The Association between Frontal Lisping and an Anterior Open Bite, a Tongue Thrust Swallow, The Concurrence of an Anterior Open Bite and a Tongue Thrust Swallow and Slow Diadochokinetic Rate.

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Declaration

I hereby declare that this research study is my own work and that it has not been submitted for any other degree or to any other university.

Signed by candidate

24/1/06

Linda Thompson **Date**

Dedication

This dissertation is dedicated to my mother, Vivienne Wallis, for her unconditional love and constant encouragement in my academic pursuits.

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Abstract

A frontal lisp is one of the most common articulation disorders in the speech of young children. However, research on the oral facial variables associated with this speech disorder are dated or inconclusive. The aim of the study was to investigate the association between a frontal lisp and an anterior open bite, a tongue thrust swallow, the concurrence of an anterior open bite and a tongue thrust swallow, and slow diadochokinetic rates. To achieve these aims, 160 children between the ages of 5 and 7 years were selected as participants for this study, 80 of whom presented with frontal lisps and 80 of whom did not. The results of this study revealed that an anterior open bite, a tongue thrust swallow and the concurrence of an anterior open bite and a tongue thrust swallow were associated with frontal lisping. In addition, the probability of a participant presenting with a frontal lisp increased six times when either an anterior open bite, a tongue thrust swallow or concurrence of these variables was present. The theoretical and physiological aspects of this association are explored. However, slow diadochokinetic rates were not associated with frontal lisping, which indicates that a frontal lisp is not associated with underlying neurological disorders such as dysarthria and apraxia. Each of these findings has an influence on therapy technique and clinical management of a frontal lisp.

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GLOSSARY OF TERMS

Allophone	A sound that is regarded as a contextual or an environmental variant of the same phoneme.
Articulator component	This is a level of representation in information processing theory that transforms a mental representation of an utterance into a motor pattern.
Cephalometric	The dimensions of a human head
Developmental verbal dyspraxia	A motor speech disorder that affects consonant production but has no associated weakness, paralysis or in coordination of the speech musculature.
Dysarthria	A speech problem caused by neuromuscular impairment, because of a lesion to the central or peripheral nervous system. Dysarthrias are caused by a paralysis, weakness or in coordination of the speech musculature and can involve disturbances to respiration, phonation, resonation and prosody.
Frequency	The number of times the variable occurred
Mixed dentition	The presence of both deciduous and permanent teeth in the mouth
Oral-facial examination	This process evaluates the structure and oral motor function of the oral articulators.
Proprioceptive feedback	Feedback from any receptor that supplies information about the state of the body.

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1. INTRODUCTION

A frontal lisp is a common speech disorder in young children (Bowen, 2002). However, research in the area of frontal lisping is dated (Hewlett, 1990). The lack of studies on frontal lisping could possibly be related to the application of phonology to the study of clinical speech data, which developed during the mid-1970's and became established in the 1980's (Hewlett, 1990). Research moved away from analysing the child's difficulty with the production of sound, i.e. articulatory difficulty, and focused more on the child's inability to use sounds appropriately to convey meaning, i.e. phonological delay (Stackhouse & Wells, 1997). Johnson and Sandy (1999) recommend that research in the area of speech production errors such as frontal lisping should continue because of potential relevance in clinical application.

This study was undertaken to update research on the association between oral facial variables and frontal lisping, which in turn could assist in the treatment of this speech disorder (Bowen, 2002). The researcher investigated the association between frontal lisping and three oral facial variables, namely an anterior open bite, a tongue thrust swallow and slow diadochokinetic (DDK) rate. In addition, the association between frontal lisping and the concurrence of an anterior open bite and a tongue thrust swallow was also investigated. Participants in this study included 160 children between the ages of 5 and 7 years, 80 of whom presented with frontal lisps (case group) and 80 of whom did not (control group).

The frontal lisp is defined as an articulation disorder, because a speaker with this speech disorder has difficulty with the production of /s/ and /z/ (Bowen, 2002; Gibbon & Grunwell, 1990; Lowe, 1994b). The frontal lisp is not viewed as a phonological error because a speaker with a frontal lisp does not have an inability to use /s/ and /z/ to convey meaning (Lowe, 1994b; Stackhouse & Wells, 1997). Thus this study focuses on the frontal lisp from a phonetic/articulatory and oromotor perspective (Stackhouse & Wells, 1997). As noted by Stackhouse and Wells (1997), clinical application issues and theoretical questions can be addressed within this perspective.

Mowrer, Wahl, and Doolan (1978) and Bowen (2002) stressed the importance of successful remediation of frontal lisping because of the negative connotations associated with this speech disorder. In the past, frontal lisping has been associated with "baby talk" or immaturity in children and has often been negatively judged in terms of intelligence, education, masculinity (in the case of male lispers) and ability to form friendships (Mowrer et al., 1978).

2. LITERATURE REVIEW

In order to understand how certain oral facial variables could affect the production of /s/ and /z/, resulting in a frontal lisp, it is necessary to also have an understanding of what the correct production of /s/ and /z/ entails. The traditional phonetic description of /s/ and /z/ classifies sounds according to place and manner of articulation (Bauman-Waengler, 1994). Thus according to this description, the lingua-alveolar, voiceless, fricative /s/ as in sun and the lingua-alveolar, voiced, fricative /z/ as in zoo, are so classified because they are produced with a narrow constriction between the tongue tip and the alveolar ridge (Kent, 1998; Ohde & Sharf, 1992). For both /s/ and /z/, the airflow from the lungs is directed by the tongue tip between the upper and lower teeth (Ohde & Sharf, 1992). If the above specifications are met, the resultant acoustic productions for both /s/ and /z/ involve relatively high intensity sibilant noises with spectral peaks between 6500 and 10 000 Hz for children (Ohde & Sharf, 1992).

Normally developing children can produce /s/ and /z/ correctly by the age of 7 years (Bauman-Waengler, 1994; Bowen, 2002; Shipley & McAfee, 1992; Vihman, 1998). This correct production seems to be related to biologic constraints (Green, Moore & Reilly, 2002). Neurologically, there needs to be sufficient motor control over the muscles involved in speech production so that they can function normally in terms of speed, strength, steadiness, coordination, precision, tone and range of motion (Love, 2000). In addition, anatomical and physiological changes need to occur in the oral cavity from birth to early childhood (Arvedson, Rogers & Brodsky, 2002; Bauman-Waengler, 1994). These changes allow for increasing complexity of function such as the ability to sustain the near approximation of the tongue and alveolar ridge, which is required for the production of /s/ and /z/ (Arvedson et al., 2002).

Anatomically, with increasing maturity, a child's oral cavity increases in size from 3 to 7 years of age (Bahr, 2001). This increase is initiated in the first 4 months of life with the absorption of the sucking pads (masses of fatty tissue within the masseter muscle) and the growth of the mandible in a vertical and forward direction (Arvedson et al., 2002; Bahr, 2001; Vihman, 1998). With the changes in growth of the mandible, the tongue, which previously rested more anteriorly in the oral cavity and which moved in a primitive protraction-retraction pattern (Arvedson et al., 2002), is able to assume a more posterior resting position and dissociate from the jaw (Arvedson et al., 2002; Bahr, 2001). This dissociation allows the tongue tip to elevate to the alveolar ridge for the production of /s/ and /z/ (Bahr, 2001).

Physiologically, for the production of /s/ and /z/, the speaker must be able to stabilize the jaw, before the tongue can dissociate from it (Bahr, 2001; Green et al., 2002). Dissociation can only be achieved if the muscles of the tongue and the jaw work in a coordinated fashion. Thus for the production of /s/ and /z/, the jaw muscles, namely the masseter, temporalis and medial pterygoid, are required to elevate and stabilize the jaw, so that dental approximation and tongue elevation towards the alveolar ridge can be achieved. Jaw instability and poor grading of tongue movements are often seen in speakers with oral motor concerns (Bahr, 1993; Love, 2000). Thus anatomical and physiological variables can affect the production of /s/ and /z/ and should be evaluated when assessing a frontal lisp.

Ohde and Sharf (1992) suggest that a possible reason for the high number of /s/ and /z/ errors in the speech of young children is that the correct production of /s/ and /z/ requires a high degree of articulatory precision. If this precision is not adhered to, subtle but perceptual changes occur which make it difficult to identify these sounds as sibilants or to accept them as normal (Ohde & Sharf , 1992).

A lisp is a speech disorder that affects the precise production of /s/ and /z/ (Bowen, 2002; Ohde & Sharf, 1992). Ohde and Sharf identified three major types of lisp that are described in terms of the nature of the tongue interference with the normal production of /s/ and /z/. These are the *protruded* or *frontal lisp* (the tongue tip is positioned between the teeth), the *dentalized* or *dental lisp* (the tongue tip is placed very close to the upper teeth so that the airstream is obstructed as it passes between the upper and lower teeth), and the *lateralized* or *lateral lisp* (when the tongue tip is placed for an /l/ sound so that the airstream is obstructed and forced to pass laterally).

The dentalised lisp differs from the frontal and lateral lisps in that it is contextually bound, i.e. it only occurs when adjacent to /θ/ and /ð/ (Ohde & Sharf, 1992).

However, the frontal and lateral lisps occur in all contexts. Thus Ohde and Sharf argue that the dentalised lisp is not a lisp but an allophone of /s/ and /z/ because (unlike the frontal and lateral lisps) it is a contextual variant of the phonemes /s/ and /z/. Ohde and Sharf identified the frontal lisp as being the only lisp which resulted in the loss of phonemic distinction between the sibilants /s/ and /θ/ and /z/ and /ð/. Thus there is also a loss of phonemic distinction between minimal pairs, such as "some" and "thumb" and "close" and "clothe" (Ohde & Sharf, 1992). For this reason it is considered a more serious speech difficulty than other lisps (Ohde & Sharf, 1992).

According to traditional phonetic analysis, the lingua-dental/interdental, voiceless, fricative /θ/ as in <u>th</u>in and the lingua-alveolar/interdental, voiced, fricative / ð/ as in <u>th</u>is, are so classified because they are produced with a narrow constriction between the tongue tip and the edge of the incisors (Kent, 1998; Ohde & Sharf, 1992). However, although the frontal lisp and /θ/ and /ð/ are both produced with the same ungrooved interdental tongue position, spectrographic analysis reveals that a frontal lisp and the production of /θ/ and /ð/ differ significantly in variability of duration (Ohde & Sharf, 1992). Thus the frontal lisp should always be viewed as an articulation error and not as a phonological disorder involving a /θ/ for /s/ and /ð/ for /z/ substitution (Hodson & Paden, 1983).

The oral facial examination has frequently been used to evaluate the articulators, in an attempt to identify any structural or functional abnormalities in the oral-facial area that could predispose or precipitate a speech problem such as a frontal lisp (Bankson & Bernthal, 1998b; Creaghead & Newman, 1985; Lowe, 1994a; Thompson & van der Walt, 1992). The structural/anatomical variables associated with frontal lisping have included missing anterior incisor teeth (Bankson & Byrne, 1962; Bankson & Bernthal, 1998b; Jann, Ward & Jann, 1964; Creaghead & Newman, 1985; Snow, 1961) and an anterior open bite (Johnson & Sandy, 1999). The functional/physiological variables associated with frontal lisping have included weak lingual muscle strength (Dworkin, 1978, 1979, 1980), a tongue thrust swallow (Fletcher, Casteel & Bradley, 1961) and slow DDK rate (Dworkin, 1978; 1980).

