, then the treatment was determined to be effective in reducing stuttering frequency (Kazdin, 1982).

Visual inspection of data trends is the preferred analysis approach for single-subject designs because quantitative statistical analyses are believed to obscure clinical relevance of findings (Bain & Dollaghan, 1991; Ingham & Riley, 1998). Furthermore, statistical analyses utilizing procedures associated with the general linear model (GLM) are inappropriate for single-subject designs due to the fact that time-series data are auto-correlated. In other words, data points are not independent of one another, violating the primary assumption underlying the GLM (Cohen & Cohen, 1983; Robey, Schultz, Crawford, and Sinner, 1999). Despite this fact, however, linear regression trend lines were plotted to assess the utility of this form of analysis. It was determined that the inclusion of linear regression lines had minimal utility primarily because data were often in fact, not linear due to the high degree of variability in stuttering frequency. Therefore, visual inspection of actual performance data was deemed the most appropriate and useful means to determine the effects of RCTO on stuttering frequency.

The total number of utterances for each task was calculated following orthographic transcription of all speaking samples. Utterance totals were subsequently divided into the number of stutter-free versus stuttered utterances for each phase of the experiment. The percentage of the sample containing instances of stuttering was reported to indicate the success of treatment across each individual task.

Measurement of Articulation Rate

Articulation rate in syllables per second, which represents the rate of production of the speech segments themselves (Turner & Weismer, 1993), was used as a means to index speech-motor execution time pre-/post-RCTO. Articulation rate is believed to eliminate inclusion of the time needed for language formulation by excluding pauses (Butterworth, 1980; Flipsen, 2003; Levelt, 1989). Only perceptually stutter-free speech utterances (i.e., speech containing neither within- nor between-word disfluencies) as determined perceptually by two research assistants (RA1 and RA3) and verified by the principal investigator were analyzed. Only stutter-free utterances were included in the analysis because contemporary views of stuttering purport that speech motor control output during “fluent” speech production is as anomalous as speech motor control output during periods of perceptible disfluent speech production in individuals who stutter (Zimmerman, 1980a). Although an utterance may be stutter-free, it does not necessarily mean that it is fluent (Finn & Ingham, 1989), only that the anomalies inherent in the output were not detectable to the listener.

Speech samples recorded onto the DAT recorder were digitized using Tf32 software (Milenkovic, 2000) at a sampling rate of 22 kHz, saved as wav files, and later analyzed using Praat software (Boersman & Weenick, 2006). Speech samples recorded onto the CD recorder were extracted using Sound Forge 8 (Sony, 2006), saved as wav files, and later analyzed in Praat software. Articulation rate for each speaking task (picture description, picture book, self-selected toy, and question-answer) was determined by first extracting stutter-free phonetic phrases from the digitized speech samples and then measuring their duration in seconds in Praat. Narrow band spectrograms were used because limited energy is often available for spectrographic analysis of child speech due to their high fundamental frequency (Pickett, 1999).

Phonetic phrases, a period of speech bounded by pauses equal to or greater than 0.25 seconds (Allen, 1973; Miller, Grosjean, & Lomanto, 1984; Flipsen, 2003; Walker, Archibald, Cherniak, & Fish, 1992), were extracted by first listening to all child utterances and orthographically transcribing them. When pauses were bounded by two stop consonants, a pause of 0.4 seconds was permitted (Flipsen, 2003). Next, the earliest stutter-free speech samples were chosen (when possible) across each type of task in the phase in which it occurred. For vowels, resonant consonants, and nasals, the fundamental frequency band was used to determine the beginning and end of a phonetic phrase, respectively. For fricatives and stops, the beginning or end of the noise burst was used to determine the beginning or end of the phonetic phrase, respectively. Phonetic phrases included in the articulation rate analyses were those that:

- consisted of more than one word
- began and ended with intelligible syllables
- were not frank imitations of the examiner
- were not produced during overly excited states or using a play register
- were free of extraneous noise
- contained sufficient energy to identify the initial or final speech segment from the spectrogram (Flipsen, 2003)
- were at least 1 second in duration whenever possible (Onslow et al., 1997), and
- were stutter-free.

Ten phonetic phrases per speaking task per phase were extracted (except for Participant 3). Thirty phonetic phrases were analyzed for P3 because only one task (question-answer interaction) was examined. After the duration of the phonetic phrase was determined, the number of syllables was calculated for each phonetic phrase by the principal investigator, divided by the duration of the phrase in seconds, and expressed in syllables per second. This was done for each task across all three phases whenever possible for all participants. Articulation rate measures were averaged across task. As mentioned earlier, not all speaking tasks were represented in each phase of the experiment due to a lack of compliance by the child. This resulted in incomplete data for this measure.

Means and standard deviations were determined using SPSS (Version 11, 2002). In addition, effect size was calculated for each mean articulation rate to estimate the magnitude of change from baseline sessions to treatment sessions across each linguistic task. The following equation provided by Busk and Serlin (1992) in Robey et al. (1999) was used to calculate effect size, where B specifies treatment periods, A specifies baseline periods, and S specifies the standard deviation of baseline periods.

$$ES = \frac{\text{Mean of } X_B - \text{Mean of } X_A}{S_A}$$

Calculation of Mean Length of Utterance

Two research assistants (RA1 and RA2) orthographically transcribed the child's utterances while viewing the digital videotapes. All unintelligible utterances were eliminated and stutter-free versus stuttered utterances were perceptually determined. Stutter-free utterances were numbered in the orthographic transcription while stuttered utterances were marked with a tick mark. The principal investigator verified the accuracy of all transcribed utterances. Discrepancies in stutter-free and stuttered utterances were verified by the principal investigator as well. If an utterance contained an ambiguous stutter, it was counted as a stuttered utterance.

For 4 of the 5 participants, 30-50 stutter-free utterances per task in each phase were used to calculate MLU. When this number of utterances was not available, whatever number of utterances was available was used for analysis. One-hundred utterances were used to determine MLU for P3 because only one task (question-answer) was completed during the experimental procedure. For the other four participants, 30-50 utterances were not always available for a particular task, in which case, the available stutter-free utterances were used. An equal number of utterances for baseline versus treatment were always compared. Because participants were often not compliant during the final phase of the experiment, the number of stutter-free utterances obtained in the extinction phase was analyzed.

MLU was calculated in accordance with Brown's guidelines (1973) for counting morphemes. After determination of the number of morphemes per utterance, the number of morphemes was summed for the entire sample and divided by the total number of utterances. Means and standard deviations for MLU across tasks in each phase were calculated using SPSS. Effect sizes were also calculated, as described above.

Determination of Participant Awareness and Changes in Emotional State

At the conclusion of the experiment, the child was interviewed concerning his or her understanding of the investigation (Appendix E). Also, the child was asked to indicate how he/she felt about the investigation by pointing to the corresponding pictorial representation of an emotion. Three simple line drawings of faces exhibiting the emotions of happy, a little bit upset, and very upset were presented to the child. These line drawings were adopted from assessment scales of pain in children (Wong & Baker, 1988). In particular, how the child felt about the time-out from speaking procedure to infer a possible change pre-/post-RCTO was the variable of interest. The interview process was conducted twice in succession for purposes of intra-participant reliability.

Participants' emotional state (e.g., anxiety about speaking) could only be inferred prior to initiation of the experiment based on parental report. If the child participants had been questioned prior to the experiment about their feelings toward their stuttering, then they would probably have been made aware of the nature of the investigation which would have been counterproductive. Therefore, the post-treatment questionnaire was primarily a means to ensure that RCTO produced no aversive reactions by the child. The child's responses to the questionnaire allowed inferences to be drawn about changes in emotional state following RCTO.

Reliability for Quantitative Measures

Intra-and inter-judge reliability for stuttering frequency was determined by having RA3 and the principal investigator re-measure 15% of the samples (randomly selected) for each experimental phase. This was done by viewing the digital videotapes of each participant approximately 2 months after completion of the investigation and re-determining percent syllables stuttered via the SMS software. Digital videotapes were viewed only one time in all cases. Mean differences and Pearson-product moment correlations were calculated in SPSS.

Intra- and inter-judge reliability for articulation rate was determined by having the principal investigator and a speech scientist naïve to the investigation re-measure the duration of 15% of phonetic phrases (randomly selected) across all tasks in each experimental phase. Phonetic phrase durations were determined using Praat software. The speech scientist was provided with the rules for phonetic phrase extraction and measurement. Mean differences and Pearson-product moment correlations for the total number of utterances for each participant were calculated in SPSS.

Syllable counts for all phonetic phrases for each participant were verified by another speech scientist unfamiliar with the investigation. Percent agreement of syllable count for the total number of phonetic phrases was determined.

Intra- and inter-judge reliability for MLU was determined by having the principal investigator and a new research assistant who had not been present during data collection, recount the number of morphemes in 15% (randomly selected) of utterances across all tasks in each experimental phase. Mean differences and Pearson-product moment correlations were calculated for the total number of utterances for each participant using SPSS.

Intra- and Inter-judge Reliability for Quantitative Measures

Intra-and inter-judge reliability for stuttering frequency for all three experimental phases across the five participants are displayed in Tables 2.1 and 2.2, respectively. For two participants (P4 and P5), Pearson-product moment correlations could not be calculated for intra-and inter-judge reliability because one replication constituted 15% of the measurement sample. This is denoted in the tables with two dashed lines. For the other three participants, intra-judge correlations ranged from .74 to .99 and mean difference scores ranged from -.79 to 1.09. For inter-judge reliability, correlations ranged from .78 to .99 and mean difference scores ranged from -1.75 to 5.09.

Table 2.1. Intra-judge Reliability for Stuttering Frequency

B = Baseline; T = Treatment; E = Extinction

	Mean Differences (% S.S.)			*Pearson r*		
	B	**T**	**E**	**B**	**T**	**E**
P1	-.16	.21	-.07	.99	.94	.99
P2	.34	.23	.16	.98	.80	.99
P3	-.32	-.43	.36	.99	-.99	.99
P4	.20	-.79	.67	--	.99	--
P5	1.09	1.04	.25	--	.74	--

Table 2.2. Inter-judge Reliability for Stuttering Frequency

B = Baseline; T = Treatment; E = Extinction

	Mean Differences (% S.S.)			*Pearson r*		
	B	**T**	**E**	**B**	**T**	**E**
P1	-.07	-.25	.28	.99	.98	.99
P2	-.16	-.17	-.64	.78	.95	.99
P3	.06	-.42	-.02	.99	.99	.99
P4	-.66	.46	1.13	--	.98	--
P5	5.09	3.22	-1.75	--	.85	--

Intra-and inter-judge reliability for articulation rate and MLU for each participant are displayed in Tables 2.3 and 2.4, respectively. For articulation rate, intra-and inter-judge correlations ranged from .99 to 1.00 and .98 to .99, respectively. Mean difference scores ranged from -.007 to .008 and -.007 and .023 for intra-and inter-judge reliability, respectively. For MLU, intra-and inter-judge correlations ranged from .97 to 1.00 and .98

and .99, respectively. Mean difference scores ranged from .00 to -.13 and .00 and -.14 for intra-and inter-judge reliability, respectively. Percentage of agreement between the principal investigator and speech scientist unfamiliar with the investigation, for syllable count for all phonetic phrases for P1-P5 were 100%, 96.5%, 100%, 90.8%, and 97.4%, respectively.

Table 2.3. Intra- and Inter-judge Reliability for Articulation Rate

	Intra-Judge Reliability		***Inter-Judge Reliability***	
	Phonetic Phrase Duration		**Phonetic Phrase Duration**	
	Mean Difference (s)	**Pearson r**	**Mean Difference (s)**	**Pearson r**
P1	-.000	1.00	-.007	.99
P2	-.005	.99	.022	.99
P3	.001	1.00	.005	.99
P4	-.003	.99	.023	.99
P5	-.007	.99	.007	.99

Table 2.4. Intra- and Inter-judge Reliability for Mean Length of Utterance

	Intra-Judge Reliability		***Inter-Judge Reliability***	
	Mean Length of Utterance		**Mean Length of Utterance**	
	Mean Difference	**Pearson r**	**Mean Difference**	**Pearson r**
P1	.00	.98	-.14	.99
P2	-.06	.99	-.02	.98
P3	.02	.99	.00	1.00
P4	-.13	.97	-.11	.98
P5	-.02	.99	-.02	.99

RESULTS

RCTO Contingency/Compliance

The number of seconds required for each participant to cease speaking when instructed to take a break during the treatment phase was used to determine the child's compliance with the RCTO procedure. These data are displayed in Table 3. The total number of breaks provided and the percentage of times that the child's compliance was ≤ 1 second during treatment for each participant are indicated in Table 3 as well. The child's compliance in pausing immediately after being instructed to take a break is thought to be critical for the success of the RCTO procedure (James, 1981a).