The absence of the front incisor teeth have been associated in the literature with frontal lisping (Bankson & Byrne, 1962; Snow, 1961). However, there is controversy in the literature about exactly which teeth need to be missing to have an effect on the production of /s/ and /z/. Snow (1961) and Bankson and Byme (1962) reported that frontal lisping was related to missing teeth in the maxilla (upper anterior spacing) whereas Creaghead & Newman (1985) reported that frontal lisping was related to missing central, lower incisors.

The children used as participants in the studies by Snow (1961) and Bankson and Byme (1962) were all aged between 5 and 8 years, which is an age that is characterized by a period of mixed dentition (Jann et al., 1964). Missing front incisor teeth were therefore present in the case and the control groups (Johnson & Sandy, 1999).

Gable, Kummer, Lee, Creaghead and Moore (1995) tried to avoid this extraneous variable by testing the relationship between missing teeth and speech production in 26 participants between the ages of 8 and 10 years. All the participants in the case group had had their anterior incisor teeth extracted before the age of five years, whereas participants in the age-matched control group presented with normal developmental dentition. Gable et al.'s results revealed that loss of maxillary incisors in children younger than 5 years did not result in defective articulation while the teeth were missing or when permanent dentition was acquired. They thus concluded that a child is able to adapt their articulation patterns to compensate for missing anterior incisor teeth.

An anterior open bite has been associated in the literature with frontal lisping (Johnson & Sandy, 1999). The anterior open bite is defined as the absence of contact between the upper and lower anterior teeth resulting in open spaces between them when the posterior teeth are in occlusion (Johnson & Sandy, 1999). The etiologies of an anterior open bite may be *genetic* (an inherent endogenous orofacial pattern), *environmental* (related to external factors such as a prolonged non-nutrient sucking habit e.g. thumb sucking) or as a result of a combination of environmental influences upon a genetic predisposition (Jann et al., 1964; Larsson, 1994; Moore, 1996).

Prolonged sucking of digits or dummies has been associated with the development of an anterior open bite (Drane, 1996; Proffit, 1986; Kellum, Gross, Hale, Eiland & Williams, 1994). However, the prolonged sucking habit has to be for more than 6 hours a day to have an effect on bite formation (Proffit, 1986). Ultrasonographic studies have revealed the anatomical reason for this association. The maxilla arch is still soft and malleable in the child with developing dentition, whereas the dummy teat or thumb is already formed, has a specific shape and is made from fairly unmalleable material (Drane, 1996). Thus while sucking, the child's maxillary arch conforms to the shape of the object sucked, contributing to an anterior open bite (Drane, 1996).

Before the 1980's, much controversy existed regarding the association between a tongue thrust swallow and the development of an anterior open bite (Bankson & Bernthal, 1998a; Hanson, 1983; Proffit, 1986). It was theorized that the pressure or force on dentition associated with a tongue thrust swallow would contribute towards the development of an anterior open bite (Bankson & Bernthal, 1998a; Proffit, 1986). However, dental alignment is only affected if direct pressure on the teeth is maintained for 6 hours or more a day (Proffit, 1986). If the typical individual swallows approximately 1000 times a day, and each swallow lasts for a second or less, then it can be assumed that the total swallowing time is 20 minutes, which would have no affect on dentition (Proffit, 1986).

Bernstein (1954) investigated the effect of dental occlusion on speech production. Although this study is dated, it is still referred to by most investigators in this area (Johnson & Sandy, 2002). Bernstein examined 437 junior school children with various speech problems and matched them to a control group who did not present with speech problems. Bernstein's results indicated that there was an association between anterior open bites and articulation defects, especially frontal lisping. The association between frontal lisping and anterior open bites was also supported by later researchers such as Jann et al. (1964); Mims, Kolas and Williams (1966) and Turvey, Journot and Epher (1976).

Bloomer (1971) suggested that a speaker could have normal speech production, despite the presence of an abnormal oral structure, if they had adaptive function of the tongue. Thus a speaker could compensate for an oral structural variable by adapting their tongue position so as to produce the most precise production of the required sound (Bloomer, 1971). However, if a speaker had an abnormal oral structure without adaptive or compensatory function of the tongue, that speaker would present with abnormal sound production (Bloomer, 1971). Thus the ability to adapt and compensate for an abnormal oral structure appears to play a significant role in speech production.

This ability to adapt articulatory placement was observed by Subtelny, Mestre and Subtelny (1964), when they investigated the tongue tip placement differences among 30 participants who had normal occlusion and normal speech, and 31 participants who presented with an anterior open bite and normal speech. All participants were described as being adolescents. Results indicated that participants with normal occlusion and normal speech mostly produced /s/ and /z/ with the tongue tip elevated above the lower incisors whereas those participants with anterior open bites and normal speech mostly produced /s/ and /z/ with the tongue tip slightly posterior to the lower incisors.

Theories of speech motor control have attempted to account for these adaptive or compensatory strategies (Levelt, 1989). Levelt reports on one of these theories, which is based on the notion of coordinative structures. A coordinative structure is an assembly of elementary movements that define a basic unit of function (Kent, 1998; Levelt, 1989). Thus although two coordinative structures may share the same anatomical structures (such as speech and swallowing), they are essentially function specific (Levelt, 1989). The coordinative structures theory describes a number of different stages whereby a preverbal concept is finally fed into an articulator component, where there is general agreement that two levels of neurophysiological output are involved (Garman, 1990).

The first level involves 'loading' of a series of target articulatory patterns, stored in the lexical representations for words in the lexicon, into the speech production mechanism. These can be thought of as "ideal targets", designed to achieve an acceptable pronunciation of the word, i.e., pronunciation compatible with the phonological presentation. Levelt (1989) terms the output at this level the "articulatory or phonetic plan" involving only the context-free or invariant aspects of motor execution and thus a motor programme still at the abstract level.

The second level of neurophysiological output involves the issuing of motor commands to the articulatory structures, by the "executive motor system". At this level the speaker's phonetic plan is realized as a coordinated motor activity, taking into account the prevailing context. Precise firing patterns for the motor neurons are established, via a two-stage processor, which Garman (1990) describes as follows:

(1) An upper command centre which initiates moment-by-moment control of the articulators;

(2) A lower command centre which executes these control signals and monitors their implementation.

The crucial role of the lower command centre is to feed information back to the upper command centre so that on-line adjustments can be made. Such a two-tiered system allows for accumulation in memory of experience concerning the relationship between prediction (upper commands) and effect (lower commands). The output of the lower centre is the set of instructions to the articulatory structures.

This two-tiered system is responsible for compensatory behaviour when the speaker has some prior proprioceptive feedback (e.g. as a consequence of an oral structural abnormality such as an anterior open bite). In these cases, the initial parameters of the phonetic plan will be set accordingly, via modification of the central processing patterns or stored templates of neural activity (Levelt, 1989).

A failure in a child's adaptive functioning would thus indicate poor or faulty proprioceptive feedback or an inability to process the feedback between the upper and lower tier in the executive motor system (Garmen, 1990). The upper command center is not informed or is unable to process information regarding the state of the oral cavity (i.e. the presence of an anterior open bite), in particular by tactile feedback from the articulators (Levelt, 1989). Thus the internally generated sensory representation is critically different from the sensory target of the motor command (Levelt, 1989). The speaker therefore may have difficulty adapting the movement and placement of the tongue to compensate for an oral structural variable such as an anterior open bite. Thus faulty processing between the upper and lower tier in the executive motor system could result in the child not being able to adapt their articulation to compensate for an anterior open bite.

Adaptive techniques are often included in the treatment of a child who presents with a frontal lisp and an anterior open bite (Johnson & Sandy, 1999; Subtelny et al., 1964). For instance, the child may be encouraged to say /s/ and /z/ with their tongue tip slightly posterior to the lower incisors, to compensate for the presence of an anterior open bite (Johnson & Sandy, 1999; Subtelny et al., 1964). The basic principle of this therapy is to encourage the child to adapt their tongue movement and placement, so as to achieve the most precise production of /s/ and /z/, despite the presence of an anterior open bite (Johnson & Sandy, 1999).

The presence of an anterior open bite can also involve orthodontic referral (Moore, 2002). Orthodontists are trained how to eliminate a prolonged non-nutrient sucking habit in an attempt to prevent the development of an anterior open bite (Moore, 2002). As the sucking habit would have to be for 6 hours or more a day to cause an anterior open bite (Proffit, 1986), orthodontists encourage their patients to reduce their sucking habits to approximately 2 to 3 hours a day (V.P. Joseph, personal communication, October 1, 2004). This reduction in sucking is proving more effective than other prevention techniques, which can cause stress and anxiety in a young child (Proffit, 1986).

However, if a child presents with a permanent anterior open bite, the orthodontist could provide surgery to close the gap between the ages of 16 and 18 years (Proffit, 1986; Van Norman, 1997). However, this operation is invasive, costly and often does not have a good clinical result (Van Norman, 1997). Thus preventative counseling for an anterior open bite is an important role for the speech therapist and the orthodontist (Van Norman, 1997).

Weak lingual muscle strength has been associated in the literature regarding frontal lisping (Dworkin, 1978, 1979, 1980). Dworkin suggested that weak lingual muscle strength was associated with the tongue's flat, forward, ungrooved posture during the production of /s/ and /z/, resulting in a frontal lisp. Dworkin measured lingual muscle strength using a Lingual Force Scale. Participants were required to push maximally and directly outward with their tongues against a cup surface that, via a transducer, converted lingual muscle strength into protrusive lingual force. The results of these investigations revealed that children with frontal lisps had weaker lingual muscle strength, compared with normal speakers.

Luschei (1991) questioned whether there was any direct association between protrusive lingual muscle strength on non-speech tasks and speech articulation, because the tongue is never protruded in this manner while articulating the sounds needed for speech. In addition, Lushei suggested that the Lingual Force Scale was a static isometric measurement that only measured the protrusive force of the tongue involving the extrinsic genioglossus and intrinsic horizontal muscles. Yet speech was a combination of static and dynamic forces, involving four pairs of extrinsic and intrinsic muscles, which worked synergistically as the tongue was manipulated during speech. He also suggested that the tongue may exert lateral, elevator and retractor forces which the Lingual Force Scale did not measure.

The studies by Dworkin (1978, 1979, 1980) also lacked information as to a target value or normative data regarding the exact protrusive lingual muscle strength needed for precise /s/ and /z/ production (Forrest, 2002). In addition, no standards exist regarding the amount of resistance that needs to be applied when testing lingual muscle strength, and thus the researcher must judge subjectively whether the participant exhibits a reduced ability to produce force (Clark, 2005).

Dworkin and Culatta (1980) found no significant differences in lingual muscle strength between normally speaking children and those who presented with frontal lisps, thus contradicting previous conclusions. It would therefore appear that the association between frontal lisping and weak lingual muscle strength remains unresolved in the literature. Forrest (2002) questioned why these studies produced different results because similar methodologies and subject groups were used. Luschei (1991) concluded that this controversy in the literature on the association between protrusive lingual force and frontal lisping could be attributed to intra-subject variability such as inconsistent instructions to participants and inter-subject variability such as the height, weight, fitness level and gender of each participant.

A tongue thrust swallow has been associated in the literature with frontal lisping (Fletcher et al., 1961). Logemann (1983) defined a tongue thrust swallow as an anterior movement of the tongue during the initiation of a swallow, rather than a coordinated smooth posterior action. This term should not be confused with a tongue thrust in speech, which involves the interdentalisation of sounds, mostly tongue tip sounds, such as /t/, /d/, /l/, /r/, /s/ and /z/ (Bankson & Berthal, 1998a).

Mason (1988) differentiated tongue thrust swallows into two different types. The first type was described as a *habit* and was seen in the absence of any morphological, structural, delimiting factors. The other type was *obligatory,* and involved factors such as enlarged tonsils, which force the child to adopt a more forward tongue position to provide mechanical clearance for breathing and swallowing. However, Love (1996) suggested that there may be neurological reasons for a tongue thrust swallow, such as damage to the twelfth cranial nerve which results in weakness in protrusion and retraction of the tongue tip during swallowing.

There is debate in the literature over whether the presence of a tongue thrust swallow in children should always be viewed as a deviant or atypical lingual muscle pattern or if it should rather be viewed as a normal transitional stage in the path from infancy to adulthood (Colletti, Geffner & Schlanger, 1976). Jann et al. (1964) and Subtelny and Subtelny (1964) suggested that due to anatomical growth in the oral cavity, there is a decrease in tongue thrust swallowing in children as they mature.

However, the exact age when a tongue thrust swallow is no longer developmentally appropriate is still debatable. Hanson (as cited by Bankson & Bernthal, 1998a) reported this age to be around 5 years whereas Mason and Proffit (1974) suggest around 12 years of age. The ad hoc committee report by ASHA in 1989 stated that "at some time in development, a tongue protrusion swallow was no longer the norm and could be considered undesirable or as a contributing and maintaining factor for frontal lisping" (ASHA 1989 ad hoc committee quoted in Bankson & Bernthal, 1998a, p 201).

The association between a tongue thrust swallow and frontal lisping was investigated by Fletcher et al. (1961), who studied 1615 school children between the ages of 6 and 18 years and found that children who demonstrated a tongue thrust swallow were more likely to have associated frontal lisps than children who did not. An association between frontal lisping and a tongue thrust swallow was also found by researchers such as Jann et al. (1964); Mason and Profitt (1974); Ronson (1965); Subtelny et al. (1964); Ward, Malone, Jann and Jann (1961).

These early researchers, such as Ronson (1965), hypothesized that the association between a tongue thrust swallow and frontal lisping was because speech emerged from earlier appearing non-speech oromotor behaviors, such as sucking, swallowing and chewing. They suggested that if an articulator's movement was impaired for swallowing, it would also be impaired for speech production. Thus the interdental pattern of tongue movement observed in the production of /s/ and /z/, resulting in a frontal lisp, was thought to be related to or emerging from the existing interdental pattern of tongue movement observed in a tongue thrust swallow. Support for the notion that a frontal lisp evolves from earlier appearing oromotor behaviour such as a tongue thrust swallow, was drawn from the fact that speech and swallowing share the same articulatory structures (i.e. the tongue), the same muscle groups and both develop progressively from birth (Ruark & Moore, 1997).

However, the hypothesis that speech emerges from non-speech behaviour such as swallowing is not supported by the theory of coordinative structures (Levelt, 1989). While the notion of coordinative structures supports the fact that swallowing involves largely the same muscles as speech, this theory emphasizes that the muscle's coordination for speech and for non-speech tasks differ substantially (Levelt, 1989). Each speech and non-speech function has a particular neuro-muscular coordination, set to act as an autonomous functional system, called a coordinative structure (Levelt, 1989; Kent, 1998). While each muscle can act in many ways, it has limited degrees of freedom when functioning as part of a coordinative structure (Levelt, 1989). Thus, while the tongue is used for speech and swallowing, its freedom is limited when performing either of these functions.

The notion of coordinative structures is supported by researchers such as Moore and Ruark (1996; 1997), who observed that normal speech and non-speech tasks were not physiologically related. Electromyographic (EMG) analysis has been used to evaluate differences between speech and non-speech oral motor behaviours in young children below the age of 2 years (Moore & Ruark, 1996; Ruark & Moore, 1997). In their investigations, Ruark and Moore (1996, 1997) used surface electrodes to measure EMG waveforms that targeted lip muscle and mandibular activity. Their results demonstrated task-specific differences in the coordinative organization of lip and mandibular muscle activity for speech and non-speech behaviours. This task-specific organization supports the premise that the function of the articulators in speech production develops independently from their function in swallowing and chewing. Thus speech does not emerge from earlier appearing oral motor behaviours (Levelt, 1989; Ruark & Moore, 1996, 1997).

One of the therapeutic approaches which has been recommended to improve a tongue thrust swallow, is termed myofunctional therapy, but is also referred to in the literature as tongue thrust therapy, oral motor therapy or myotherapy (Barnes, 1994; Mason & Proffit, 1974). ASHA classifies the tongue thrust swallow as a myofunctional disorder because in myofunctional disorders, the tongue moves forward in an exaggerated way during swallowing (Clark, 2005). Myofunctional therapy involves daily tasks that are designed to change the behaviour of the tongue during swallowing and increase the patient's awareness of their tongue positioning during chewing, swallowing and at rest (Barnes, 1994). However, there is no compelling evidence in treatment literature on the efficacy of these treatment techniques (Clark, 2005).

In addition, there is a history of controversy regarding the speech therapists' involvement in the use of myofunctional therapy techniques to correct a tongue thrust swallow (Barnes, 1994). Colletti et al. (1976) reported that the Joint Committee on Dentistry and Speech Pathology-Audiology ASHA (1975) did not recommend that speech therapists engage in direct therapeutic procedures to alter swallowing patterns. However, since 1975, this joint committee has changed its views considerably. According to Bankson and Bernthal (1998a, p. 200), in 1991, ASHA's Legislative Council made the following official statement. "Investigation, assessment, and treatment of oral myofunctional disorders are within the purview of speech-language pathology". The statement also set out specific required knowledge and skills that should be acquired by each therapist involved in the practice of myofunctional therapy.

Speech therapists have referred children to orthodontists if they presented with tongue thrust swallows, in the hope that the orthodontist could correct the tongue thrust swallow with the use of an appliance (Barnes, 1994; Luke & Howard, 1983). However, appliances such as a gate appliance or a tongue spur or crib (also called a fence) have been criticized by orthodontists because they inflict pain and suffering on children, which is out of proportion to their necessity (Moore, 2002). In addition, current research has revealed that as soon as the appliance is withdrawn, the tongue resumes its original pattern of thrusting during swallowing (Barnes, 1994; Moore, 2002). Thus referral to an orthodontist for a tongue thrust swallow is not currently recommended (V.P. Joseph, personal communication, October 1, 2004).

The concurrence of the variables anterior open bite and a tongue thrust swallow have been associated in the literature with frontal lisping (Jann et al., 1964). Jann et al. examined the relationship between speech defects and the concurrence of an anterior open bite and a tongue thrust swallow in children in the early primary grades and reported a high incidence of frontal lisping. In addition, they concluded that when there was concurrence of an anterior open bite and a tongue thrust swallow, there was a greater likelihood of a child presenting with a frontal lisp than if each of these variables occurred on their own.

However, Subtelny et al. (1964) used radiographic techniques to examine the relationship between the effect of anterior open bites and tongue thrust swallows on the production of /s/ and /z/ in 81 adolescents and adults. These researchers found that the incidence of concurrence of these variables in normal speakers was comparable to the incidence of concurrence in those with frontal lisps. They thus concluded that concurrence was not necessarily a causal factor for frontal lisping.

Slow DDK rates have been associated in the literature with frontal lisping (Dworkin, 1978; 1980; McNutt, 1977). DDK rate refers to "an individual's ability to rapidly start and stop the movement of the articulators and to execute repetitive, alternating or sequential movements typically associated with speech articulation" (Johnson, 1980, p.63). DDK rate is essentially a test of the coordination of the oral musculature and the articulators (Bankson & Bernthal, 1998a; Hanson, 1983; Luschei, 1991). Although DDK rate is essentially a measure of the rate of speech production, it also is a measure of articulator accuracy, consistency and endurance (Williams & Stackhouse, 1998).

DDK rate is commonly used in clinical evaluation of disorders of the central nervous system and for the assessment, diagnosis and treatment of patients with a neurological deficit of the speech mechanism (Prathanee, Thanaviratananich and Pongyanyakul, 2003). One of the major constraints imposed on motor speech production is the rate at which speech can occur (Creaghead & Newman, 1985; Prathanee, 1998). While there are many theories as to the factors controlling speech rate, it has been assumed that a slow rate on DDK tasks may indicate an underlying motor impairment (Clark, 2005).

Cohen, Waters and Hewlett (1998) thus suggest that DDK rate should be included in oral facial examinations of children with speech difficulties, for diagnostic purposes. For instance, DDK tasks involving alternating motion rates (AMRs) are generally irregular in most forms of dysarthria and thus abnormalities of rate and regularity of AMRs are useful in the identification of several dysarthria types (Duffy, 1995). In addition, sequential motion rate (SMR), which demands a measure of ability to move quickly from one articulatory position to another, is useful in the identification of apraxia (Duffy, 1995).

The syllables most frequently used to assess DDK rate are /p∂/, /t∂/ and /k∂/ which can be repeated individually (alternating motion rate) or in sequences (sequential motion rate), such as /p∂t∂/, /t∂k∂/, /p∂k∂/, /p∂t∂k∂/ (Bankson & Bernthal, 1998a). DDK rates for other syllables can also be used if other places and manners of articulation are of interest (Duffy, 1995). For instance, Dworkin (1978; 1980) studied DDK rates in participants with frontal lisps and only included lingual DDK rate involving the tongue tip syllables /t∂/ and /d∂/, and the tongue blade syllables /k∂/ and /g∂/.

DDK rates are established either by a count-by-time procedure, in which the examiner counts the number of syllables spoken in a given time, or by a time-by-count measurement, in which the examiner notes the time required to produce a designated number of syllables (Shipley & McAfee, 1992). In both these procedures, the given time in which to repeat syllables or the number of syllables to be repeated in a given time, is at the discretion of the examiner (Shipley & McAfee, 1992).