Table 3. RCTO Contingency/Compliance Index for P1-P5

	≤ 1.0(s)	**≤ 2.0(s)**	**≤ 3.0(s)**	**≤ 4.0(s)**	**≤ 5.0(s)**	**> 5.0(s)**	**Total**	**% ≤ 1.0 (s)**
P1	17	4	6	2	6	11	46	**37.0**
P2	79	1	0	1	0	0	81	**97.5**
P3	18	0	0	0	0	0	18	**100**
P4	25	0	0	0	0	0	25	**100**
P5	27	18	15	6	6	11	83	**32.5**

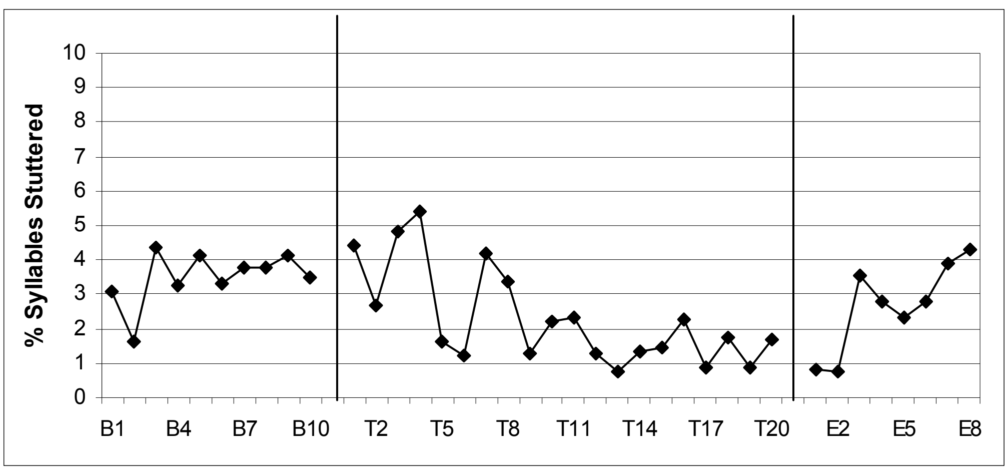
Determination of Treatment Effects/Reduction of Stuttering

To address the first purpose of the investigation, whether or not RCTO is an effective means to decrease stuttering frequency in young children, data were visually inspected by the principal investigator to examine trend, slope, and level of stuttering frequency for all participants across each phase of the experiment. Next, the percentage of the sample containing instances of stuttering was calculated across each individual task for all phases of the experiment for each participant. Data for each participant are presented in the following section.

Treatment Data for Participant 1 (P1)

Stuttering frequency data for P1 are displayed in Figure 1. Sixty-second speaking sessions were used because of P1's age and inconsistent compliance with the procedure, as revealed in Table 3. P1 stopped talking within 1 second or less when instructed to take a break in only 37% of instances.

Figure 1. Baseline, treatment, and extinction data for P1.



During baseline speaking sessions, stuttering frequency ranged from 1.64-4.35% syllables stuttered, depending on the linguistic demand of the task. Eleven sessions were necessary to establish a relatively stable baseline. Except for one data point (1.64%) obtained during a picture description task, baseline stuttering frequency values fell within the range of 3.25-4.35% syllables stuttered, and were measured during a book and self-selected toy task. The picture description task could not be repeated in either treatment or extinction phases due to the child's lack of compliance; therefore, stuttering frequency could not be compared for this task after administration of RCTO.

Twenty RCTO sessions were necessary to observe a trend in the data. During this phase, stuttering frequency ranged from .75-5.40% syllables stuttered. Patterns of variability coincided with linguistic task demands. For instance, stuttering frequency decreased below 2% syllables/stuttered during interactions with self-selected toys and increased to 2.3% syllables stuttered during the book task. Visual inspection of the graph reveals a variable, but decreasing trend in stuttering frequency during the treatment phase relative to baseline. Though initiation of treatment resulted in a sudden decrease and then a sudden increase in stuttering to a level higher than that obtained during baseline, subsequent data points show a clear overall decrease in stuttering frequency when RCTO was administered.

The increase in stuttering frequency for treatment sessions 7 and 8 are likely due to the P1's refusal to stop talking during the break despite being instructed to do so. When these data points were excluded from the visual analysis, overlap of treatment values is observed for only one of the initial baseline values obtained during the picture description task. This value should be interpreted with caution, however, due to the fact that this task could not be replicated in baseline or treatment phases.

During the extinction phase when breaks were no longer provided following each instance of stuttering, stuttering frequency demonstrated a steady increase. Values ranged from .80-4.30% syllables stuttered. The observed increasing slope and level of stuttering frequency during this phase indicates that administration of RCTO was responsible for the positive effects on stuttering observed in the treatment phase. The highest stuttering frequencies occurred for several picture description tasks at the conclusion of this phase. Due to the fact that data for picture description were not obtained during the treatment phase, this task was not analyzed for changes in articulation rate and MLU for P1.

Table 4 contains the total number of utterances divided into stutter-free and stuttered utterances across each linguistic task, along with the percentage of the sample containing stuttered utterances, for each experimental phase.

Table 4: Stutter-free versus stuttered utterances for P1.

P1	**Baseline**		**Treatment**		**Extinction**
	Book1	Toy1	Book2	Toy1	Toy2
Stutter-Free	74	58	45	35	40
Stuttered	30	16	18	5	5
Total	104	74	63	40	45
% Stuttered	**29%**	**22%**	**29%**	**13%**	**11%**

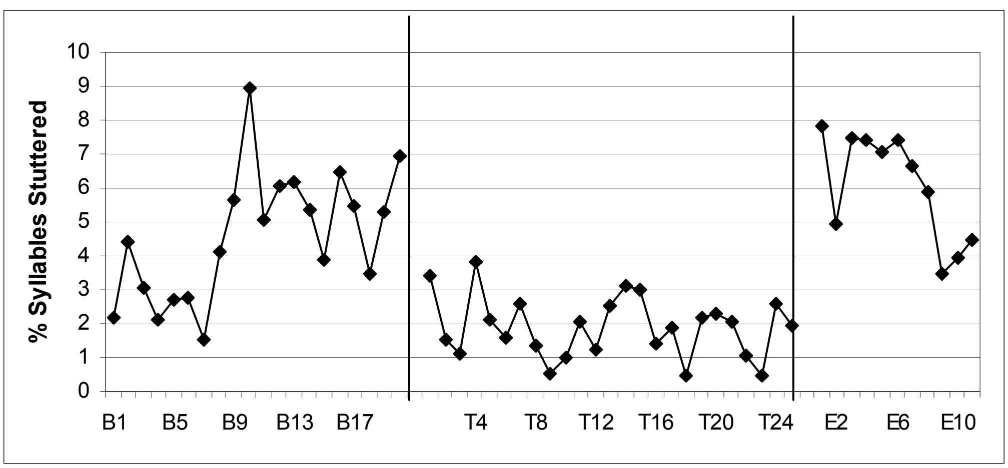
Inspection of the table reveals that the percentage of the sample containing stuttered utterances for the book task is exactly the same from baseline to treatment (29%). It should be noted that a different book was used in the baseline and treatment phases. Also, the child was not compliant in taking breaks during data trials for this task (treatment sessions 7 and 8).

Utterances produced during the self-selected toy task revealed a reduction in stuttering. The percentage of the sample that contained stuttered utterances decreased from 22% during baseline to 13% during treatment. The same toy was used for baseline and treatment phases (Spiderman Memory Game), while cars and blocks were used during the extinction phase. Only data from one toy for each phase was analyzed to determine the most immediate effects of administration and extinction of RCTO. Therefore, the increase in stuttering from the treatment to extinction phase discussed earlier is not evident from Table 4. The increase in stuttering frequency during extinction occurred for picture description which as mentioned previously, was not analyzed due to missing data.

Treatment Data for Participant 2 (P2)

Stuttering frequency data for P2 are displayed in Figure 2. Ninety-second speaking sessions were used because P2 was older and compliant.

<u>Figure 2. Baseline, treatment, and extinction data for P2.</u>



During baseline speaking sessions, stuttering frequency ranged from 2.17-9.0% syllables stuttered depending on the linguistic demand of the task. Twenty sessions were necessary to establish an increasing trend in stuttering frequency. Stability was not possible due to the high variability in stuttering frequency across linguistic tasks. Visual inspection of the graph reveals a decreasing trend in stuttering frequency from the baseline to treatment phase.

Twenty-five RCTO sessions were necessary to observe a decreasing trend in stuttering frequency across linguistic tasks. Variability was attributed to linguistic demand of the task. Stuttering frequency was generally higher during question-answer tasks (2.5-4.0% syllables stuttered) than during interactions with books and self-selected toys (0.5-2.5% syllables stuttered).

Inspection of Table 3 reveals that compliance was not an issue with this participant. P2 required less than 1 second to pause from speaking when instructed to take a break in 97.5% of instances.

During the extinction phase when breaks were no longer provided, stuttering frequency demonstrated a marked increase (1.95-7.82% syllables stuttered). The abrupt increase in slope and level of stuttering frequency during this phase indicates that RCTO was responsible for the positive effects on stuttering observed during treatment. Subsequent variability during this phase resulted when linguistic demand of the task was altered. This phase was terminated when stuttering frequency demonstrated an increasing trend. Eleven sessions were necessary to achieve this trend.

Table 5 contains the total number of utterances divided into stutter-free and stuttered utterances across each linguistic task, along with the percentage of the sample containing stuttered utterances, for each experimental phase. Inspection of the table reveals a decrease stuttering frequency from baseline to treatment phases based on the percentage of the sample containing stuttered utterances for all tasks examined. The book task showed the greatest reduction (47-18%), followed by the question-answer task (43-17%), and finally the self-selected toy task (18-9%).

Table 5: Stutter-free versus stuttered utterances for P2.

P2	Baseline			Treatment			Extinction		
	Book1	Toy1	QA	Book1	Toy2	QA	Book2	Toy3	QA
Stutter-Free	20	66	57	40	68	40	12	76	28
Stuttered	18	14	43	9	7	8	5	50	39
Total	38	80	100	49	75	48	17	126	67
% Stuttered	**47%**	**18%**	**43%**	**18%**	**9%**	**17%**	**30%**	**40%**	**58%**

Inspection of the table also reveals an increase in stuttering during the extinction phase based on the percentage of the sample containing stuttered utterances for each task. Stuttering did not return to baseline values for the book task but only 17 utterances could be elicited for this task. For the self-selected toy and question-answer tasks, the percentage of the sample containing stuttered utterances increased to values greater than those obtained during baseline.

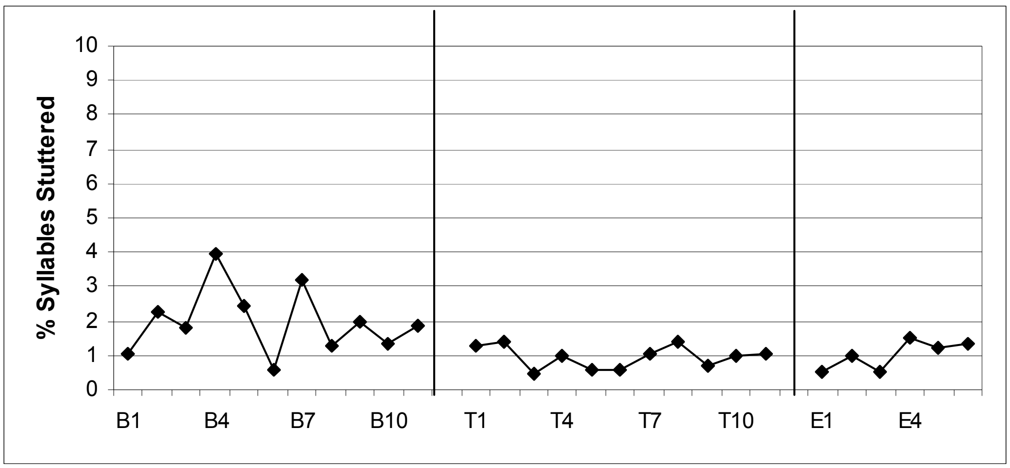
It should be noted that the same book was used during the baseline and treatment phases, but a different book was used during the extinction phase. Also, a different toy was used for each phase of the experiment.

Treatment Data for Participant 3 (P3)

Stuttering frequency data for P3 are displayed in Figure 3. Ninety-second speaking sessions were used because P3 was older and compliance was not an issue (see Table 3). P3 stopped talking when instructed to take a break in 100% of instances. During baseline sessions, stuttering frequency ranged from 1.06-4.0% syllables stuttered. As stated previously, only the question-answer task was employed for this participant;

therefore, the variability in baseline values cannot be ascribed to differences in linguistic task. Stuttering frequency increased when P3 was excited about sharing a particular experience, which may have contributed to this variability. Eleven baseline sessions were necessary to establish a trend of increasing stuttering frequency.

Figure 3. Baseline, treatment, and extinction data for P3.



Visual inspection of the graph reveals a substantial decrease in stuttering frequency variability during the treatment phase. Due to the fact that P3's stuttering frequency was already low (but highly variable) during baseline, the amount of reduction in stuttering frequency during treatment was marginal. During this phase, stuttering frequency ranged from .45-1.42% syllables stuttered. Treatment data overlapped with four of the initial baseline values, indicating a weak trend in stuttering frequency reduction. Eleven RCTO sessions were necessary to establish a visually stable trend in treatment data.

During the extinction phase, stuttering frequency did not increase above 1.50% syllables stuttered. Stuttering frequency did not exhibit the high degree of variability observed during baseline, either.

The total number of utterances divided into stutter-free and stuttered utterances for the question-answer task, along with the percentage of the sample containing stuttered utterances, for each experimental phase are displayed in Table 6.

Table 6: Stutter-free versus stuttered utterances for P3.

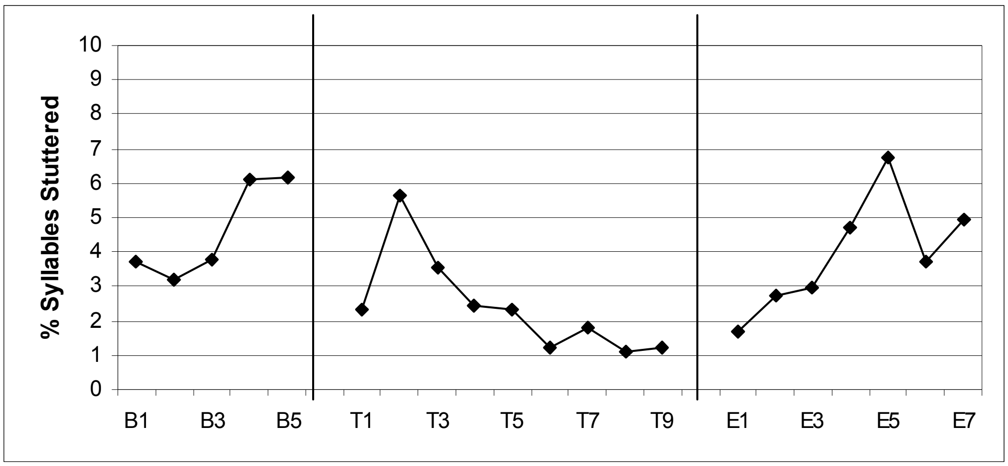
P3	Baseline	Treatment	Extinction
	QA	QA	QA
Stutter-Free	139	122	118
Stuttered	52	18	10
Total	191	140	128
% Stuttered	**27%**	**13%**	**8%**

Inspection of the table reveals that the percentage of the sample containing stutters for the question-answer task reduced from baseline to treatment phases (27% to 13%). As mentioned earlier, this percentage value did not increase to baseline levels during the extinction phase, suggesting that other factors were responsible for the treatment effects besides RCTO.

Treatment Data for Participant 4 (P4)

Stuttering frequency data for P4 are displayed in Figure 4. Ninety-second speaking sessions were used because compliance was not an issue (see Table 3). P4 stopped talking within 1 second or less when instructed to take a break in 100% of instances. During baseline sessions, stuttering frequency ranged from 3.72-6.17% syllables stuttered, depending on the linguistic demand of the task. Lower frequencies were measured during the picture description and book tasks while higher frequencies of stuttering were measured for the question-answer task. Five sessions were necessary to establish an increasing trend in stuttering frequency during baseline.

Figure 4. Baseline, treatment, and extinction data for P4.



Visual inspection of the graph reveals a variable, but decreasing trend in stuttering frequency during the treatment phase relative to baseline. Though initiation of treatment resulted in a sudden decrease and then a sudden increase in stuttering, subsequent data points show a clear decrease in slope and level of stuttering frequency when RCTO was administered relative to baseline values.

Nine RCTO sessions were necessary to observe a visually stable trend in treatment data. During this phase, stuttering frequency ranged from 1.1-5.6% syllables stuttered. Patterns of variability were observed depending on the linguistic demand of the task. Stuttering frequency decreased below 2.0% syllables/stuttered during interactions with self-selected toys and the picture description task, and increased as high as 3.5% during the book and question-answer tasks.

During the extinction phase when breaks were no longer provided for instances of stuttering, frequency of stuttering demonstrated a steady increase. Values ranged from 1.7-6.7% syllables stuttered. The increase in slope and level of stuttering observed during this phase indicates that administration of RCTO was responsible for reducing stuttering during the treatment phase. Variability in stuttering was observed depending on the linguistic demand of the task. Seven sessions were necessary to establish an increasing trend in stuttering frequency.

The total number of utterances divided into stutter-free and stuttered across each task, along with the percentage of the sample containing stuttered utterances, for each experimental phase are displayed in Table 7.

Inspection of the table reveals that the percentage of the sample containing stuttered utterances for the picture description task slightly increased from baseline to treatment (8% and 9%, respectively). Given that only 11 utterances were obtained during the treatment phase, results for this task should be interpreted with caution. A more substantial increase in the percentage of the sample containing stuttered utterances occurred for the picture description task during the extinction phase, however (25%).

Table 7: Stutter-free versus stuttered utterances for P4.

P4	**Baseline**			**Treatment**			**Extinction**		
	PD	Book1	QA	PD	Book2	QA	PD	Book1	QA
Stutter-Free	22	44	44	10	64	22	21	13	78
Stuttered	2	16	24	1	14	1	7	1	19
Total	24	60	68	11	78	23	28	14	97
% Stuttered	**8%**	**27%**	**35%**	**9%**	**18%**	**4%**	**25%**	**7%**	**20%**

Utterances produced during the book task revealed a slight decrease in stuttering frequency. The percentage of the sample that contained stuttered utterances decreased from 27% during baseline to 18% during treatment. A different book was used for baseline and treatment phases; however, the book used during baseline was also used during extinction. Further inspection of Table 7 reveals that stuttering frequency continued to decrease during extinction for the book task based on the percentage of the sample containing stuttered utterances (7%). It is uncertain if RCTO was responsible for the longer lasting positive effects on stuttering even after its removal, or if using the same book from baseline resulted in a practice effect. It should be noted that only 14 utterances were obtained for the book task during extinction; therefore, this result should be interpreted with caution.

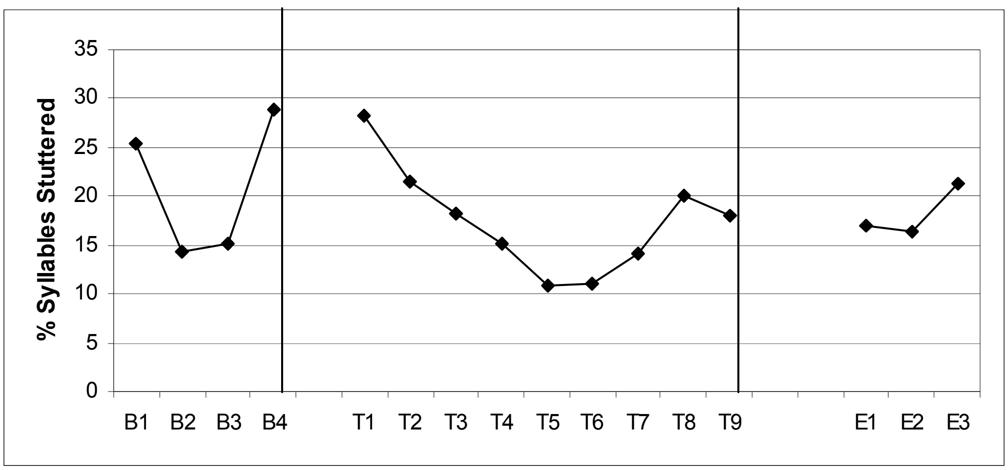
Utterances produced during the question-answer task revealed a marked reduction in stuttering when RCTO was administered. The percentage of the sample containing stuttered utterances decreased from 35% during baseline to 4% during treatment. This result should be interpreted with caution, however, because only 23 utterances were obtained during treatment while 68 utterances were obtained during baseline. Although the percentage of the sample containing stuttered utterances increased during the extinction phase for this task, it did not reach base rate levels despite the fact that 97 utterances were obtained. This finding supports that claim that the effects of RCTO were longer lasting, at least initially, during the extinction phase.

It should be noted that several self-selected toys were used throughout all phases of the experiment. Unfortunately, data collected during baseline with toys could not be included in the analysis because the child was either singing, counting, or using a play register for the majority of the interaction. Therefore, the self-selected toy task could not be analyzed.

Treatment Data for Participant 5 (P5)

Stuttering frequency data for P5 are displayed in Figure 5. Ninety-second speaking sessions were used because initially, P5 was very talkative and compliant.

Figure 5. Baseline, treatment, and extinction data for P5.



During baseline speaking sessions, stuttering frequency ranged from 14.4-28.8% syllables stuttered, depending on the linguistic demand of the task. Four sessions were necessary to establish a trend of increasing stuttering frequency. A stable baseline could not be established because of the high degree of task-dependent variability in stuttering frequency. For instance, stuttering ranged from 14.4-15.2% syllables stuttered during self-selected toys, but increased to a range of 24.4-28.8% syllables stuttered for the picture description and book tasks.

Visual inspection of the graph reveals a curvilinear trend in stuttering frequency during the treatment phase. Following administration of RCTO, stuttering frequency steadily decreased, and then steadily increased. This was likely the result of P5's lack of compliance during this phase. Inspection of Table 3 reveals that P5 paused from speaking within 1 second or less only 27 times out a total of 83 "breaks". When instructed to take a break, P5 would respond by saying "no", "I can't" or would just continue talking. Because of the severity of stuttering frequency and P5's lack of compliance with the RCTO procedure, only 65% stuttering instances were timed-out.

Nine RCTO sessions were necessary to establish a trend of decreasing stuttering frequency. During this phase, stuttering frequency ranged from 10.95-28.32% syllables stuttered. Although patterns of variability were attributed to linguistic demand of the task, inconsistent compliance with the RCTO procedure was primarily responsible for the variability and minimal success of the procedure. As revealed in Table 3, P5 stopped talking within 1 second or less when instructed to take a break in only 32.5% of instances. For those trials in which P5 was compliant, stuttering frequency decreased relative to baseline measures.

During the extinction phase when breaks were no longer provided, stuttering frequency initially remained unchanged relative to treatment data, but then increased to near-baseline values. P5 was only compliant for three speaking sessions during this phase. The observed increase in slope and level of stuttering frequency during this phase suggests that administration of RCTO was likely responsible for the positive effects on stuttering when they were observed during the treatment phase.

The total number of utterances divided into stutter-free and stuttered utterances across each linguistic task, along with the percentage of the sample containing stuttered utterances for each experimental phase are displayed in Table 8.

Table 8: Stutter-free versus stuttered utterances for P5.

P5	**Baseline**			**Treatment**			**Extinction**	
	PD	Toy1	Book1	PD	Toy2	Book2	PD	Toy3
Stutter-Free	23	53	27	24	64	27	18	39
Stuttered	25	37	37	13	37	20	21	28
Total	48	90	64	37	101	47	39	67
% Stuttered	**52%**	**41%**	**58%**	**35%**	**37%**	**43%**	**54%**	**42%**

Inspection of the table reveals that the percentage of the sample containing stuttered utterances for the picture description task decreased from baseline to treatment phases. The percentage of the sample that contained stuttered utterances decreased from 52% during baseline to 35% during treatment.

Utterances produced during the book task demonstrated a reduction in stuttering following RCTO. The percentage of the sample that contained stuttered utterances decreased from 58% during baseline to 43% during treatment. It should be noted that a different book was used in each phase. The self-selected toy task revealed only a slight reduction in stuttering (41-37%, respectively). Different toys were used throughout each experimental phase.

During the extinction phase, stuttering frequency exceeded baseline levels for the picture description and self-selected toy tasks. Data were not available for the book task during this phase.

Changes in Speech Timing

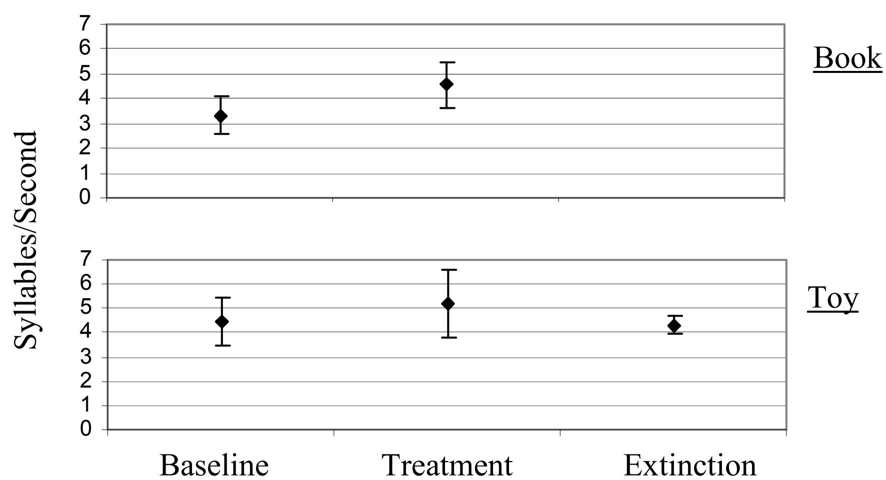
To determine if a change in speech timing occurred pre-/post-RCTO, articulation rate in syllables/second was determined for each task in each phase of the experiment for all participants. The magnitude of change from baseline to treatment (if one occurred) was determined based on the absolute effect size value. Descriptive data for articulation rate across each task examined for each participant in all phases of the experiment are displayed in graphs in the following section. Absolute effect size values representing the magnitude of change from baseline to treatment sessions are presented as well.

Results were also compared with normative data. Average articulation rate is known to increase with age. Data on articulation rate variability trends are less clear, however (Kent & Forner, 1980; Walker, Archibald, Cherniak, & Fish, 1992). On average, children 4-years of age produce about 3 – 4 syllables/per second within a range of 2.46 to 5.24 syllables/second, and 5-year old children produce about 4.2 – 5.2 syllables/second within a range of 3.01 to 5.42 syllables/second (Amster, 1984; Hall et al., 1999; Haselager, Slis, & Rietveld, 1991; Meyers & Freeman, 1985; Pindzola, Jenkins, & Lokken, 1989). Children as young as age 3 are able to produce speech within the adult range of 5-6 syllables/second more than half the time during conversational speech, while 5-year old children produce speech in the adult range about 85% of the time (Walker et al., 1992).

Articulation Rate Data for P1

Articulation rate data for P1 for all tasks examined are displayed in Figure 6. Data for the book task are displayed in the upper graph of Figure 6. Visual inspection of the graph reveals an increase in average articulation rate (M = 3.33 and 4.55 syllables/second, respectively) and variability (S.D. = .76 and .95 syllables/second, respectively) from baseline to treatment phases. Baseline articulation rate for this task was at the lower end of the normative average range, while mean articulation rate during the treatment phase was above-average for a child 4 years, 5 months of age. The increase in articulation rate from baseline to treatment was determined to have an absolute effect size of 1.60. Data could not be obtained during the extinction phase for this task due to P1's lack of compliance with this particular task.

Figure 6. Articulation rate data for P1.