Dworkin (1978 and 1980) compared 45 frontal lisping (experimental) and 45 normal speaking (control) subjects, between the ages of 7 and 12 years. He used the count-by-time procedure involving the syllables /ta/, /da/, /ka/ and /ga/. In both these studies he found that the lingual DDK rates in frontal lispers were significantly slower than non-lispers. However, Dworkin and Culatta (1985) found no difference in the DDK rate between children presenting with frontal lisps and those who did not. The differences between Dworkin's earlier and later research can be attributed to methodological issues. In Dworkin's later research, more participants were included in the case and control groups, which increased the power of the statistical analysis (Collett, 1991). In addition, each syllable train was measured three times as opposed to once and three clinicians acted as inter-raters. The improved methodology of Dworkin's later research adds greater weight to its conclusions, however, more research is needed in this area.

Oral motor exercises have been recommended for the treatment of frontal lisps, when the frontal lisp has been associated with slow DDK rate (Bahr, 2001; Mackie, 1996). The rationale for their use is that speech is a motor behaviour and thus if speech rate is impaired, alleviating underlying motor impairments will bring about improved speech (Clark, 2005).

Forrest (2002) claimed that even though oral motor exercises have been used to treat a variety of speech disorders, a ubiquitous definition of what constitutes an oral-motor exercise does not exist. In addition, oral motor exercises cannot be considered a legitimate treatment protocol for any child with an articulation disorder because of the few empirical evaluations of the efficacy of these non-speech activities in effecting speech change (Clark, 2005; Forrest, 2002). In addition, Moore and Ruark (1996) claim that the coordinative frameworks of non-speech behaviors contribute little towards meeting the priorities of speech. Thus to date, speech therapists either reject the use of oral motor exercises because of lack of evidence and support for these treatments in managing speech disorders, or they seek to contribute to the evidence base by investigating their benefits (Clark, 2005).

From this literature review, there appears to be a gap between clinical application and theoretical knowledge regarding the association between certain oral facial variables and frontal lisping. A better understanding of the theory behind why certain oral-facial variables are associated with frontal lisping, may assist in the selection of more appropriate and effective therapies for this speech disorder. For instance, ASHA has stated that there is some evidence to suggest that a tongue thrust swallow and frontal lisping may co-exist in some people, and thus more research is needed "on the nature of oral myofunctions." (ASHA 1991 Position Statement, cited in Bankson & Bernthal, 1998a, p. 201).

For the purpose of this study, three oral facial variables were selected for further research, namely an anterior open bite, a tongue thrust swallow and DDK rate. In addition, the concurrence of an anterior open bite and a tongue thrust swallow was also included in this study. The variable anterior open bite was selected because research on an association between frontal lisping and an anterior open bite is very dated. Moreover, a significant association between anterior open bites and frontal lisping would contribute to preventative counseling for this oral facial variable (Johnson & Sandy, 1999).

The association between frontal lisping and a tongue thrust swallow was included in this study because although early literature made the association between a tongue thrust swallow and frontal lisping, this association was later challenged. In addition, further research is needed on the association between the articulators functioning in speech and swallowing. In other words, while it is acknowledged that the coordination of the articulatory structures used for speech and swallowing are different (Ruark & Moore, 1996; 1997), the question remains whether an impairment in swallowing means that the production of /s/ and /z/ will always be unaffected.

The association between the concurrence of anterior open bites and tongue thrust swallows, and frontal lisping was included in this study because of the controversy in the literature regarding their association. In addition, if concurrence of the variables anterior open bite and tongue thrust swallow are more likely to be associated with frontal lisping than if each of these variables was present on their own, this finding would have important implications in terms of preventative counseling. The parent/caregiver of a child presenting with concurrence of these variables could be informed that when both these variables co-occur, there is an even greater likelihood of their child presenting with a frontal lisp, than if each of these variables occurred on their own. The association between frontal lisping and DDK rate was included in this study because of controversy in the literature regarding their relationship. Prathanee (1998) indicated that due to this controversy, further research in this area is needed.

The relationship between missing front incisor teeth and frontal lisping was not included in this study. The exclusion of this oral facial variable was based on the fact that participants in this study were between the ages of 5 and 7 years and thus in a period of mixed dentition (Jann et al., 1964). This age group was selected for this study because this is the age range during which most children are referred for speech therapy (Bowen, 2002). Missing front incisor teeth would therefore be regarded as a normal oral-facial variable and would be present in both the case group (children aged 5-7 years who presented with frontal lisps) and the control group (children aged 5 to 7 years who did not present with a frontal lisp).

The association between frontal lisping and weak lingual muscle strength was also not included in this study because lingual muscle strength was weakly associated with frontal lisping in the literature (Clark, 2005; Luschei, 1991). In addition, there is a lack of information as to a target value or normative data regarding the exact protrusive lingual muscle strength needed for correct /s/ and /z/ production (Clark, 2005; Forrest, 2002). There is also no evidence to suggest that lingual muscle strength on non-speech tasks is in any way related to the muscle strength needed for the precise articulation of sounds (Lushei, 1990).

It was hoped that the results of this study would add to the existing body of knowledge on the association between an anterior open bite, a tongue thrust swallow, the concurrence of an anterior open bite and a tongue thrust swallow, slow DDK rate and frontal lisping. Preventative counseling for these variables would in turn have strong implications for rehabilitation involving parents and professionals in a primary level of care. In addition, the findings in this study may have relevance for clinical application.

3. METHODOLOGY

This section presents the aims, research design, participant selection criteria, and description of the participants involved in this study. In addition, the test material, methods of data collection and data analysis are described.

The purpose of this study was to describe the relationship between three oral facial variables that have been associated in the literature with frontal lisping, namely an anterior open bite, a tongue thrust swallow and slow DDK rate. In addition the concurrence of an anterior open bite and a tongue thrust swallow was also investigated.

3.1 Aims

The aims of this study were to determine:

3.1.1 whether there was a higher frequency of anterior open bites in children aged 5 to 7 years with frontal lisps relative to children aged 5 to 7 years without frontal lisps.

3.1.2 the probability of a frontal lisp occurring if an anterior open bite was present.

3.1.3 whether there was a higher frequency of tongue thrust swallows in children aged 5 to 7 years with frontal lisps relative to children aged 5 to 7 years without frontal lisps.

3.1.4 the probability of a frontal lisp occurring if a tongue thrust swallow was present.

3.1.5 whether there was a higher frequency of concurrence of anterior open bites and tongue thrust swallows in children aged 5 to 7 years with frontal lisps than in children aged 5 to 7 years without frontal lisps.

3.1.6 the probability of a frontal lisp occurring if concurrence of an anterior open bite and a tongue thrust swallow was present.

3.1.7 whether children aged 5 to 7 years with frontal lisps have slower DDK rates than children aged 5 to 7 years without frontal lisps.

3.2 Research Design

In order to address the aims of the present comparative descriptive study, a case-control research design was adopted (Katzenellenbogen, Joubert & Abdool Karim, 1997) since this design allows for a quantitative comparison between participants who present with a frontal lisp (the case group) and participants who do not present with a frontal lisp (control group) (Bankson & Bernthal, 1998a). Although there are limitations inherent in a case-control study, such as selection bias (Katzenellenbogen et al., 1997), this issue was addressed by screening the participants selected for the study according to strict selection criteria which did not depend upon the presence of anterior open bites, tongue thrust swallows or slower DDK rates, but on whether the participants lisped or not.

Identification of the oral facial variables associated with frontal lisping has usually involved investigating one variable. However, the design of this study allowed for the investigation of three oral facial variables, as a study which involves more than one variable, will contribute to a better understanding of possible relatedness of variables and how these variables relate to frontal lisping (Bankson & Bernthal, 1998a).

3.3 Participants

The sample in this study consisted of two distinct groups of participants. The case group comprised participants presenting with a frontal lisp. The control group comprised participants who did not present with a frontal lisp.

3.3.1 Sample Size

In line with statistical theory, the research hypothesis assumed that there was no difference between the case group and the control group on the three variables tested – anterior open bites, tongue thrust swallows and DDK rates. This is referred to as the null hypothesis. To test the null hypothesis, it was necessary to ensure that the sample size had sufficient power to reject the null hypothesis, if in fact a true difference exists between the cases and the controls. In order to do this, it was necessary for the researcher to make assumptions about the true (but unknown) proportions between the two groups tested, and about the size of the difference between the two groups that would be clinically important.

Thus the number of participants needed for this study was calculated assuming that anterior open bites, tongue thrust swallows, the concurrence of these two variables and slower DDK rate would be present in 20% of the case group and 5% of the control group. Based on these hypothetical values, Fleiss (1981) has shown that the probability of detecting a difference of 15% between the two groups (the power of the test) would be 80% if 72 participants were used in each group and 90% if 94 participants were used in each group. Fleiss (1981) concluded that a test with a power of between 80-90% is acceptable and accordingly a sample size of 80 in each group was chosen (Fleiss, 1981; Collett, 1991). In total there were 160 participants in this study.

3.3.2 Selection Criteria

The following criteria were applied in the process of participant selection for the case and the control group:

3.3.2.1 Inclusion Criteria

Children were included in the case group if they presented with frontal lisps and included in the control group if they did not present with frontal lisps, as determined by performance on the Goldman-Fristoe Test of Articulation.

In addition, all the participants in the case and control groups should:

a. be between the ages of 5.0 and 7.0 years. Based on single item pronunciation, acceptable pronunciation of /s/ and /z/ should be achieved between 5 and 7 years of age and thus developmental lisps should have been inhibited by this age (Bauman-Waengler, 1994; Vihman, 1998).

b. not present with articulation errors on the sounds /t/ and /k/, as these sounds were included in the DDK task administered in this study. The reason for this exclusion is that any errors on /t/ and /k/ may have affected the production and timing of DDK rate involving the syllables /t∂/ and /k∂/ (Cohen et al., 1998; Lushei, 1991) and thus affect the test results.

c. have no obvious physical disability and not be receiving any form of physiotherapy or speech therapy for dysarthria. This exclusion was necessary to eliminate any neuromotor disorders that may be affecting speech production (Workinger & Kent, 1991).

d. have hearing within normal limits as determined by a pure tone audiological screening assessment, with cut-off at 20db hearing level. Hearing impaired individuals were excluded because of the positive association between hearing loss and articulation errors (Bankson &

Bernthal, 1998a).

e. not have had any oral surgery to change oral structure or function. This criteria was to ensure that there had been no changes to the participant's oral structure, such as the correction of an anterior open bite, which could affect speech production (Johnson & Sandy, 2002).

f. not have received any previous speech therapy, to ensure that the participants' natural speech production had not been altered in any way.

g. have English as their first language. This criteria was used to ensure that each participant understood the English instructions that were given by the researcher. There is also no evidence to support the presence of dialectical differences in English that would accept the frontal lisp as a normal phonological process and not as a speech disorder (Wells, 1982).

h. attend mainstream schools, so as to avoid testing children with special needs, such as Down's syndrome or severe learning disabilities. Both of these diagnoses have been associated with speech production errors (Bankson & Bernthal, 1998a).