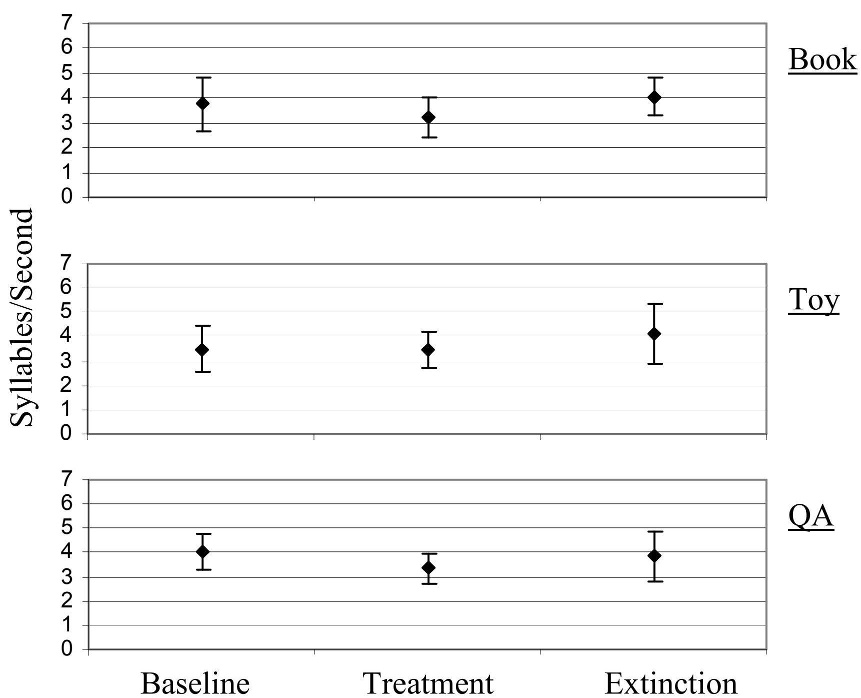
Data for articulation rate for the self-selected toy task are displayed in the lower graph of Figure 6. Only eight stutter-free utterances were available to calculate articulation rate for the treatment phase, and nine for the extinction phase. Visual inspection of the graph reveals an increase in average articulation rate (M = 4.43 and 5.20 syllables/second, respectively) and variability (S.D. = .98 and 1.37 syllables/second, respectively) from baseline to treatment phases. This increase was determined to have an absolute effect size of 1.11. A decrease in articulation rate (M = 4.32 syllables/second) and variability (S.D. = .38 syllables per second) to values less than those obtained during baseline was observed when RCTO was extinguished. Mean articulation rate values were in the above-average range during baseline and extinction phases, and were in the adult range during the treatment phase for this task.

Articulation Rate Data for P2

Articulation rate data for P2 for all tasks examined are displayed in Figure 7. Data for the book task are displayed in the upper graph of Figure 7. Visual inspection of the graph reveals a decrease in average articulation rate and variability from baseline to treatment phases (M = 3.76; S.D. = 1.08 and M = 3.20; S.D. = .81 syllables/second, respectively). Mean baseline articulation rate values were below average for a 5-year old child; however, P2 was 6:5. Normative data are not available for children this age; however, average articulation rate values are expected to be about 4.5 syllables/second for a child this age based on data for children in second grade (about 7 – 8 years of age) (Haselager et al., 1991). The decrease to an even slower rate during the treatment phase was determined to have an absolute effect size of .52. During the extinction phase, articulation rate increased to a value higher than that obtained during baseline (M = 4.05 syllables/second), closer to the normative average, with an even lower variability than that obtained during baseline or treatment phases (S.D. = .78 syllables/second).

Data for articulation rate for the self-selected toy task are displayed in the middle graph of Figure 7. Visual inspection of the graph reveals no change in average articulation rate (M = 3.50 and 3.49 syllables/second), but a slight decrease in variability from baseline to treatment phases (S.D. = .97 and .74 syllables/second, respectively). An increase in average articulation rate and variability for this task was observed for the extinction phase (M = 4.09; S.D. = 1.23 syllables/second). Mean articulation rate values were below average for this task during all phases of the experiment.

Figure 7. Articulation rate data for P2.



Data for articulation rate for the question-answer task are displayed in the lower graph of Figure 7. Visual inspection of the graph reveals a decrease in average articulation rate and variability from baseline to treatment phases (M = 4.03; S.D. = .72 and M = 3.36; S.D. = .63 syllables/second, respectively). The change in articulation rate from baseline to treatment phases was determined to have an absolute effect size of .93.

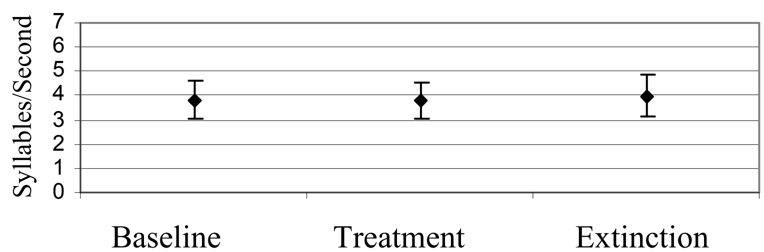
During the extinction phase, average articulation rate increased but did not reach baseline values (M = 3.84 syllables/second). Variability during this phase, however, increased to a value higher than that observed for either baseline or treatment phases

(S.D. = 1.00 syllables/second). Mean articulation rate values were again below average normative values for all phases of the experiment during this task.

Articulation Rate Data for P3

Data for articulation rate for the question-answer task are displayed in Figure 8. Because only one task was used for this participant, 30 phonetic phrases were used to calculate articulation rate in each phase (versus the usual 10 when multiple tasks were used).

Figure 8. Articulation rate data for P3.

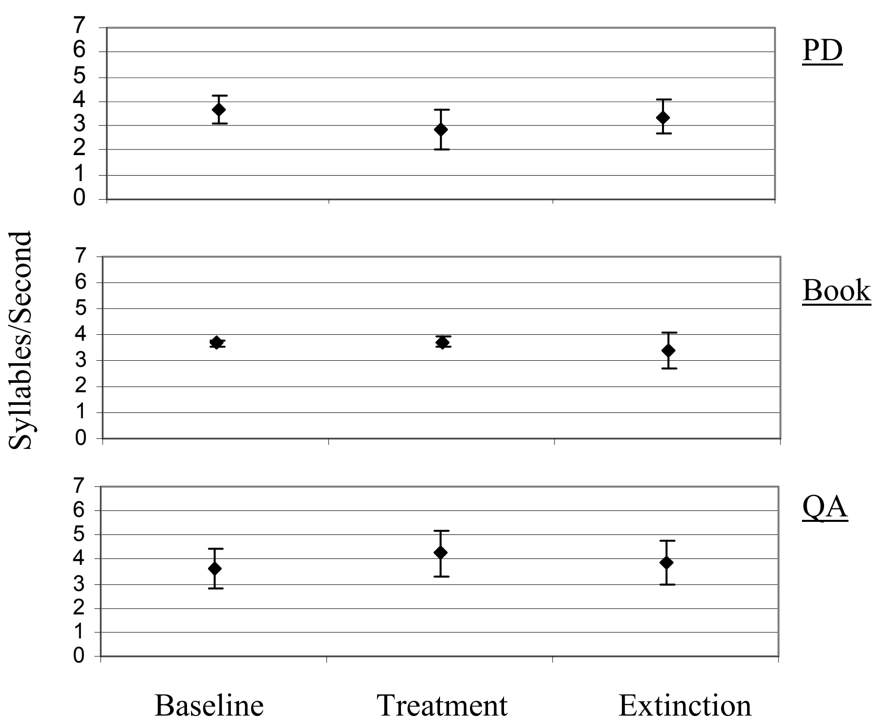


Visual inspection of the graph reveals no change in average articulation rate (M = 3.82 and 3.80 syllables, respectively) or variability (S.D. = .75 and .75 syllables/second, respectively) from baseline to treatment phases. A slight increase in average articulation rate and variability was observed during the extinction phase, however (M = 3.99 syllables/second; S.D. = .84 syllables/second). Mean articulation rate values were well below age expectations for a child 7:0 years of age, which on average, would be 4.51 syllables/second. P3's values still fell at the low end of the normative range (3.57 – 5.45 syllables/second), however (Haselager et al., 1991).

Articulation Rate Data for P4

Articulation rate data for P4 for all tasks examined are displayed in Figure 9. Data for the picture description task are displayed in the upper graph of Figure 9. Visual inspection of the graph reveals a decrease in average articulation rate (M = 3.69 and 2.84 syllables/second, respectively), but an increase in variability (S.D. = .57 and .80 syllables/second, respectively) from baseline to treatment phases. This decrease had an effect size of 1.50. During the extinction phase, average articulation rate increased to near-baseline values (M = 3.36 syllables/second); however, variability did not (S.D. = .70 syllables/second). P4's mean articulation rate values were below average for a child 5 years, 7 months of age; however, mean values fell at the lower end of the normative range (3.01 – 5.42 syllables/second) (Hall et al., 1999; Haselager et al., 1991) for this task during each phase of the experiment.

Figure 9. Articulation rate data for P4.



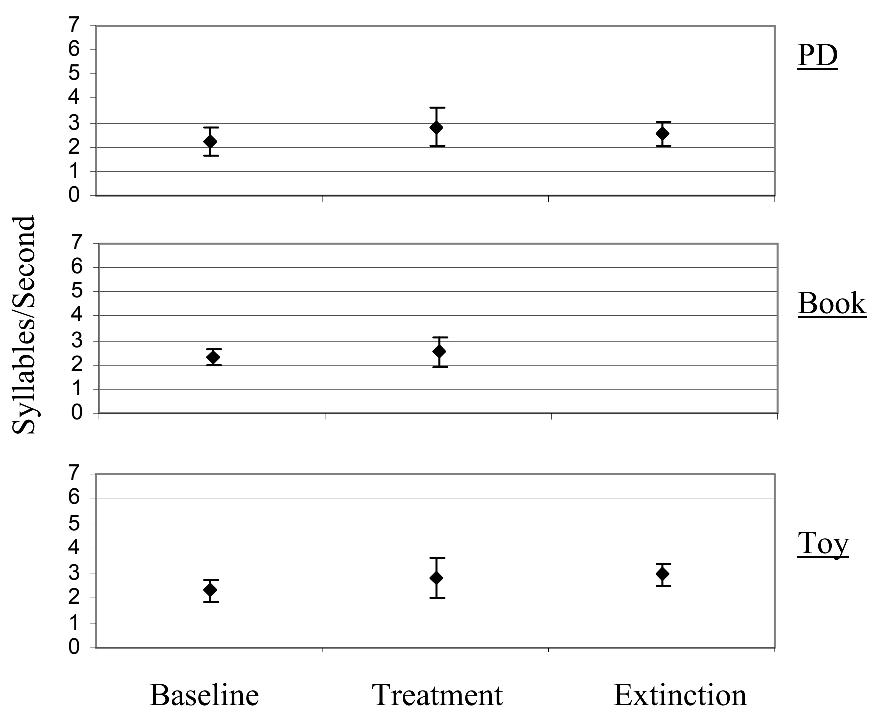
Data for articulation rate for the book task are displayed in the middle graph of Figure 9. Visual inspection of the graph reveals a slight increase in average articulation rate (M = 3.66 and 3.73 syllables/second, respectively) and variability (S.D. = .15 and .16 syllables/second, respectively) from baseline to treatment. This increase was found to have an absolute effect size of .48. During the extinction phase, average articulation rate decreased slightly lower than baseline levels (M = 3.42 syllables/second), but variability increased to a value higher than that obtained during baseline and treatment phases (S.D. = .69 syllables/second). Again, these mean values were below average but still within the normative range.

Data for articulation rate for the question-answer task are displayed in the lower graph of Figure 11. Visual inspection of the graph reveals an increase in average articulation rate (M = 3.62 and 4.26 syllables/second, respectively) and variability (S.D. = .83 and .94 syllables/second, respectively) from baseline to treatment. This increase was more on par with mean age expectations (Walker et al., 1992), and was found to have an absolute effect size of .77. During the extinction phase, average articulation rate and variability showed a decreasing trend toward baseline levels (M = 3.88; S.D. = .92 syllables/second).

Articulation Rate Data for P5

Articulation rate data for P5 for all tasks examined are displayed in Figure 10. Data for articulation rate for the picture description task are displayed in the upper graph of Figure 10. Visual inspection of the graph reveals an increase in average articulation rate (M = 2.25 and 2.83 syllables/second, respectively) and variability (S.D. = .58 and .81 syllables/second, respectively) from baseline to treatment phases. This increase was found to have an absolute effect size of 1.01. Only five phonetic phrases were available for analysis during the extinction phase. Average articulation rate decreased during the extinction phase, but did not return to baseline values (M = 2.57 syllables/second). Variability, however, decreased values lower than that obtained at baseline (S.D. = .47 syllables/second) during this phase. Mean articulation rate values were well below average (3 – 4 syllables/second) for a child who is 4 years, 7 months of age, but still within the normative range, although at the very low end of the normative range (Haselager et al., 1991; Pindzola et al., 1989).

Figure 10. Articulation rate data for P5.



Data for articulation rate for the book task are displayed in the middle graph of Figure 10. Visual inspection of the graph reveals an increase in average articulation rate (M = 2.30 and 2.53 syllables/second, respectively) and variability (S.D. = .32 and .60 syllables/second from baseline to treatment. This increase was found to have an absolute effect size of 0.71. Only five utterances were available to determine articulation rate for baseline data; therefore, these results should be interpreted with caution. No data were available for this task during the extinction phase due to P5's lack of compliance with this particular task. Again, mean articulation rate values were well below age expectation for this task.

Data for articulation rate for the self-selected toy task are displayed in the lower graph of Figure 10. Visual inspection of the graph reveals an increase in average articulation rate (M = 2.30 and 2.81 syllables/second, respectively) and variability (S.D. = .44 and .82 syllables/second, respectively). This increase was found to have an absolute effect size of 1.17. During the extinction phase, average articulation rate increased further (M = 2.94 syllables/second), while variability returned to near-baseline values (S.D. = .44). Mean articulation rate values were well below age expectation for this task as well.

Changes in Utterance Length

To determine if a change in utterance length occurred pre-/post-RCTO, mean length of utterance (MLU) was determined for each task examined in each phase of the experiment for all participants. The magnitude of change from baseline to treatment (if one occurred) was determined based on the absolute effect size value. Descriptive data for MLU across each task for each participant in all phases of the experiment are displayed in graphs in the following section. Absolute effect size values representing the magnitude of change from baseline to treatment sessions are presented as well.

MLU is highly correlated with chronological age in children 3 to 13 years of age, and is considered a valid and stable developmental measure of linguistic maturity (Miller, 1981; Miller et al., 2005; Owens, 1992). Therefore, results were compared to age-referenced normative data (Miller et al., 2005) in the following section as well.

MLU Data for P1

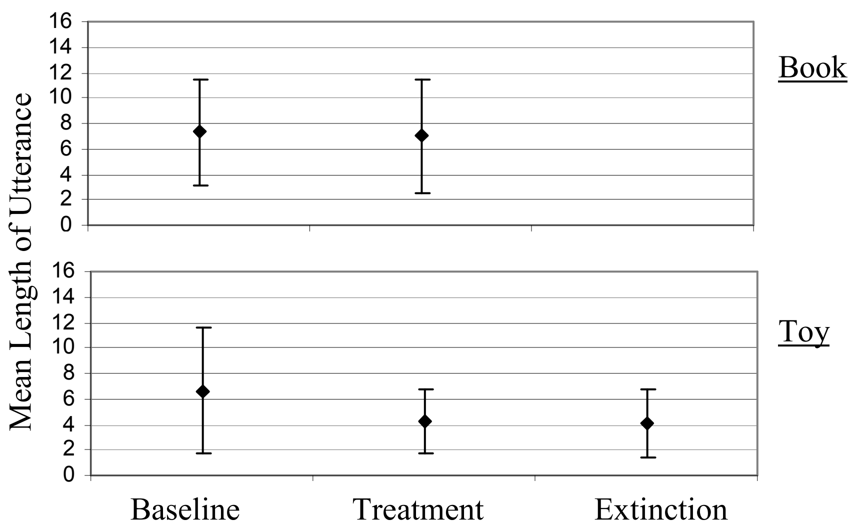
MLU data for P1 for all tasks examined are displayed in Figure 11. Data for MLU for the book task are displayed in the upper graph of Figure 11. Forty-five utterances were used to calculate MLU for baseline and treatment phases. Visual inspection of the graph reveals a slight decrease in average MLU (M = 7.31 and 7.02, respectively) and variability (S.D. = 4.19 and 4.47, respectively) from baseline to treatment phases. This decrease in MLU was found to have an absolute effect size of .07. As mentioned previously, data could not be obtained for this task during the extinction phase.

Average MLU and standard deviation for a child 4 years of age is 4.32 and 1.35, respectively (Miller et al., 2005). Mean MLU and standard deviation values obtained during baseline and treatment sessions greatly exceeded developmental norms for this task.

Data for MLU for the self-selected toy task are displayed in the lower graph of Figure 11. Thirty-five utterances were used to calculate MLU for each phase. Visual inspection of the graph reveals a decrease in average MLU (M = 6.66 and 4.29, respectively) and variability (S.D. = 4.92 and 2.53, respectively) from baseline to treatment phases. This decrease in MLU to more age-appropriate values was found to have an absolute effect size of .48. Variability still exceeded normative data, however.

A decrease in average MLU occurred during the extinction phase (M = 4.09), with a slight increase in variability (S.D. = 2.62). As mentioned previously, a different toy was used during this phase which may have contributed to the decrease.

Figure 11. Mean Length of Utterance (MLU) data for P1.



MLU Data for P2

MLU data for P2 for each task examined are displayed in Figure 12. Data for the book task are displayed in the upper graph of Figure 12. Only twenty utterances were available to calculate MLU for baseline and treatment phases, while only 12 utterances in the extinction phase. Visual inspection of the graph reveals a decrease in average MLU (M = 7.20 and 6.65, respectively) and variability (S.D. = 6.96 and 5.60, respectively) from baseline to treatment. The change in average MLU had an absolute effect size of .08. Average MLU and variability showed an even greater decrease for this task during the extinction phase (M = 5.50; S.D. = 4.12). These values should be interpreted with caution given the limited number of utterances used to calculate MLU for this task.

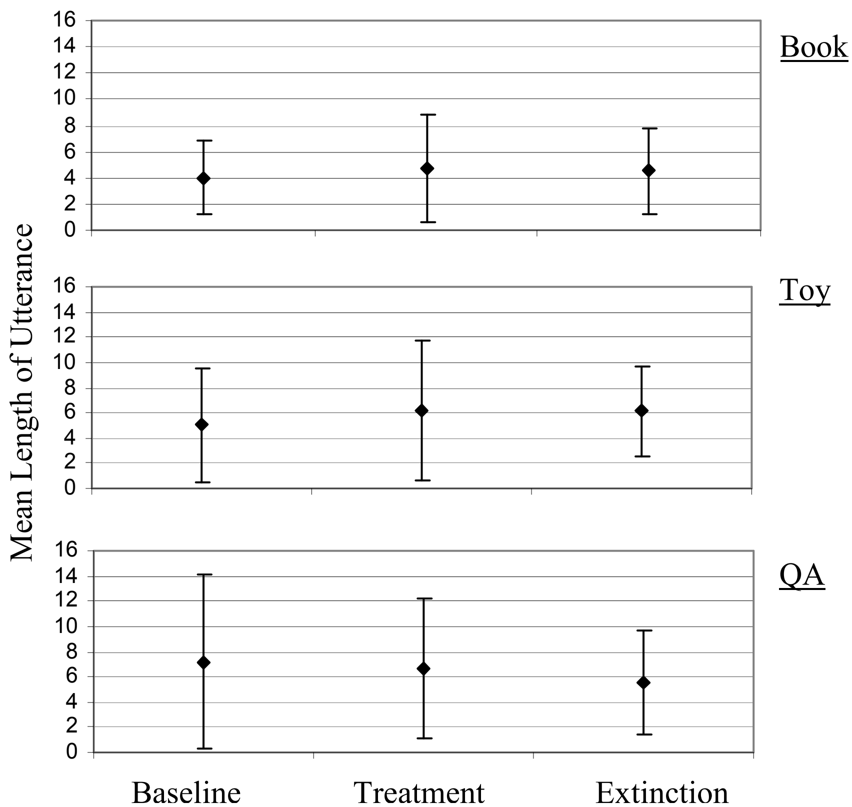
Average MLU and standard deviation for a 6-year old child is 5.53 and 1.31, respectively. Mean MLU and standard deviation values during baseline and treatment phases greatly exceeded developmental norms, while average MLU during the extinction phase was age-appropriate. Variability still exceeded normative data during this phase, however.

Data for MLU for the self-selected toy task are displayed in the middle graph of Figure 12. Fifty utterances were used to calculate MLU for this task in each experimental phase. Visual inspection of the graph reveals an increase in average MLU (M = 4.00 and 4.70, respectively) and variability (S.D. = 2.81 and 4.06, respectively) from baseline to treatment phases. This change had an effect size of .25. Average MLU and variability decreased during the extinction phase but did not return to baseline values (M = 4.52; S.D. = 3.25 syllables/second). Mean MLU and standard deviation values were below age expectations during all phases for this task; however, variability exceeded normative data.

Data for MLU for the question-answer task are displayed in the lower graph of Figure 12. Forty utterances were used to calculate MLU for the baseline and treatment phases, while only 28 utterances were available in the extinction phase. Visual inspection of the graph reveals an increase in average MLU (M = 5.03 and 6.18, respectively) and variability (S.D. = 4.50 and 5.57, respectively) from baseline to treatment. This change had an effect size of 0.26. During the extinction phase, average

MLU only slightly decreased (M = 6.11), but MLU variability decreased lower than baseline values (S.D. = 3.62). Because only 28 utterances were available for the MLU calculation during the extinction phase, these values should be interpreted with caution.

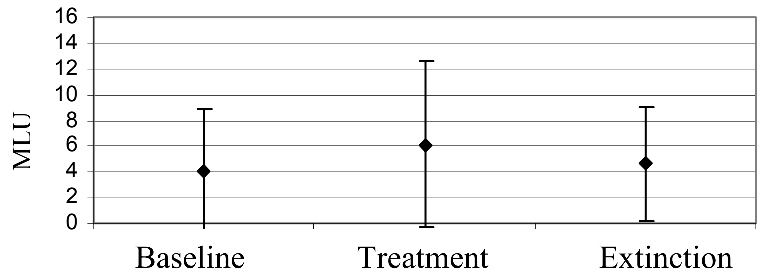
Figure 12. Mean Length of Utterance (MLU) data for P2.



MLU Data for P3

MLU for P3 for the question-answer task are displayed in Figure 13. One-hundred utterances were used to calculate MLU in each phase. Visual inspection of the graph reveals an increase in average MLU and variability from baseline to treatment phases (M = 4.03; S.D. = 4.90 and M= 6.09; S.D. = 6.42, respectively). This change had an effect size of 0.42. During the extinction phase, average MLU and variability decreased to values similar to those obtained during baseline (M = 4.61; S.D. = 4.42).

Figure 13. Mean Length of Utterance (MLU) data for P3.



Mean MLU and standard deviation for a 7-year old child is 6.30 and 1.36, respectively. Baseline and extinction average MLU were well below age expectation; however, MLU obtained during the treatment phase was more on par with age-appropriate values. Variability exceeded normative data for all phases of the experiment.

MLU Data for P4

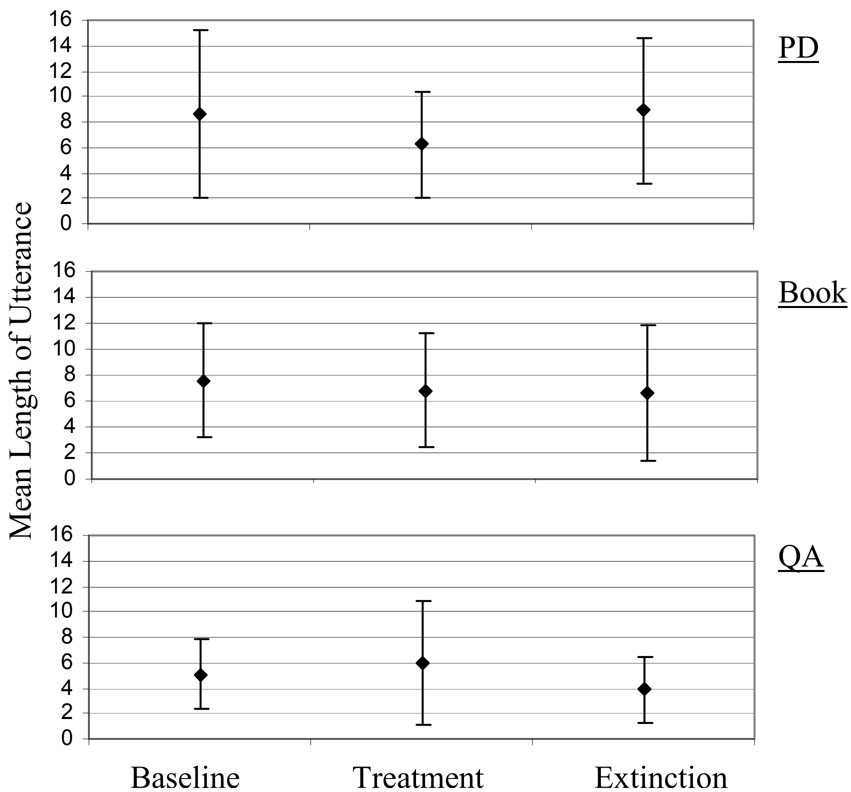
MLU data for P4 for all tasks examined are displayed in Figure 14. Data for MLU for the picture description task are displayed in the upper graph of Figure 14. Only ten utterances were available to calculate MLU for all experimental phases; therefore, these results should be interpreted with caution. Visual inspection of the graph reveals a reduction in average MLU (M = 8.60 and 6.20, respectively) and variability (S.D. = 6.55 and 4.19, respectively) from baseline to treatment phases. This reduction had an absolute effect size of .37. During the extinction phase, average MLU exceeded baseline values (M = 8.90) while variability approached baseline values (S.D. = 5.71). Mean MLU and standard deviation for a child 5 years, 7 months of age is 5.53 and 1.31, respectively (Miller et al., 2005). Mean and standard deviation MLU values obtained during all phases of the experiment for this task greatly exceeded age expectations.

Data for MLU for the book task are displayed in the middle graph of Figure 14. Forty-three utterances were available to calculate MLU for baseline and treatment phases, while only 13 utterances were available from the extinction phase. Visual inspection of the graph reveals a reduction in average MLU (M = 7.56 and 6.81, respectively) with variability largely unchanged (S.D. = 4.37 and 4.39, respectively) from baseline to treatment phases. This reduction had an absolute effect size of 0.17. During the extinction phase, average MLU continued to decrease (M = 6.62) while variability increased to a value higher than that obtained during baseline and treatment phases (S.D. = 5.28). This was likely due to the limited number of utterances available in the analysis. Mean and standard deviation MLU values obtained during all phases of the experiment greatly exceeded age expectations for this task as well.

Data for MLU for the question-answer task are displayed in the lower graph of Figure 14. Twenty-two utterances were available to calculate MLU for all experimental phases. Visual inspection of the graph reveals an increase in average MLU (M = 5.05 and 6.00, respectively) and variability (S.D. = 2.75 and 4.86, respectively) from baseline to treatment phases. This increase had an absolute effect size of 0.35. Baseline mean and standard deviation values were more on par with normative data, though variability was still high relative to age-referenced norms.

During the extinction phase, average MLU and variability decreased to values less than those obtained during baseline (M = 3.86; S.D. = 2.57). In fact, average MLU obtained in the extinction phase for this task was well-below developmental norms considering this participant's age, while variability remained above age appropriate values.