3.3.3 Participant Recruitment, Identification and Sampling

3.3.3.1 Recruitment of the control participants

The control participants were recruited from a co-educational, multiracial pre-primary school in Cape Town. The school operates from two campuses and teaches children between 4 and 7 years of age.

3.3.3.2 Identification of the control participants

The researcher was given a list, by both principals at the two school campuses, of children who they thought fitted all the participant selection criteria. The principal's information on each child was obtained from school records and routine audiological screening assessments, which had been administered by an audiologist assigned to their school.

3.3.3.3 Sampling of the control participants

Information sheets (See Appendix A) and consent forms (See Appendix B) were sent to 122 parents/guardians of children attending the two participating school campuses who appeared to meet the participant selection criteria. Of the 122 consent forms sent, 98 consent forms were signed and returned, indicating an adequate response rate of 88% (Babbie, 1995). When tested by the researcher, of the 98 potential participants, 14 presented with frontal lisps and were therefore transferred to the case group with parent/guardian consent. Of the remaining 84, four potential participants were randomly excluded to achieve the proposed sample size of 80.

3.3.3.4 Recruitment of the case participants

The case participants were recruited from the following referrals:

- The researcher's private speech therapy practice (N=21).
- Other speech therapists in private practice (N=33).
- Schoolteachers who had been informed about the study by speech therapists practising at their schools (N=12).
- Participants originally selected for the control group but who did not meet the criteria for control group selection because they presented with frontal lisps (N=14).

3.3.3.5 Identification of the case participants

The researcher informed members of STAPPO in the Western Cape (Speech Therapy Association Private Practitioners Organization) of the study and the participant selection criteria. Each member was requested to notify the researcher of any potential participants for this study.

3.3.3.6 Sampling of the case participants

In total, 88 potential participants who met with the selection criteria for the case group were referred individually from the sources mentioned above. Upon referral, each potential participant's parent/guardian was given an information sheet (See Appendix A) and consent form (See Appendix B) if they met the criteria for participant selection. This selection process continued over approximately four months. Upon testing by the researcher, 8 children referred for inclusion into the case group did not meet the criteria and were thus excluded. The reasons for exclusion were:

- six potential participants did not present with frontal lisps but presented with lateral lisps.
- one potential participant requested not to continue with the assessment because he felt anxious.
- one potential participant had a diagnosis of left hemiplegia and was receiving physiotherapy at the time of the study.

3.3.4 Description Of Participants

One hundred and sixty participants from the two participating school campuses and from private referrals were selected to participate in this study. All the participants met the selection criteria and were either assigned to the case group, consisting of 80 participants who presented with frontal lisps, or the control group, consisting of 80 participants who did not present with frontal lisps. All the participants tested in this study lived in the southern or northern suburbs of Cape Town. The main characteristics of the 160 participants used in the study are included in Table 1.

Table 1. Gender, Age, Grade, Race and Speech Errors of the Case and Control Groups

Participants	**Case**	**Control**
Gender		
Male	49	49
Female	31	31
Age (Yrs)		
Mean age	6.1	6.0
Age range	5.0 to 6.11	5.0 to 6.11
Grade		
Pre-primary	18	34
Grade 0	38	46
Grade 1	24	0
Race		
Black	4	6
Coloured	6	8
White	69	66
Asian	1	0
Speech Errors (other than a frontal lisp)		
Immature /r/	1	1
Substitution of /f/ for /θ/	21	17
Immature /r/ and a substitution of /f/ for /θ/	1	2

Note. Grades are not precisely defined, as the pre-schools involved in this study used different terminology. For instance, the group in which a child turns 5 can be called the Nursery, Middle group or Pre-primary whereas the group in which a child turns 6 can be called Grade 0, the Older group or Reception. However, the term Grade 1 (the year the child turns 7) was consistent for all the primary schools involved in this study.

3.4 Materials

3.4.1 Information Sheets

Information sheets (See Appendix A) were provided to parents/guardians of children who could be potential participants for this study. These sheets briefly informed the parent/guardian of the research project and the test procedures.

3.4.2 Consent Forms

Consent forms (see Appendix B) were sent to each potential participant involved in the study. The parent/guardian consented to their child's participation in this study be signing the form.

3.4.3 The Goldman-Fristoe Test of Articulation

a) Rationale For Choosing This Test

The Goldman-Fristoe Test of Articulation is a well respected test of individual sound production (Bleile, 1995), as it assesses all of the consonant sounds in the English language and is appropriate for pre-school and school age children (Bleile, 1995). It was thus possible to identify frontal lisps and production errors on /t/ and /k/, as per participant selection criteria. It also enabled the researcher to document the repertoire of articulation abilities in all the participants.

The Goldman-Fristoe Test of Articulation is also an uncomplicated test to administer because it tests several sounds within the stimulus word (Goldman & Fristoe, 1969). The simple, brightly coloured pictures stimulate the child to respond and reduce distractibility.

Bankson and Bernthal (1998b) state that the time required to administer a test and the attractiveness of the test materials are relevant factors in selecting a test. The test is also easily portable and the pictures are neatly displayed on an Easel-Kit. Although the validity and reliability of this test has not been established on various South African population groups, the researcher, in her clinical experience, has found that all the pictures are familiar to most children living in the suburbs of Cape Town. The researcher thus decided that this test would be suitable for children from the Cape Metropole.

b) Description of the Test

This test comprises three subtests but for the purpose of this study, only two of the subtests were administered. These included the Sounds-in-Words subtest and the Sounds-in-Sentences subtest. The Stimulability subtest was not included because it provides information regarding the order in which error sounds should be treated, which was not relevant to this study (Goldman & Fristoe, 1969).

The Sounds-in-Words subtest comprises of an Easel-Kit with 35 coloured pictures depicting objects and activities that are familiar to a young child

(Goldman & Fristoe, 1969). The Sounds-in-Sentences subtest consists of two narrative stories illustrated by sets of five or four pictures respectively (Goldman & Fristoe, 1969). Both subtests are designed to provide a systematic means of assessing an individual's articulation of consonant sounds, in all positions of words and in blends, that are found in English (Goldman & Fristoe, 1969).

c) Scoring of the Test

The scoring of the Goldman-Fristoe Test of Articulation is simple and involves an easy-to-use recording form. Phonetic transcription, place, voicing and feature analysis, phonological pattern/process analysis or age appropriateness of phonological productions were not recorded and were not the stated purpose of administering this test. This test scores and analyses sound productions in a variety of contexts (Goldman & Fristoe, 1969), and was thus appropriate for this study.

There is a form for recording each participant's response on the Sounds-in-Words Subtest and the Sounds-in-Sentences Subtest for the Goldman-Fristoe Test Of Articulation. The words being tested are coded by colour and number. This helps to designate the particular sound and to show the position of the sound being tested within each word (Goldman & Fristoe, 1969).

3.4.4 An Informal Recording Form

An informal recording form (See Appendix C) was formulated to record each participant's results in this study. This form was an abridged and adapted version of the form used by Thompson and Van Der Walt (1992) for their presentation of oral facial examinations. The standard oral facial examination usually involves examination of facial characteristics, teeth, palatal and pharyngeal areas and the tongue (Creaghead & Newman, 1985). The oral facial examination used in this study, however, only focused on the three oral facial variables being investigated, namely an anterior open bite, a tongue thrust swallow and DDK rates.

The informal recording form consisted of the following sections:

Section A: general information.

Section B: The results of the Goldman-Fristoe Test of Articulation. Speech errors were recorded to divide the participants into case (presented with a frontal lisp) or control (did not present with a frontal lisp) groups, to eliminate those children who did not fit the participant selection criteria because they presented with production errors on the /t/ or /k/ sounds and to record the presence of any other errors of speech.

Section C: The presence or absence of an anterior open bite.

Section D: The presence or absence of a tongue thrust swallow.

Section E: for recording the number of DDK repetitions for /t∂/, /k∂/ and /t∂k∂/ respectively.

3.5 Procedures

3.5.1 Pilot Study

A pilot study is recommended to refine the methodology of the main study (Katzenellenbogen et al., 1997). However, a pilot study was not conducted prior to this study. The researcher has 22 years work experience with children who present with articulation errors such as a frontal lisp and has routinely administered the standardized tests and observations included in the protocol of this study in her daily work.

3.5.2 Consent

Certain ethical procedures were followed before any participant was selected for this study.

- The research proposal received ethical approval by the Faculty of Health Sciences Research Ethics Committee of the University of Cape Town.
- Permission was obtained from the Western Cape Education Department to approach the schools selected to participate in the study.
- Permission was then requested and obtained from each of the principals at the two school campuses to recruit their learners as participants for this

study (See Appendix D).

- Information sheets (See Appendix A) and consent forms (See Appendix B) were sent to each potential participant's parent/guardian. Consent was obtained from each parent/guardian before testing was initiated.

3.5.3 Administration of the Goldman-Fristoe Test

- **Setting**

The case participants were assessed individually by the researcher in her private speech therapy room or in a speech therapy room attached to the referring school. Control participants were also assessed individually by the researcher in a private room, used for speech therapy purposes, at each of the two school campuses. All the testing environments were quiet, had adequate lighting and contained a table with two or three chairs.

- **Time**

In total, the administration of the Goldman-Fristoe Test of Articulation, the two observations involving anterior open bites and tongue thrust swallows, and scoring DDK rate, took approximately 30 minutes for each participant to complete. The assessments occurred over a period of approximately 4 months.

- **Method of Test Administration**

The assenting participant sat opposite the researcher, who established rapport by asking the participant general information. Each child's articulation was then screened for the presence or absence of a frontal lisp and errors on /t/ and /k/, by administering the Goldman-Fristoe Test of Articulation.

The procedure for the Sounds-in-Words Subtest required the researcher to read the instructions associated with each stimulus picture in a natural conversational style. For the Sounds-in-Sentences Subtest, the researcher read the first story to the child, who was then required to recount the story in his/her own words, using the pictures as memory aids. The same procedure was followed for the second story.

In both the Sounds-in-Words Subtest and the Sounds-in-Sentences Subtest, the researcher recorded the presence or absence of a frontal lisp and any other articulations errors, directly onto the assessment form. Children were then assigned to the case group (if they presented with a frontal lisp) or control group (if they did not present with a frontal lisp) or not accepted as a participant because of articulation errors on /t/ or /k/.

3.5.4 Observation of an Anterior Open Bite

This involved testing for the presence of an anterior open bite using the observational skills recommended by Mims et al. (1966), Creaghead et al. (1985) and Proffit (1986). Standard instructions were given to each participant to test for the presence of an anterior open bite. The instructions were as follows: *"I want you to bite your teeth together as hard as you can so that your back teeth come* *together. Then I am going to part your lips with my fingers to see if there is a gap between your front teeth. Are you ready, now bite…".*

An anterior open bite was marked as present on the assessment form if, while biting, the anterior teeth revealed a vertical space between the upper and lower incisors (Drane, 1996; Mims et al., 1966; Newman et al., 1985).

Orthodontists use cephalometric radiographs for measuring the exact width of an anterior open bite (Luke & Howard, 1983; Johnson & Sandy, 1999). However, this instrumentation was not used because the exact width of each participant's anterior open bite was not relevant to this study. Bernstein (1954) concluded that the extent of an anterior open bite does not seem to influence frontal lisping.

3.5.5 Observation of a Tongue Thrust Swallow

The researcher assessed for the presence of a tongue thrust swallow using the observational skills outlined by Fletcher et al. (1961) and Ward et al. (1961). These skills involved the researcher placing her fingers over the participant's masseter muscle and hyoid bone and using her thumbs to break the labial seal. This procedure exposed the participant's tongue for observation during swallowing.

Standard instructions were given to each participant to test for the presence of a tongue thrust swallow. The instructions were as follows: *"I want you to swallow for me while I put my hands on you like this (demonstration) and use my thumbs to part your lips like this (demonstration). Are you ready, now swallow..."*

Although a videofluoroscopy could be used to determine the presence of a tongue thrust swallow (Logemann, 1983), it was considered an invasive procedure, as it required the participants (children) to be unnecessarily exposed to radiation. In addition, speech therapists do not always have access to videofluoroscopy for the evaluation of a tongue thrust swallow. The researcher therefore suggests that in a developing country like South Africa, where professionals cannot always access formal instrumentation, observation is still an acceptable and unavoidable method of assessment.

A tongue thrust swallow has been defined as the tongue tip protruding against (Dworkin & Calutta, 1980) or between (Fletcher et al., 1961; Mason & Proffit, 1974) the anterior incisors. However, without videofluoroscopy, the former swallowing pattern cannot be accurately detected. Therefore, the researcher recorded the presence of a tongue thrust swallow on the informal recording form if, during the initiation of a swallow, a forward gesture of the tongue between the anterior incisors was observed (Mason & Proffit, 1974). This procedure was used by Fletcher et al. (1961) in their extensive survey of 1182 students from the first to the fourth grade. This swallowing pattern was not only easy to observe but it also related to the interdental tongue thrusting pattern associated with frontal lisping (Mason & Proffit, 1974).

3.5.6 Assessment of DDK Rate

This process involved assessing each participant's DDK rate, using the count-by-time procedure (Prathanee, 1998). This involved counting the number of syllables each participant repeated in 15 seconds. This procedure was recommended by Prathanee (1998) for large sample testing, because it limits the time to 15 seconds for each syllable repetition task. The count-by-time measurement of DDK rate is thus quicker to administer than the time-by-count measurement of DDK rate and therefore seemed more appropriate for the large scale screening involving small children, which was required for this study (Cohen et al., 1998). DDK rates were obtained from each participant on repetition of the following syllables involving tongue tip and tongue blade mobility: /t∂/ and /k∂/ representing alternating motion rate (Duffy, 1995) and /t∂k∂/ representing sequential motion rate (Duffy, 1995).

Cohen et al. (1998), Dworkin and Calutta (1985) and Lushei (1991) agree that the accuracy and validity of testing DDK rates in young children is questionable because of inter-participant variables. Thus performance on DDK tasks can be influenced by each child's aim in completing the task (Cohen et al., 1998; Luschei, 1991). This problem is exacerbated when instructions for the task are inconsistent and thus could be interpreted differently (Cohen et al., 1998; Luschei, 1991). To deal with this problem, the precise instructions given to each participant in this study, for each syllable sequence, were the same. The instructions were as follows: *"I want you to say some sounds for me as fast and as clearly as you can. You must start when I say 'go' and stop when I say 'stop'. I am going to count how many sounds you can make and at the end I am going to tell you how many sounds you made. I'll show you how to make each sound and then you can practise each sound until you feel ready to be timed. The first sound is…." A 60-second interval was given between each target utterance so that the researcher could demonstrate the next syllable sequence (Prathanee, 1998).*

Fletcher (1972) highlighted the fact that in the absence of formal instrumentation, a syllable counting technique involving a stopwatch was still an accurate estimate of DDK rate. Fletcher also suggested that the ease of data collection and the relatively low cost of stopwatches make a syllable count procedure an attractive alternative for data acquisition, especially in clinical assessments where time is such a critical factor. Thus a stopwatch was used to time each 15 second interval and the researcher marked each repetition of */t∂/*, */k∂/* and */t∂k∂/* with a pen stroke on paper.

Scoring DDK rate involved the researcher counting the number of syllables that each participant repeated in a 15 second time period. Each pen stroke was recorded as one point and at the end of each 15 second interval, the points were totaled and recorded (Prathanee, 1998).

3.6 Ethical Considerations

This research was informed by the Medical Research Council Ethics Guidelines (2005).

3.6.1 Autonomy

A parent/guardian of each child tested was required to sign an informed consent form (Appendix B) permitting participation in the study. Each parent/guardian was informed of the nature of the study and that participation was voluntary. The consent form clarified that personal benefit would not necessarily be derived and confirmed that participation could be discontinued at any time by parent/guardian or child, without penalty. Assent was also obtained from each participant and their wishes were respected. One potential participant requested not to continue with the assessment because he felt anxious and his assessment was immediately discontinued.

3.6.2 Confidentiality

All participants' names were recorded in Section A of the informal recording form (Appendix C). This record enabled the researcher to address each participant by name and thus establish rapport. However, for statistical and confidentiality purposes, each participant was allocated a number once testing was completed. All information on the recording form was kept confidential (locked in a file cabinet) and was available only to the researcher. Parents/guardians were assured that their child would not be identified in any way in the report or publications of the study.

3.6.3 Beneficence

Each child was assessed by a competent researcher with 22 years of experience in the field of articulation therapy for children and parents/caregivers were invited to contact the researcher for their child's results (Appendix A). Parents were always informed of whether their child needed therapy. Three parents/guardians of the control group and 47 parents/guardians of the case group contacted the researcher for feedback on their child's performance.

3.6.4 Non-Maleficence

The researcher treated none of the participants referred by other speech therapists after the study was completed. There was thus no supercession arising from the research process. No participants were harmed in any way.

3.7 Validity

The validity of the study was enhanced by the use of a standard protocol based on a review of the literature (Katzenellenbogen et al., 1997). The assessment of speech production involved the Goldman-Fristoe Test of Articulation, which is a well respected articulation test for children (Bleile, 1995). The presence of an anterior open bite was assessed using the observational skills recommended by Proffit (1986), who is well respected in the field of contemporary orthodontics. A tongue thrust swallow was assessed using the observational skills recommended by Fletcher et al. (1961), who used these skills for extensive surveys involving young children. In addition, a tongue thrust swallow was marked as present if the tongue protruded through the anterior incisors, which Mason and Proffit (1974) reported to be a reliable observation. DDK rate was assessed using the count-by-time procedure, which is recommended for large sample testing (Prathanee, 1998).

3.8 Sampling Bias

All the parents/guardians of the 80 case participants signed and returned a consent form. However, 24 of the 122 parents/guardians who received consent forms to be potential participants in the control group did not return their consent forms. To eliminate any bias in the sampling procedure, these 24 parents/guardians were telephoned by the researcher to ensure that the reasons for not consenting were not associated with any of the test procedures being administered.

The most common reason (15 out of 24) was that the parent/guardian had forgotten to return the consent form. None of the reasons given to the researcher for not returning the consent forms were associated with any of the tests being administered to the control participants. Detailed reasons are in Appendix E.

3.9 Inter- rater Reliability

As the data collection process for information on anterior open bites, tongue thrust swallows and DDK rate all involved subjective rating, it was deemed important to include inter-rater reliability measures to ensure accuracy and to prevent measurement bias (Katzenellenbogen et al., 1997). For the same reason, substantial statistical analysis was devoted to testing inter-rater reliability.

The researcher and an independent rater assessed 10% of the case participants (8 of 80 case participants) and 10% of the control participants (8 of 80 control participants). The independent rater was a private speech therapist with 15 years of experience who works primarily with children presenting with speech disorders.

The researcher and the independent rater assessed simultaneously but independently every 10th referral in the case and control groups. According to Fleiss (1981), this percentage is adequate for inter-rater reliability measures. The researcher and the independent rater did not discuss their results until each assessment form had been completed. This procedure blinded the assessors to each other's ratings, which was important to address bias.

Inter-rater reliability was analyzed separately for each of the three oral facial variables tested, namely anterior open bites, tongue thrust swallows and DDK rate. The measurements for anterior open bites and tongue thrust swallows were nominal (i.e. absent/present) and accordingly, the Kappa (K) statistic was used to measure the agreement between the researcher and the independent rater (Armitage, Berry & Mathews, 2001; Collett, 1991). The researcher and the independent rater both tested 16 participants - eight from the case group and eight from the control group.

A summary of the inter-rater results for anterior open bites is depicted in Table 2 below.

Table 2. Comparison of Researcher and Independent Rater Scores for Anterior Open Bites

	Anterior open bite absent		**Anterior open bite present**	
Group	Researcher	Rater	Researcher	Rater
Case	7	7	1	1
Control	8	8	0	0

Note. The researcher and the independent rater scored an anterior open bite as present or absent in the same participants.

As can be seen in Table 2, there was 100% agreement between the researcher and the independent rater for both the control and the case group and in each case a Kappa (K) statistical score of 1 was obtained.

A summary of the inter-rater results for tongue thrust swallows is depicted in Table 3 below.

Table 3. Comparison of Researcher and Independent Rater Scores for Tongue Thrust Swallows

	Tongue Thrust Swallow Absent		Tongue Thrust Swallow Present	
Group	Researcher	Rater	Researcher	Rater
Case	7	7	1	1
Control	7	7	1	1

Note. The researcher and the independent rater scored tongue thrust swallow as present or absent in the same participants.

As can be seen in Table 3, there was 100% agreement between the researcher and the independent rater for both the control and the case group and in each case a Kappa (K) statistical score of 1 was obtained.

In summary, there was 100% agreement between the scores of the researcher and the independent rater for the presence or absence of an anterior open bite and a tongue thrust swallow.

The extent of the correlation between the researcher and the independent rater on DDK rates counted for /tə/, /kə/ and /təkə/ is graphically represented on scatter diagrams presented in Figures 1, 2 and 3 below.