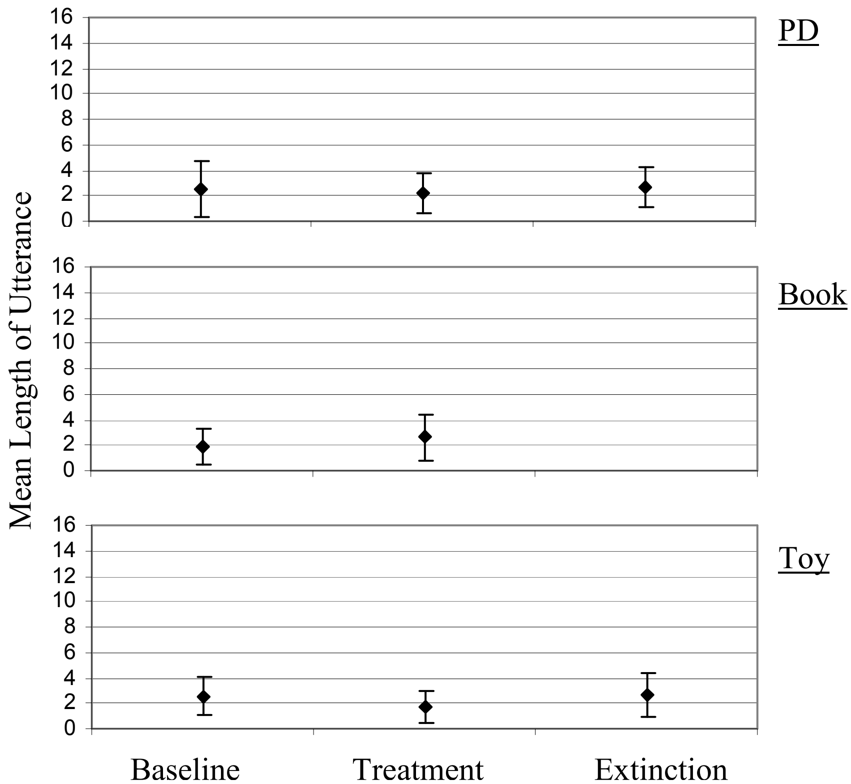
Figure 14. Mean Length of Utterance (MLU) data for P4.



MLU Data for P5

MLU data for all tasks examined are displayed in Figure 15. Data for MLU for the picture description task are displayed in the upper graph of the figure. Twenty-three utterances were available to calculate MLU for baseline and treatment phases, and only 18 utterances were available during the extinction phase for this task. Visual inspection of the graph reveals a decrease in MLU (M = 2.48 and 2.26, respectively) and variability (S.D. = 2.17 and 1.57, respectively, from baseline to treatment. This decrease was found to have an absolute effect size of 0.10. During the extinction phase, MLU surpassed baseline levels (M = 2.67) while variability remained virtually unchanged (S.D. = 1.53).

Figure 15. Mean Length of Utterance (MLU) data for P5.



Data for MLU for the book task are displayed in the middle graph of Figure 15. Only 27 utterances were available to calculate MLU for baseline and treatment phases. No data were available during the extinction phase. Visual inspection of the graph reveals an increase in average MLU (M = 1.85 and 2.59, respectively) and variability (S.D. = 1.38 and 1.82, respectively). This increase was found to have an absolute effect size of .54.

Data for MLU for the self-selected toy task are displayed in the lower graph of Figure 15. Fifty utterances were used to calculate MLU for baseline and treatment phases, while 39 utterances were available during the extinction phase. Visual inspection of the graph reveals a decrease in average MLU (M = 2.58 and 1.74, respectively) and variability (S.D. = 1.55 and 1.26, respectively) from baseline to treatment. This decrease was found to have an absolute effect size of .54. During the extinction phase, average MLU and variability surpassed baseline levels (M = 2.72; S.D. = 1.73).

Average MLU and standard deviation values for a child 4 years, 7 months of age is between 4.32 – 5.57 and 1.03 – 1.35, respectively (Miller et al., 2005). Mean MLU values obtained for each task examined during all phases of the experiment for P5 were well below age expectations. MLU variability exceeded age-appropriate normative data in all cases, however.

Participant Awareness and Changes in Emotional State

Data for P1

In response to the questions, “Can you tell me about the experiment” and “What did you think about it?” P1 stated only that it was about “coloring and play-doh” and didn’t know what it was about. In response to “Do you know why I took a break sometimes?” P1 stated “because I was tired.” In response to “what did you think about the breaks?” P1 stated that he felt “good” and pointed to the happy face which indicated that he was okay with the breaks. When the interview was repeated, P1 again stated that RA1 took breaks because he/RA1 (or both) was tired. When prompted the second time to answer the question about how he felt about the breaks, he pointed to the face which indicated the emotion of “a little bit upset.” It is likely that P1 didn’t understand the question at this point because he went on to explain that he was upset because he didn't get to play a particular game/toy during the investigation.

Data for P2

In response to the question, "Can you tell me about the experiment"? P2 responded with "It's about drawing, coloring and teaching people." In response to "What did you think about it?" she stated "I think that it is trying to interview me". In response to "do you know why I took a break sometimes?" P2 stated that she didn't know. She also stated that she felt "sleepy" when RA1 took a break sometimes and pointed to the happy face. She stated "We took too many hours" when again asked why RA1 took breaks sometimes, and again pointed to the happy face and said she felt good about RA1 taking a break sometimes.

Data for P3

In response to the questions, "Can you tell me about the experiment" and "What did you think about it?" P3 stated that it was about art and having fun and that it was "great". In response to "Do you know why I took a break sometimes?" P3 said "no". In response to "What did you think about the breaks?" P3 stated "I was just happy" and pointed to the happy face. When the interview was repeated, P3 again stated that he didn't know and forgot why RA2 took a break sometimes, and again stated that he felt "happy" about the breaks while pointing to the happy face.

Data for P4

In response to the questions, "Can you tell me about the experiment" P4 stated "when we do the cake I'm so happy." In response to "What did you think about it?" P4 began to describe the steps involved in making a cake. In response to “Do you know why I took a break sometimes?” P4 said “no”. In response to “What did you think about the breaks?” P4 stated that she was happy and pointed to the happy face. When the interview was repeated, P4 stated that she “came here to have some fun” in response to “What was the experiment about.” She also shook her head no in response to “Do you know why I took a break sometimes?” P4 again stated that she was happy about the breaks while pointing to the happy face.

Data for P5

In response to the questions, “Can you tell me about the experiment” P5 stated “We had snack and played book and ate.” In response to “What did you think about it?” P5 stated “I don’t know.” In response to “Do you know why I took a break sometimes?” P5 said “I don’t’ know.” In response to “What did you think about the breaks?” P5 stated he was “sad” while pointing to the face depicting “a little bit upset.” When the interview was repeated, P5 stated “we played books and those and these.” In response to “What was the experiment about” he again stated “I don’t know.” In response to “Do you know why I took a break sometimes?” P5 again stated that he didn’t know and that he was “sad” when RA1 took breaks. However, he went on to say that he was sad because he fell down. His mother reported that earlier that day, P5 fell down and cut his leg. It is difficult to interpret his response to this question.

Summary of Results

A qualitative summary of results for stuttering frequency, articulation rate, and MLU across all linguistic tasks for each participant is provided in Table 9. Reduction in stuttering frequency from baseline to treatment was either minimal (Min.), moderate (Mod.), or substantial (Sub.). These were operationally defined as follows: minimal change was less than 25% reduction, a moderate change was a 25-50% reduction, and a substantial change was a greater than 50% reduction in stuttering frequency. Table 9 also indicates the increase or decrease associated with articulation rate and MLU across all linguistic tasks for each participant depicted with an arrow in the appropriate direction. Effect size values are provided as well.

Reductions in stuttering frequency and changes (if any) in articulation rate and MLU differed depending on the linguistic task within and across subjects. No clear group trends in stuttering frequency reduction, or changes in articulation rate or MLU could be identified pre-/post-RCTO. However, some emerging trends were apparent across participants, depending on the task. For instance, for P1 and P5, a moderate reduction in stuttering frequency for the toy task was associated with an increase in articulation rate and a decrease in MLU. For P2, P3, and P4, a moderate or substantial reduction in stuttering frequency for the question-answer task was associated with an increase in MLU. Differential effects for articulation rate were observed, however.

In some cases, a change in articulation rate and MLU were not necessarily associated with a change in stuttering frequency. Furthermore, the non-systematic and highly variable findings for articulation rate and MLU suggest that these factors are not likely to be responsible for the positive effects of RCTO on stuttering frequency. In addition, the lack of explicit awareness about the procedure for all participants based on responses to the post-treatment questionnaire, as well as the lack of any clear change in emotional state suggests that other factors are at work that must be contributing to the success of RCTO. Each factor examined in the current investigation, as well as speculations about how RCTO works to reduce stuttering frequency, are discussed in the following section.

Table 9. Descriptive Summary of Results for P1-P5.

	Stuttering Frequency Reduction				*Articulation Rate/E.S.*				*MLU/E.S.*			
	PD	**Book**	**Toy**	**QA**	**PD**	**Book**	**Toy**	**QA**	**PD**	**Book**	**Toy**	**QA**
P1	---	None	Mod.	---	---	↑ 1.60	↑ 1.11	---	---	↓ 0 .07	↓ 0.48	---
P2	---	Sub.	Mod.	Sub.	---	↓ 0.52	No Δ	↓ 0.93	---	↓ 0.08	↑ 0.25	↑ 0.26
P3	---	---	---	Mod.	---	---	---	No Δ	---	---	---	↑ 0.42
P4	None	Mod.	---	Sub.	↑ 1.50	↑ 0.48	---	↑ 0.77	↓ 0.37	↓ 0.17	---	↑ 0.35
P5	Mod.	Min.	Mod.	---	↑ 1.01	↑ 0.71	↑ 1.17	---	↓ 0.10	↑ 0.54	↓ 0.54	---

DISCUSSION

Effectiveness of RCTO

The first purpose of this investigation was to determine if RCTO was an effective way to reduce stuttering frequency in young children. Results revealed that RCTO was in fact effective in reducing stuttering frequency in all participants; however, the magnitude of reduction was highly variable depending on the linguistic demand of the task, the child's compliance, and the severity of his or her stuttering. In the majority of cases, stuttering reduced to near-zero levels during tasks involving less linguistic demand (self-selected toys). Utterances produced during toy interactions for baseline and treatment sessions were often shorter in length. As a result, stuttering frequency was already lower at baseline during these interactions (Zackheim & Conture, 2003). In contrast, book tasks and question-answer interactions elicited more narrative language grammatical structures during baseline and treatment sessions, which were longer in length and often more complex (e.g., "she closed the door because the dog was by herself and the kitty was by herself" versus "This one's Spiderman"). As a result, stuttering frequency was higher for these tasks during baseline sessions, and did not reduce to near-zero levels during the treatment phase.

It is reasonable to suggest then that the nature of the task likely contributed to differences in stuttering frequency reductions during RCTO administration. Shorter, less complex utterances are semantically and pragmatically appropriate during toy interactions, particularly when verbally prompted with "what are you making?" A simple, one- or two-word response would suffice (e.g., "a cake"). Stuttering would be less likely to occur in this instance. On the other hand, the verbal prompt, “tell me everything that might be happening in this picture” would require longer, more complex language structures to respond appropriately. The likelihood of instances of stuttering occurring is much greater during this type of task. Future studies are needed to further examine the influence of linguistic task on the effects of RCTO and stuttering frequency.

The child’s compliance in pausing from speaking when instructed to take a break was critical for RCTO to effectively reduce stuttering frequency. Two participants (P1 and P5) were not consistently compliant during the administration of RCTO and refused to stop talking when instructed to take a break. As a result, reductions in stuttering frequency were not as great (P5), or were more highly variable (P1). These participants were also the youngest (4 years of age) which suggests that this treatment approach may not be suitable for very young children who stutter. The children who were compliant (those who stopped talking almost immediately when instructed to take a break) had the greatest success with this procedure.

The child’s compliance raises the question of the importance of contiguity. In the present investigation, compliance indicated how quickly the child responded to the stimulus (stopped talking), and not whether the RCTO stimulus was contingent on stuttering. Recall that James (1981a) defined “contingent” as delivery of the response stimulus within 1 second of the behavior. In the present study, RCTO was never delivered within 1 second by the RA because of the 2-way radio system used to signal the RA to take a break had a delay in the system (usually 1-2 seconds, and in some instances, up to 4 seconds). This delay may have rendered the treatment less effective than it might have been otherwise. Nevertheless, the present results demonstrate that contingency as defined by James (1981a) was not absolutely necessary to evoke a positive effect following administration of RCTO. This issue of contingency and stuttering, therefore, requires further investigation.

Severity of stuttering also dictated the effectiveness of RCTO in reducing stuttering frequency. Previous research on RCTO has indicated that this treatment is not appropriate for severe forms of stuttering (e.g., hesitations, blocks) (James, 1981). Based on P5's results, RCTO appears also to not be suitable for individuals with a very high frequency of stuttering. Although P5's stuttering did not demonstrate what typically characterizes severe forms of stuttering (e.g., he did not demonstrate hesitations or blocks), his stuttering frequency was so high that administration of RCTO on every instance of stuttering would have resulted in P5 remaining in time-out for the majority of the treatment phase. His high stuttering frequency may therefore have contributed to his non-compliance with the procedure, and its lack of effectiveness.

Articulation rate and RCTO

Measurement of articulation rate addressed one aspect of the second purpose of this investigation, which was to determine if a change in speech timing could be detected following the RCTO procedure. Articulation rate was measured pre-/post-RCTO because changes in speech timing have been speculated to underlie the positive effects of RCTO. The present articulation rate data after RCTO administration are the first to be reported for children younger than 10 years of age.

On the one hand, one might expect that with young children who stutter, articulation rate might increase with a treatment-induced reduction in stuttering frequency. This might occur because core characteristics of stuttering such as syllable prolongations and repetitions decrease. Reduction or elimination of these stuttering features would presumably result in increasing overall speaking rate (including pauses) and articulation rate (excluding pauses) (Flipsen, 2003). However, this would not have influenced the results of this investigation because only stutter-free utterances were included in the analysis.

On the other hand, numerous studies have shown that at least for adults, articulation rate decreases following fluency-inducing conditions, for which RCTO is one example (e.g., Andrews et al., 1982; Brayton & Conture, 1978). In fluency-inducing conditions (e.g., delayed auditory feedback), articulation rate slows because of an increase in segment durations (Andrews et al., 1982; Perkins, Bell, Johnson, & Stocks, 1979). The exact nature of why reductions in articulation rate decrease stuttering frequency is unknown. As discussed previously, use of a slow speech rate might accommodate an over-reliance on feedback motor control mechanisms believed to be used by individuals who stutter (Max et al., 2004). Also, use of a slower speech rate might allow more time for linguistic and phonological processing prior to motor speech execution (Karniol, 1995; Perkins, Kent, & Curlee, 1991). Young children who stutter have been shown to already use a slower speech rate when compared to fluent age-matched peers (Hall et al., 1999). This was the case for participants in the present investigation as well, although results were task dependent in some cases.

Findings for the present investigation revealed both an increase and decrease in articulation rate (except for P3 who exhibited no change in rate) following RCTO. In some cases, the direction of change in articulation rate from baseline to treatment for a particular linguistic task appeared to depend on the nature of the child's utterance after the break (time-out). For example, when the child repeated the utterance that was initially produced with an instance of stuttering after the time-out, an increase in articulation rate relative to baseline values was observed. This occurred for P1 for both tasks examined, and P5 for the picture description task, where the majority of utterances produced after the break were repetitions of utterances that were previously stuttered. In other instances, when the child continued with his or her topic of discussion, that is, produced a new utterance after the time-out, articulation rate either remained unchanged or decreased relative to baseline values.

The increase in articulation rate following repetition of previously stuttered utterances can be explained by the stuttering adaptation effect. Stuttering adaptation refers to the reduction and elimination of stuttering instances that occurs with consecutive oral readings (or productions) of the same material (Prins & Hubbard, 1990). The reduction in stuttering that occurs with repeated productions of the same utterance is thought to reflect a “practice effect.” It has been speculated that increases in speech rate accompany this practice effect (Wingate, 1986a). Further exploration of this trend in a more systematic fashion is necessary to support this speculation.

Mean Length of Utterance and RCTO

Calculation of mean length of utterance (MLU) addressed the next aspect of the second study purpose, which was to determine if a change in utterance length could be detected following the RCTO procedure. MLU was measured in the present investigation because of the relationship between utterance length and stuttering frequency. Longer utterances are believed to stress the language system by exceeding the child's grammatical encoding abilities, thereby increasing the likelihood of stuttering (Gaines, Runyan, & Meyers, 1991; Weiss & Zebrowski, 1992). It can be argued then that reductions in stuttering frequency following RCTO might have resulted from reductions in MLU. This was not always the case, however. In some cases, MLU increased and in some cases it decreased.

In those cases where MLU increased during RCTO, a pausing/phrasing strategy was sometimes used to manipulate utterance length. That is, frequent pauses were interjected without consideration for utterance boundaries. This was the case for P2 and P3. It is unlikely that this strategy was used consciously; however, in the case of P3 who had received stuttering therapy, it is uncertain if such a strategy was formally taught during treatment given that utterance length manipulation is an integral component of several treatment programs for young children who stutter (Costello, 1983; Riley & Riley, 1984; Ryan, 1979). P3 exhibited this strategy during baseline sessions, which suggests that he likely uses pausing/phrasing to compensate for his stuttering; however, during treatment sessions, this strategy was used to a much greater extent.

Another possible reason for the increase in MLU that accompanied a moderate or substantial reduction in stuttering frequency may have simply been a familiarity effect with each of the tasks. Given that each task was repeated during each phase of the experiment with the same verbal prompts, the exception being that a different picture, book, toy, or set of questions was used, suggests that the child may have just become with familiar with the task requirements. In the case of P4, this was likely the case because some of the questions during the question-answer interaction task were repeated several times (e.g., tell me again how you made the cake).

In cases where MLU decreased from baseline to treatment, results were similar to those of Bonelli et al. (2000) who investigated utterance length and complexity in young children following direct treatment for stuttering with the Lidcombe Program. Like Bonelli et al. (2000), MLU values in the present investigation at baseline for several participants exceeded mean age expectations. The reduction in stuttering frequency from RCTO resulted in MLU decreasing to more age-appropriate values, suggesting that the child’s use of language was now more appropriately matched to his or her capacity for language (Bonelli et al., 2000). Related to this is the fact that individuals who stutter tend to use simple linguistic structures more often than fluent speakers as a compensatory strategy to avoid stuttering (Muma, 1971). Reductions in MLU from baseline to treatment for several participants in the present investigation may have served the same compensatory purpose.

Another area of language that was not formally examined in the present investigation, which appeared to change following RCTO was pragmatic language functioning. For instance, P2 frequently responded with “I don’t know” or “I forgot” following administration of RCTO. This often served to change the topic of discussion or move on to another activity altogether. Such remarks were not used during baseline data collection. This was the case for P5 as well. During the treatment phase, particularly immediately after a “break”, P5 would respond with “I don’t know” or “I can’t.” These responses were produced 23 times during the treatment phase compared to 1 time during baseline. Future research is needed to formally examine potential pragmatic strategies used to reduce or avoid stuttering following RCTO, and their effects on language length and complexity.

Participant Awareness and Emotional State

The third and final aspects of the second study purpose addressed whether or not a change in participant awareness and emotional state could be detected following the RCTO procedure. Participant awareness and changes in emotional state were examined because evidence suggests that these factors may contribute to the success of RCTO in reducing and eliminating stuttering. Based on responses to the post-treatment questionnaire, it did not appear that participants were explicitly aware of the nature of the investigation, and could not state why the interacting RA took breaks sometimes. Therefore, it appears then that explicit awareness was not critical to the success of RCTO. It is uncertain how the child’s awareness of his or her stuttering prior to the investigation might have contributed to reductions in stuttering frequency following RCTO, however. This was especially true for P2. Although P2 did not state directly that she was aware of what the experiment was about, her mother reported that during a bathroom break, P2 stated “my stuttering is getting better.” This indicated that she may have had some implicit awareness that RCTO was administered to treat her stuttering, which may have contributed to success of the procedure. To this end, all of the participants may have had an implicit awareness of the procedure, but the post-treatment questionnaire may have been too abstract for young children to grasp, or else the questionnaire was given too long after RCTO was no longer provided. Future studies will require more sensitive ways to address the issue of participant awareness, particularly for young children.

Four of the participants (P1, P2, P3, and P4) did not have any negative reactions or attitudes about their speech or stuttering prior to the investigation based on parental report prior to the investigation. It is uncertain at this time if P5 was demonstrating social anxiety about stuttering. Responses to the questionnaire revealed that RCTO did not produce any negative reactions in the participants. Results were difficult to interpret, however, for the two youngest participants (P1 and P5) because it is uncertain if they understood the question. Based on their poor compliance during the treatment phase, it seems reasonable to conclude that they may have been at the least irritated by the procedure. However, both participants appeared to enjoy playing with RA1 and were hoping to return to the laboratory at a later time. Their irritation with the procedure may have contributed to the variable and limited effectiveness of RCTO with these participants. That fact that P2 and P5 exhibited linguistic avoidance behaviors not demonstrated during baseline sessions, also suggests a possible change in emotional state pre-/post-RCTO. The exact nature of this change is uncertain. Again, the post-treatment questionnaire was too abstract a concept, especially for the youngest participants, and was given too long after RCTO had been extinguished. More sensitive procedures are required to address the factor of emotional state.

Theoretical Considerations Underlying Changes in Stuttering

Some of the emerging trends observed pre-/post-RCTO in the stutter-free speech of participants in the present investigation support several current theories on stuttering. First, the decrease in MLU and subsequent decrease in stuttering frequency during RCTO administration in several participants provides support for psycholinguistic theories of stuttering. Psycholinguistic models speculate that a mismatch between the child's linguistic maturity (limited capacity) and the linguistic demands of the task exists, which results in stuttering (Bonelli et al., 2000; Postma & Kolk, 1993; Zackheim & Conture, 2003).

Several participants in the current investigation had mean MLU values that greatly exceeded mean age expectations, possibly taxing their language system. Further support for this speculation is the fact that two of these participants were also bilingual, and possessed some degree of knowledge of a second language that they were learning simultaneously along with their primary language, English (Siguan & Mackay, 1987). Stuttering is more prevalent among bilingual speakers, particularly "early" bilinguals or those who acquire their second language between 0 and 6 years of age. Therefore, it is suggested that stuttering occurs because of a syntactic overload (Karniol, 1992) resulting from the same brain structures being utilized for the simultaneously learning of both languages (Van Borsel et al., 2001).

Language proficiency is also speculated to be an important factor, in that an individual who is bilingual is more apt to stutter in the language that he/she is less proficient or less familiar with (Scott Trautman & Keller, 2000). Given that these two participants demonstrated instances of code switching, an indicator of linguistic proficiency, language proficiency may have been problematic in these cases. Production of utterances with an MLU that far exceeded age expectations may have overloaded the language operating system of these two participants. This possibly contributed to stuttering in their cases. On several occasions, longer utterances were syntactically incorrect, which again suggests expressive language difficulties in these participants. Further research on the linguistic abilities of young children learning two languages simultaneously, and present with stuttering, is needed.

Several participants increased articulation rate during RCTO administration, particularly after repetition of the same utterance previously produced with a stuttering behavior. This is of interest because it follows the motor learning hypothesis of stuttering adaptation (Max & Caruso, 1998). This hypothesis purports that reduction of stuttering frequency during repeated production of the same material is attributed to repeated practice of the same articulatory movement sequences (Max, Caruso, & Vandevenne, 1997). Motor learning is believed to occur because of the increase in speed of articulatory movements associated with the reduction in stuttering.

This hypothesis (Max & Caruso, 1998) carries with it the assumption that stuttering is a deficit in speech motor learning. Max (2004) speculated that individuals who stutter may have an impaired ability to effectively acquire and update internal models of speech production in the presence of on-going rapid developmental changes (e.g., neural, physiological) during early childhood. An internal model is "a representation in the central nervous system of the normal properties of lower-level reflex, muscular, biomechanical and acoustic components of the speech production mechanism" (Perkell et al., 1997, p. 231). According to motor control theory, internal models work by mimicking or representing the normal input and output characteristics of the motor system in response to motor commands (Miall & Wolpert, 1996) from efference copies of those issued motor commands (Kawato, 1999).

An efference copy is defined as an exact copy of the expected sensory consequences of the motor program (von Holst, 1954). When voluntary movement is initiated by a signal in primary motor cortex, an efference copy of that signal is sent to the cerebellum via pontine nuclei where the instructions sent from motor cortex (planned movement) and the actual movement performed (via sensory feedback) are compared (von Holst, 1954). This allows any errors to be corrected without interruption to on-going movement. The inherent delay in closed-loop feedback systems is avoided when motor control information is the transmitted in an open-loop, feedforward control fashion (Kawato, 1999). Feedforward transmission of motor control information is achieved using internal models that evaluate efference copies of prepared motor commands (Miall & Wolpert, 1996).

Feedforward circuits and internal models are used during speech production in the same fashion as in other skilled movements (Perkell et al., 1997). Internal models of speech production are acquired during early childhood in the babbling phase (Guenther, 1995). According to Guenther's (1995; 2003) neural network model of speech motor skill acquisition and speech production (DIVA) briefly mentioned earlier in this paper, random movements of the speech articulators during the babbling stage provide auditory, proprioceptive, and tactile feedback signals to the brain. This then enables the brain to learn the transformations from planned acoustic trajectories (desired movement in auditory-temporal space) to time-varying patterns of motor commands (movement of the articulators in the desired movement directions).

The Guenther model operates under the assumption that the child can hear and perceive speech sounds. Because adult models of speech production are the targets which the child's motor system attempts to achieve when learning to produce speech sounds (Guenther & Perkell, 2004), the child must perceive these speech sound targets before he or she can produce them correctly (Guenther, 2003). This requires that the child hear speech models in his or her environment (Perkell et al., 1997). Then, as children begin to babble, it is hypothesized that premotor cortex cells representing intended syllabic productions (auditory "targets" or expected sound patterns) project to higher-order auditory cortex cells where they are compared to incoming auditory information from primary auditory cortex (auditory feedback signal of the child's actual production). Any difference between the auditory target and actual auditory signal is mapped as an error signal through the cerebellum to motor cortex and corrected (Guenther, 2003; Guenther & Perkell, 2004). Because of developmental changes in the subsystems of speech production during early childhood (e.g., lengthening of the vocal tract), internal models or representations of speech production require continuous updating until they become stable. A greater reliance on feedback control mechanisms is necessary until feedforward mechanisms become more accurate with maturity.

For children who stutter, there may be an impaired ability to acquire and update, or activate and use internal models of speech production due to impaired auditory feedback control (Max, 2004; Max et al., 2004). Neuroimaging studies have shown bilateral activation of primary and secondary auditory cortices during speech production in fluent speakers. Activation in these areas is typically the result of hearing one's own voice (as during an overt reading task); however, activation in these auditory regions has been found to be absent bilaterally in adults who stutter (Brown, Ingham, Ingham, Laird, & Fox, 2005). Lack of auditory activation during overt speech in young children (if in fact this is the case) would impede the child's ability to use auditory feedback from self-generated speech sound production to acquire correct mappings between central motor commands and their acoustic consequences (Max et al., 2004). As a result, Max et al. (2004) hypothesized that planned motor commands are correct prior to execution, but the predicted sensory consequences of those commands will not match the desired consequences. This mismatch arises because the internal model used to compare the predicted consequences of the motor output with the intended motor output was not correctly updated or acquired, as a result impaired auditory feedback monitoring. The mismatch between the predicted and desired consequences, despite the fact that the motor plan may have been correct prior to motor execution, might result in the CNS reissuing the motor plan until the sensory consequences of that motor plan match the desired consequences. The reissuing of motor commands by the CNS as the result of impaired auditory feedback monitoring and failure to acquire or update internal models of speech production could give rise to sound or syllable repetitions and prolongations (Max et al., 2004).