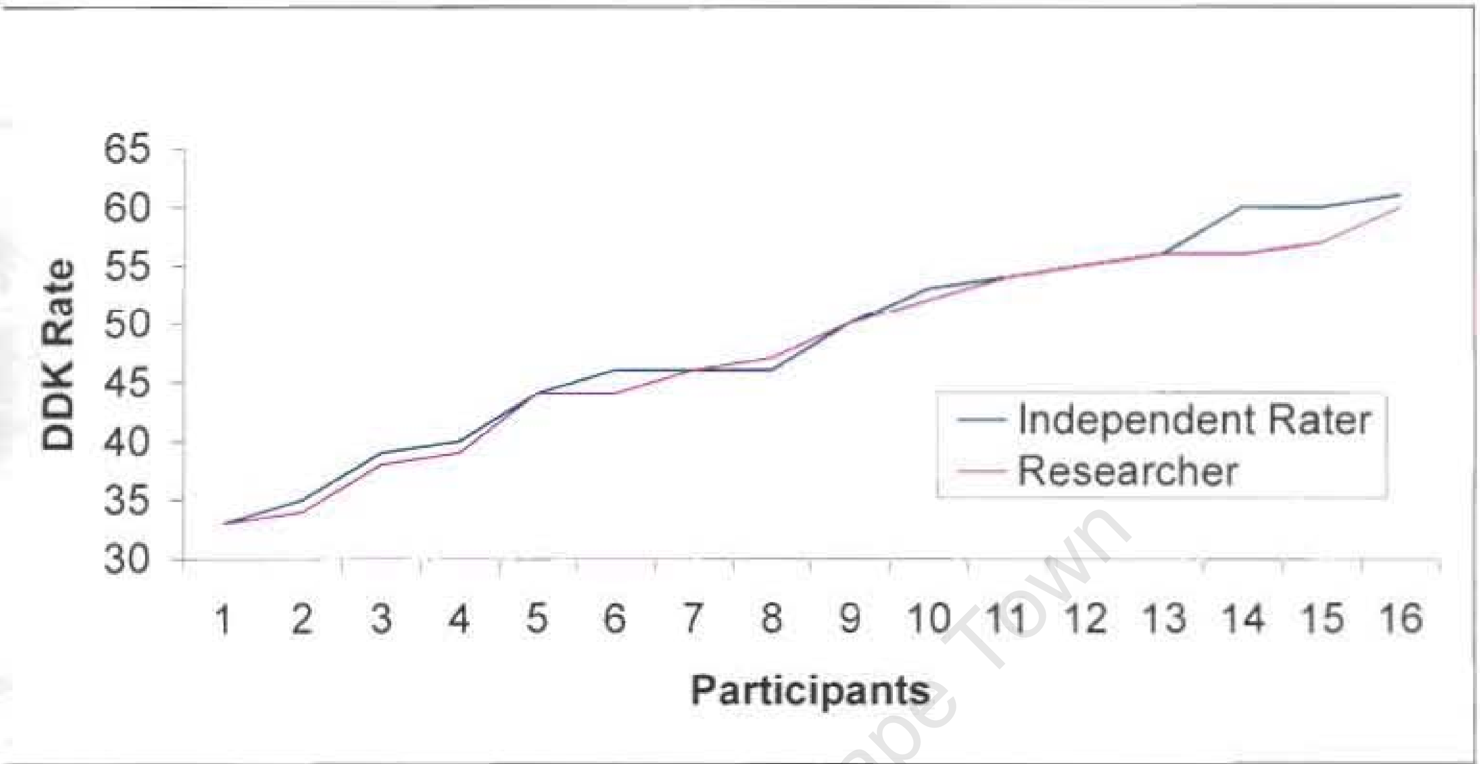

Figure 1. A line diagram plotting the independent rater and researcher's counts (Y) against participants arranged in order of increasing counts (X) for /tə/.

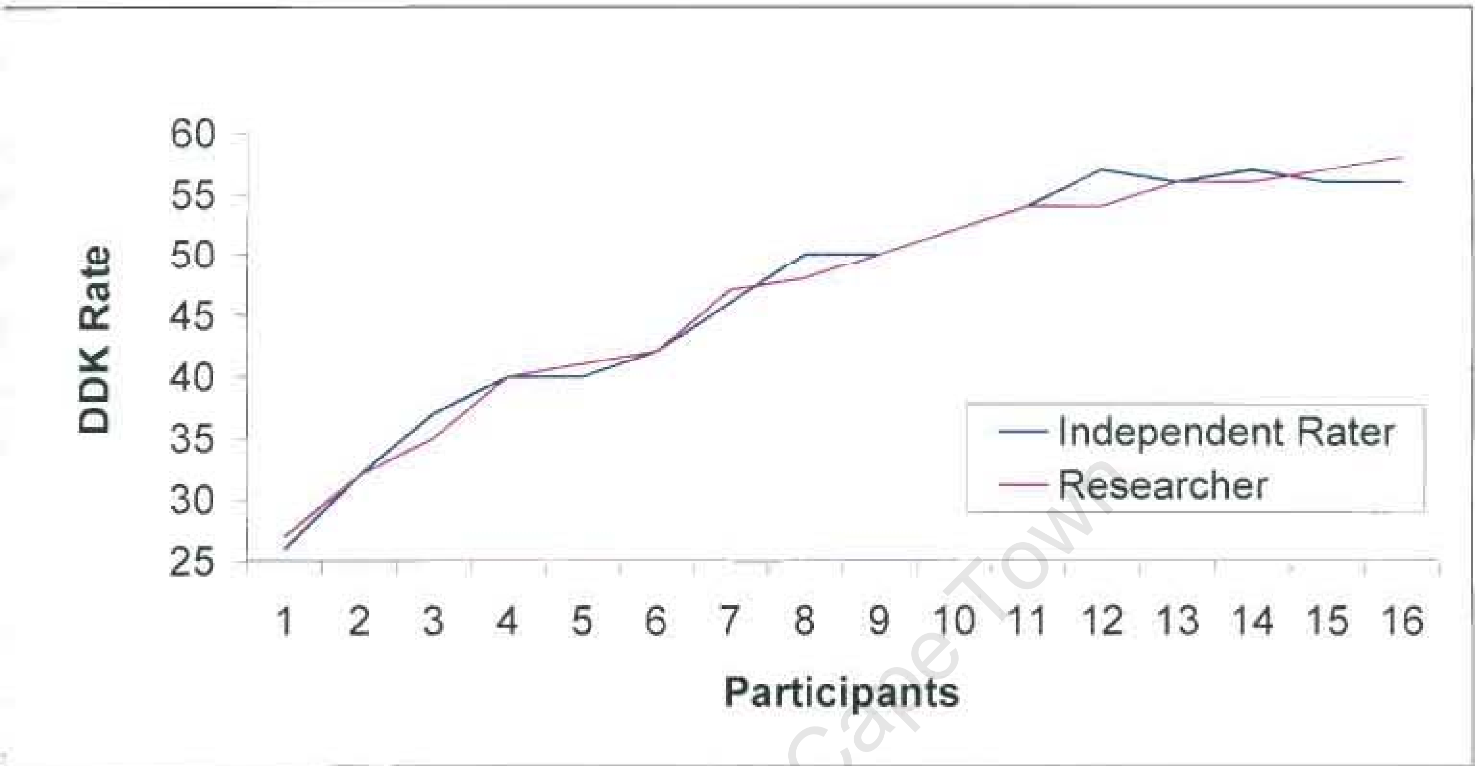

Figure 2. A line diagram plotting the independent rater and researcher's counts (Y) against participants arranged in order of increasing counts (X) for /k∂/.

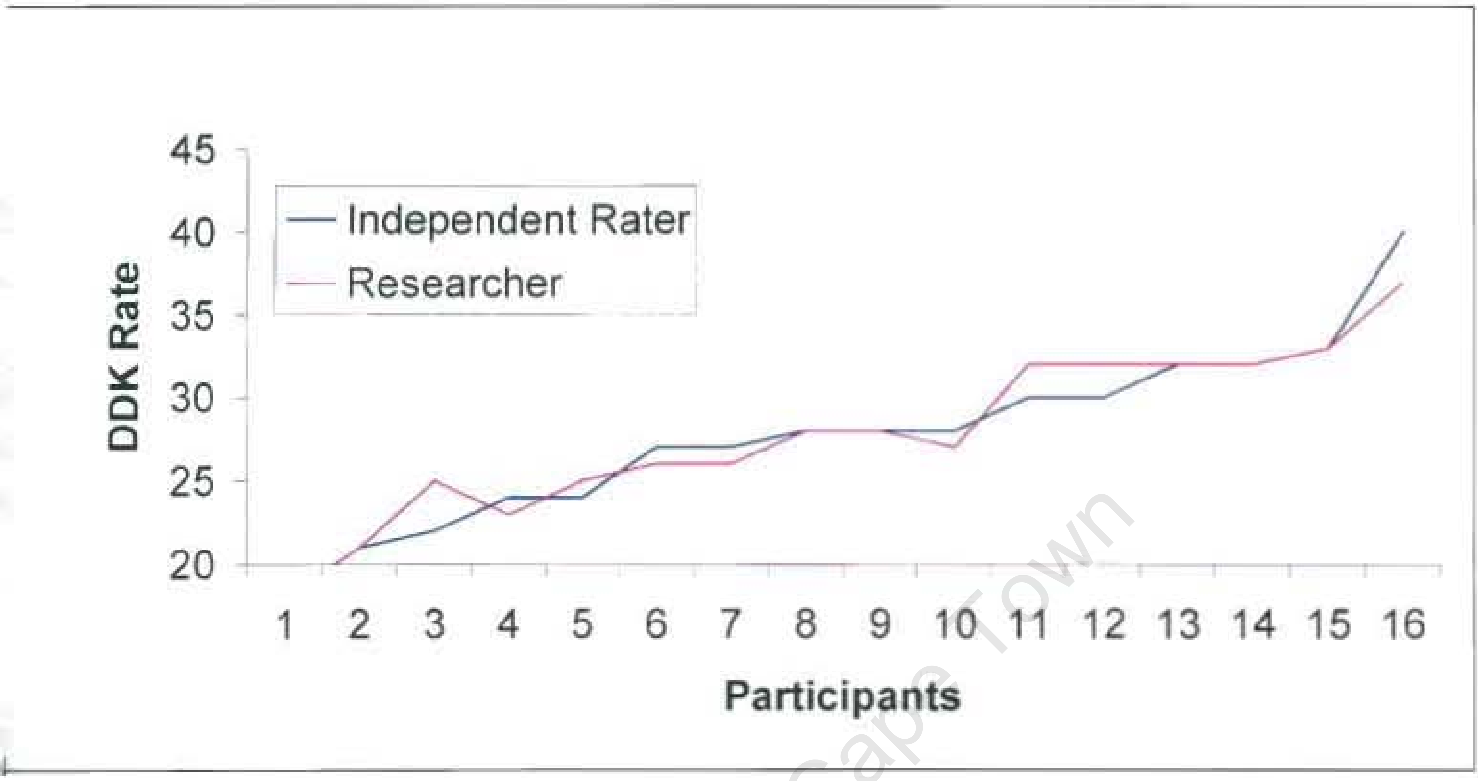

Figure 3. A line diagram plotting independent rater and researcher's counts (Y) against participants arranged in order of increasing counts (X) for /t∂k∂/.

The degree of correlation was analyzed further by Regression Analysis, which is summarized in Table 4.

Table 4. DDK Rates – Regression Analysis of Researcher and Independent Rater Scores.

Sound	**Correlation**
t∂	.990
k∂	.991
t∂k∂	.964

Note. There were highly significant correlations between the scores of the researcher and the independent rater ($p < .004$).

In order to compare two raters, Altman (1991) suggests that comparisons should be made on the differences between the two raters' scores. Thus inter-rater reliability was tested further by calculating between rater reliability. The reliability statistic used was the intra class correlation co-efficient, which is the correlation between measurements made on the same participant by the two raters (Armitage et al., 2001). The results are presented in Table 5 below.