Inactivation or deactivation (Braun et al., 1997) of auditory cortices has been shown to be even greater when stuttering frequency increases (Brown et al., 2005), while stimuli that consistently induce fluency (e.g., delayed auditory feedback, frequency altered feedback, masking, unison reading), also induce activation of auditory cortex. Proficient speakers do not rely on auditory feedback to monitor speech production; however, when auditory feedback is altered or distorted, attention is forced to the auditory signal (Borden, 1979), and speakers compensate by altering their speech patterns (e.g., slow overall speech rate) to match the auditory consequences, as in delayed auditory feedback.

For children who stutter, external auditory stimulation is hypothesized to facilitate overall activation of auditory cortex in a similar fashion. This in turn improves the efficiency of feedback monitoring and subsequent updating or acquiring of internal models of speech production (Max et al., 2004). Therefore, it has been speculated that treatments for stuttering which provide an external auditory stimulus (e.g., “take a break”) will serve to induce fluency by increasing activation of internal models used to monitor efference copies of motor commands (Max et al., 2004). Max (2004) has argued that the success of the Lidcombe program, for which RCTO is one component (Onslow et al., 1997), successfully eliminates stuttering in young children because it provides the necessary external cue needed to activate auditory cortex. The Lidcombe Program requires that the child repeat the utterance initially produced with an instance of stuttering until it is produced stutter-free. This over-practice is also believed to contribute to the child's ability to correctly acquire and update the necessary internal models of speech production (Max, 2004).

A similar speculation can be made based on the findings of the present investigation. RCTO provided the necessary external cue to activate auditory cortex as well as increase activation of internal models. The increases in articulation rate observed when utterances were repeated until they were stutter-free after the time-out provide support that motor learning (or at the least, sensorimotor adaptation) occurred. The maintenance of stuttering frequency reduction immediately after RCTO was removed further supports the speculation that short-term motor learning (updating of internal models) may have occurred. The necessity to update and use internal models for feedfoward control of speech production is a plausible argument based on computer simulation of stuttering using the DIVA model, described earlier. When the neural network model is programmed with increased feedback control relative to feedforward control, the likelihood that the synthesizer's output will contain instances of stuttering significantly increases. However, when the model is programmed with its normal settings, that is, with greater feedforward projections relative to feedback control projections, the synthesizer produces fluent speech output (Civier & Guenther, 2005).

Success of RCTO in the present investigation also appears to support the notion that individuals who stutter might need to rely more on other types of afferent feedback (DeNil & Abbs, 1991) besides auditory feedback for successful speech and language acquisition, if in fact auditory feedback mechanisms are impaired. For instance, the RA interacting with the participants would not only provide the auditory cue “take a break”, but would also put her head down immediately prior to this instruction. For two participants (P2 and P4), the visual cue of RA1 putting her head down was sufficient to cue them to pause from speaking. Throughout the experimental procedure, these two participants would constantly look up at RA1 during communicative interactions watching for this visual cue. It is reasonable to suggest then that children who stutter may need external sensory cues (e.g., auditory, visual) to acquire, update, and use internal models of speech production.

Summary and Future Directions

The variables examined in the present investigation (articulation rate, mean length of utterance, participant awareness, and change in emotional state) were not sufficient to explain the reduction in stuttering frequency with RCTO. Articulation rate, MLU, and emotional state did not show any clear trends. Participant awareness may have contributed to the success of the procedure, but only for one child.

The participants were not told why they were being asked to put their heads down; however, the treatment might have been more effective if they had. Also, the two participants who indicated irritation with the procedure might have had a more positive response if they had known the purpose of "timing out."

It might be fruitful for future investigations of RCTO in young children to include examination of suprasegmental speech variables. In the present study, it was noted that three participants (P1, P2, and P4) decreased vocal loudness during the RCTO procedure, and even spoke in a whisper at times. Also, pitch range was perceptually truncated during RTCO relative to baseline in four participants (P1, P2, P3, and P4).

Further investigation of speech and language variables that potentially change after RCTO administration may help determine how children who stutter acquire speech and language skills, which in turn could eliminate stuttering before it became a life-long impairment.

APPENDIX A

PARTICIPANT RECTRUITMENT MATERIALS

TELEPHONE SCREENING QUESTIONS FOR DIRECTORS OF PRESCHOOL AND DAYCARE PROGRAMS

Hello. I am calling to inform you of a research project that I am conducting at the University of Arizona which involves preschool children who stutter. The purpose of this project is to determine if a behavioral procedure called time-out from speaking, which has been shown to produce temporary periods of stutter-free speech in young children, causes other changes in speech, and if listeners can hear these other changes in the speech of your child if they exist.

We are wondering if you might distribute a parent letter to ALL parents and guardians of the children at your school or daycare which provides specific information about the study and subject criteria for the study, along with the parent/guardian consent form. We will drop the letters and forms off to your school or daycare at your convenience. If a parent is interested in having their child participate in the study, they can call the Principal Investigator to obtain more information, have any questions answered, and participate in the telephone screening to determine if their child is eligible for the study.

Thank you for your time. I can be reached at 621-2210 or 907-9000 if any questions, concerns, or comments which may arise before we deliver the letters and forms. I will also answer any questions that you may have when I arrive at your school to deliver the letters and forms.

Good-bye.

Dear Parent or Legal Guardian,

I am writing to inform you of a research project that I am conducting at the University of Arizona with young children between the ages of 2 years, 5-months and 7 years, 11-months of age. The purpose of this project is to better understand the speech of children who do and do not stutter. Stuttering is when a child produces syllable prolongations or repetitions (b------all or b-b-b-b-b-all) and one-syllable word repetitions (I-I-I-I-I), and may or may not occur with other behaviors (e.g., eye blinking). Stuttering typically begins between the ages of 2 and 5 years of age, and there is currently no way to determine whether children will recover on their own or require clinical intervention.

The purpose of my research project is to better understand stuttering using a procedure called time-out from speaking. Each child participant will play with a talking puppet and an examiner. The puppet will be made to go to sleep for 5 seconds when your child repeats a syllable, word, or phrase. This procedure has been shown to eliminate stuttering (or other forms of disfluent speech like word repetitions) for brief periods in young children. I am interested to see if there are other changes in speech following the reduction or elimination of stuttering. I'm also interested to see how this procedure works in children who do not stutter. In this way, I can make comparisons of the speech of children who do and do not stutter.

To participate, your child may stutter or not stutter, be between 2 years, 5-months and 7 years, 11-months of age, have normal hearing, speak English as his or her first language, not be enrolled in speech-language therapy for stuttering at this time, not received previous direct treatment for stuttering, and have no history of neurological injury, disease, or handicapping condition based on your knowledge.

Your child will receive stickers and small prizes for his or her participation and you will be compensated for your child's participation. A research participant parking space is available behind the Speech and Hearing building so there would be no costs to you associated with parking on the University of Arizona campus.

If you have questions or would like additional information about the project, or if you're interested in having your child participate in the project, please contact Kimberly A. Farinella at 293-1419 or 907-9000.

Sincerely,

Kimberly A. Farinella, Ph.D. Candidate, CCC-SLP
Project Director
Department of Speech, Language, and Hearing Sciences
University of Arizona
kaf@u.arizona.edu

TELEPHONE SCREENING QUESTIONS FOR PARENTS/GUARDIANS OF POTENTIAL CHILD SUBJECTS
(*This information is confidential*)

Nature of phone call (check all that apply):

1) To ask questions about the project ____
2) To obtain further information about the project _____
3) Interested in having child participate in the project _____

If interested only in asking questions about the project or to obtain further information about the project, the principal investigator will answer any questions and provide whatever information the parent/guardian is seeking; however, no personal identifying information will be obtained, and no information will be written down about the caller or his or her child.

If the parent/guardian is interested in having their child participate in the project, the investigator will determine if the child meets subject criteria and the following information will be recorded on this sheet:

General Information

Date of contact: _________________

Parents Names: ____

Child's Name: ____DOB: ___________

Chronological Age: _______

Address: ____

Phone: ______________________________

I have some questions about your child which will help me determine if he/she would be a good candidate for participation in this research project. Is it okay to ask you a few questions about your child? You do not have to answer any question(s) you don't want to and you are free to end this telephone interview at any time.

<u>Subject Criteria Questions</u>

Does your child speak English as his or her first-language (circle one)

YES NO

Does your child ever stutter or exhibit speech that is disfluent such as prolonging sounds with effort (i.e., mmmmmmy), sound or word repetitions (i.e., I-I-I-I-I w-w-w-w-ant _______), or blocking on sounds completely?

YES NO

If yes, please describe.

____

____

____

____

Is your child currently enrolled in speech-language therapy or receive any special services from anyone?

YES NO

If yes, what is your child enrolled for?

____

____

____

____

Has your child ever received speech-language treatment for stuttering?

YES NO

If yes, please describe.

Does your child have a history of head injury, disease, or handicapping condition other than stuttering to the best of your knowledge?

YES NO

If yes, please explain.

Speech/Language/Hearing Information

Do you have any other concerns about your child's speech? If yes, please describe.

Do you have any concerns about your child's hearing? If so, please describe.

____

____

Do you have any concerns about your child's language skills? If so, please describe.

____

____

____

____

APPEARS THAT YOUR CHILD MAY / MAY NOT MEET SUBJECT CRITERIA FOR THIS PROJECT.

(If child appears to meet criteria) Would you like to schedule a time for you and your child to come to the Department of Speech, Language, and Hearing Sciences at the University of Arizona to participate in further screening of your child's speech, language, fluency, and hearing skills to determine eligibility for this project? If yes, what would be a convenient time for you?

(If child doesn't appear to meet criteria) At this time, it appears that your child does not meet the criteria for this project. Thank you for your interest and if there are any further questions I can answer for you, please let me know. Thank you again for your time.

APPENDIX B

PARENT/GUARDIAN QUESTIONNAIRE

(*This information is confidential)*

Child’s Name ______________________________Birth date: __ __/__ __/__ __ __ __

Subject Code: ________________

Parent(s)/Guardian(s) Names: ____

Phone Number: _____________________________

Child’s Native Language: ________________

Other languages spoken at home: _________________________

Child’s Ethnicity and Race: (Please indicate ethnicity AND race; check all that apply)

Child’s Ethnicity: ___ Hispanic or Latino ___ Not Hispanic or Latino

Child’s Race: ___ American Indian/Alaska Native ___ Asian ___ White

___ Hawaiian/Pacific Islander ___ Black/African American

What kinds of talking does your child do on a daily basis (e.g., use of words, phrases, or sentences to communicate; number of words spoken at a time; vocabulary used)?

Tell me about your child’s speech (articulation), language (understanding and expression of language), and fluency (stuttering) skills?

Speech/Articulation:

Language (receptive and expressive):

Fluency (stuttering):

Does your child demonstrate repeat sounds or words or prolong sounds with obvious effort and tension (delete the jargon) syllable prolongations, syllable and word repetitions, hesitations or blocks, or secondary characteristics (e.g., eye blinking, foot stomping)? How often does your child exhibit these behaviors?

Is there any time when your child's stuttering is better or worse?

Is your child aware of his or her stuttering? If yes, please explain.

Have you ever drawn attention to your child's disfluencies or stuttering? If so, how (i.e., have you ever told your child to slow down? If so, was it effective in reducing or eliminating your child's stuttering moment?)

How do you think your child feels talking with other children? Teachers? Siblings? Parents?

Has your child ever been frustrated during attempts to communicate and during instances of stuttering?

Can people always understand your child? (children, teachers, siblings, parents)

Other comments or concerns?

APPENDIX C

LIST OF PICTURE BOOKS

Brown, M. (1987). *Arthur's Baby: An Arthur Adventure*. Boston, MA: Little Brown & Company.

Cousins, L. (2003). *Maisy's Rainbow Dream*. Cambridge, MA: Candlewick Press.

DePaola, T. (1978). *Pancakes for Breakfast*. Orlando, FL: Harcourt Brace & Company.

Laden, N. (1994). *The Night I Followed the Dog*. San Francisco, CA: Chronicle Books.

Numeroff, L. (1985). *If you Give a Mouse a Cookie*. New York, NY: HarperCollins.

Numeroff, L. (2002). *If you Take a Mouse to School*. New York, NY: HarperCollins.

Pilkey, D. (1997). *The Adventures of Captain Underpants: The First Epic Novel*. New York, NY: Scholastic, Inc.

Silverhardt, L. (2004). *Dora Discovers Colors, Numbers, Shapes, & Letters*. New York, NY: Simon & Schuster Children's Publishing Division.

APPENDIX D

LIST OF QUESTIONS

1. Tell me everything you did today.
2. What is your favorite game to play?
3. How do you play it?
4. Who are your friends?
5. What do you like to do with your friends?
6. Where do you go to school or daycare?
7. What did you learn at school or daycare today?
8. Tell me about a book your teacher read to you at school or daycare?
9. What is your favorite T.V. show?
10. Do you have brothers and sisters?
11. What things do you do with your brothers and sisters?
12. What foods did you eat during the day?
13. Do you help your mom or dad cook food at your house?
14. How do you make (e.g., eggs, sandwiches, cake)?
15. What restaurants do you eat at?

APPENDIX E

POST-TREATMENT INTERVIEW

Subject Code: _______________ Date: ________________

Investigator's Name: ________________________

Please record responses verbatim.

Questions to be asked of child:

1. (Say child's name), can you tell me about the experiment?

2. What did you think about it?

3. Do you know why I took a break sometimes?

4. How did you feel when I took a break sometimes?

5. Were you okay with it (Point to face #0 = happy face) a little bit upset (face #2), or very upset (#4)? Can you show me the picture of how you felt when I took a break?

6. So why did I take a break sometimes?

7. Can you tell me again how you felt? Now look at the pictures and show me again how you felt when I took a break sometimes.

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