Table 5. Between Rater Reliability for DDK Rates of 16 Participants

Statistics	t∂	k∂	t∂k∂
Mean	48.30	46.90	27.80
Mean difference	-.81	-.12	-.06
SD of the difference	1.33	1.31	1.44
SD of the sum	17.63	19.34	10.21
Intra class correlation co-efficient	.99	.99	.98

Note. The researcher and the independent rater scored tongue thrust swallow as present or absent in the same participants.

There was very good between rater reliability on all three variables, namely /t∂/, /k∂/, and /t∂k∂/. The mean difference between the scores of the two raters was small compared to the mean total. The reliability of the rating scores was 99%, 99% and 98% for /t∂/, /k∂/, and /t∂k∂/ respectively.

In summary, the researcher's counts/scores and the independent rater's counts/scores correlated perfectly for anterior open bites and tongue thrust swallows, and showed a high degree of correlation for DDK rate. Accordingly researcher bias was deemed not to impact significantly on the data collected and statistical analysis proceeded.

3.10 Analysis of Data

Data was collected by the researcher for the case group of 80 participants and for the control group of 80 participants for three oral facial variables, namely anterior open bites, tongue thrust swallows and DDK rate. Frequency of occurrence of each variable was tabulated and these tables appear in Appendix F (case group) and Appendix G (control group). For statistical purposes, present was scored as 1 and absent as 0 for anterior open bites, tongue thrust swallows and concurrence of these variables. DDK rates were counted per 15 second time intervals. Data collected by the independent rater (for reliability purposes) is reflected in the second line of data for participants number 10, 20, 30, 40, 50, 60, 70 and 80 in Appendices F and G.

3.10.1 Frequency of anterior open bites, frequency of tongue thrust swallows and frequency of concurrence of anterior open bites and tongue thrust swallows

The frequency of anterior open bites, the frequency of tongue thrust swallows and the frequency of concurrence of anterior open bites and tongue thrust swallows in the case and control groups was compared using Fisher's Exact Test. According to Collett (1991), this is an appropriate test to use on nominal data.

3.10.2 Probability of a frontal lisp occurring if an anterior open bite, a tongue thrust swallow or concurrence of an anterior open bite and a tongue thrust swallow were present.

This was calculated using case - control logistic regression (Collett, 1991). Collett shows that logistic regression can be used to estimate the odds of a participant presenting with a frontal lisp if they present with a risk factor. In this study these risk factors are the presence of an anterior open bite, a tongue thrust swallow or concurrence of these two variables.

3.10.3 Analysis of DDK rates in the two groups

For each participant, DDK rates were reported per time interval of 15 seconds. The rate was the number of times the subject uttered a specific syllable (/t∂/, /k∂/ and the bi-syllable /t∂k∂/) within that time interval. Unlike the scores for the presence or absence of anterior open bites and tongue thrust swallows, DDK rates involved counts (i.e. rates) and accordingly provided data of a ratio level of measurement. As the data is not normally distributed, the non-parametric Mann-Whitney U Test was used (Sprent & Smeeton, 2001), to test for differences between DDK rates.

4. RESULTS

The results are presented in accordance with the aims of the study. Thus the results for the frequency of anterior open bites, tongue thrust swallows and concurrence of anterior open bites and tongue thrust swallows in the two groups, the probability of a frontal lisp occurring in the presence of an anterior open bite, a tongue thrust swallow or concurrence of an anterior open bite and a tongue thrust swallow and DDK rates in the two groups are presented. Each of the seven aims is restated under the headings below.

4.1 Frequency of anterior open bites in the two groups

The aim was to determine whether there was a higher frequency of anterior open bites in the case group relative to the control group. The frequency of anterior open bites in the case and control groups was compared using Fisher's exact test.

The results reflecting the frequency of anterior open bites in the case and control group are presented in Table 6.

Table 6. Frequency of an anterior open bite.

Category	Case Group (%) N	Control Group (%) N
AOB Present	(20%) 16	(3.75%) 3
AOB Absent	(80%) 64	(96.25%) 77
Total	(100%) 80	(100%) 80
95% Confidence interval	11.2% to 28.8%	2.69% to 4.81%

Note. Frequency in the two groups significantly different, $p < .003$

The case group presented with 20% anterior open bites, while the control group presented with 3.75%. There were significantly more participants with anterior open bite in the case group than in the control group, $p < .003$. There was no overlap between the confidence intervals indicating that it may be concluded, with a 95% degree of confidence, that there were significantly more participants presenting with anterior open bite in the case group than in the control group. Thus those participants with frontal lisping presented with a significantly higher frequency of anterior open bite than those participants without frontal lisping.

4.2 Probability of a frontal lisp in the presence of an anterior open bite

The aim was to determine how much more likely it was (i.e. what were the odds) that a participant would also present with a frontal lisp, if that participant presented with an anterior open bite.

The likelihood of a participant with an anterior open bite presenting with a frontal lisp was determined using an odds ratio . The odds ratio (OR) was defined as:

$$OR = \frac{\text{Odds on being a frontal lisper if an anterior open bite is present}}{\text{Odds on being a frontal lisper if an anterior open bite is absent}}$$

The odds ratio indicated that a participant who presented with an anterior open bite was 6.47 times more likely (i.e. the odds ratio was 6.47) to have a frontal lisp. As 6.47 is substantially greater than one (which would signal no significant difference at the 95% confidence interval) it can be concluded that the presence of an anterior open bite significantly increased the likelihood of that participant also having a frontal lisp.

4.3 Frequency of tongue thrust swallows in the two groups

The aim was to determine whether there was a higher frequency of tongue thrust swallows in the case group relative to the control group. The frequency of tongue thrust swallows in the case and control groups was compared using Fisher's exact test.

The results reflecting the presence or absence of tongue thrust swallows in the case and control group are presented in Table 7.

Table 7. Frequency of a tongue thrust swallow.

Category	Case Group (%) N	Control Group (%) N
TTS Present	(28.8%) 23	(6.25%) 5
TTS Absent	(71.2%) 57	(93.25%) 75
Total	(100%) 80	(100%) 80
95% Confidence interval	18.9% to 38.7%	5.6% to 7.7%

Note. Frequency in the two groups significantly different, $p < .001$

The case group presented with 28.8% of tongue thrust swallows, while the control group presented with 6.25%. There were significantly more participants with tongue thrust swallows in the case group than in the control group, $p < .001$. There was no overlap between the confidence intervals, indicating that it may be concluded, with a 95% degree of confidence, that there were significantly more participants presenting with tongue thrust swallows in the case group than in the control group. Thus those participants with frontal lisping presented with a significantly higher frequency of tongue thrust swallow than those participants without frontal lisping.

4.4 Probability of a frontal lisp in the presence of a tongue thrust swallow

The aim was to determine how much more likely it was (i.e. what the odds were) that a participant would present with a frontal lisp, if that participant presented with a tongue thrust swallow.

The likelihood of a participant with a tongue thrust swallow presenting with a frontal lisp was determined using an odds ratio (OR) calculated as follows:

$$OR = \frac{\text{Odds on being a frontal lisper if a tongue thrust swallow is present}}{\text{Odds on being a frontal lisper if a tongue thrust swallow is absent}}$$

The odds ratio indicated that a participant who presented with a tongue thrust swallow was 6.05 times more likely to have a frontal lisp. As 6.05 is substantially greater than one (which would signal no significant difference at the 95% confidence interval) it can be concluded that the presence of a tongue thrust swallow significantly increased the likelihood of that participant also having a frontal lisp.

4.5 Frequency of the concurrence of anterior open bites and tongue thrust swallows in the two groups

The aim was to determine whether there was greater concurrence of anterior open bites and tongue thrust swallows in the case group than in the control group. The frequency of this concurrence was compared using Fisher's Exact Test. The results reflecting the frequency of concurrence of anterior open bites and tongue thrust swallows in the case and control group are presented in Table 8.

Table 8. Concurrence of an Anterior Open Bite and a Tongue Thrust Swallow.

Category	Case Group (%) N	Control Group (%) N
Jointly Present	(18.75%) 15	(3.75%) 3
Not jointly present	(81.25%) 65	(96.25%) 77
Total Participants	(100%) 80	(100%) 80
95% Confidence interval	10.59% to 29.03%	0.786% to 10.57%

Note. Concurrence differs significantly at $p < .005$

The case group presented with 18.75% concurrence, while the control group presented with 3.75%. There were significantly more participants with concurrence of anterior open bites and tongue thrust swallows in the case group than in the control group, $p < .005$. There was no overlap between the confidence intervals, indicating that it may be concluded, with a 95% degree of confidence, that there were significantly more participants presenting with a concurrence of anterior open bites and tongue thrust swallows in the case group than in the control group. Thus those participants with frontal lisping presented with a significantly higher frequency of concurrence of anterior open bites and tongue thrust swallows than those participants without frontal lisps.

4.6 Probability of a frontal lisp in the presence of concurrence of an anterior open bite and a tongue thrust swallow

The aim was to determine how much more likely it was (i.e. what the odds were) that a participant would present with a frontal lisp, if that participant presented with concurrence of an anterior open bite and a tongue thrust swallow.

The likelihood of a participant with concurrence of an anterior open bite and a tongue thrust swallow presenting with a frontal lisp was determined using an odds ratio (OR) calculated as follows:

$$OR = \frac{\text{Odds on being a frontal lisper if concurrence is present}}{\text{Odds on being a frontal lisper if concurrence is absent}}$$

The odds ratio indicated that a participant who presented with concurrence of an anterior open bite and a tongue thrust swallow was 6.7 times more likely to have a frontal lisp. As 6.7 is substantially greater than one (which would signal no significant difference at the 95% confidence interval) it can be concluded that the presence of concurrence of an anterior open bite and a tongue thrust swallow significantly increased the likelihood of that participant also having a frontal lisp.

4.7 DDK rates in the two groups

The aim was to determine whether the case group (frontal lispers) had slower DDK rates than the control group (i.e. non frontal lispers). This result was determined using the Mann-Whitney U Test (Sprent & Smeeton, 2001).

The results of this test and the arithmetic means of the DDK rates for each group are presented in Table 9.

Table 9. DDK performance.

Syllable	Control M No. Reps.	Case M No. Reps.	Mann-Whitney U statistic	*p* value
/tə/	49.06	49.99	2940.5	.376*
/kə/	45.36	46.13	3013.5	.524*
/təkə/	28.09	28.12	3186.5	.963*

Note. No significant difference between case and control groups at $p < .05$.

The results indicate that the DDK rates of the case group (i.e. participants with frontal lisps) for */tə/*, */kə/* and */təkə/* were not slower than the DDK rates of the control group (i.e. participants without frontal lisps).

4.8 Summary of results

The results indicated that the case group (i.e. children with frontal lisps) presented with a significantly higher frequency of anterior open bite, tongue thrust swallow and concurrence of anterior open bite and tongue thrust swallow than the control group (i.e. children without frontal lisps). In addition, participants with anterior open bite, or a tongue thrust swallow, or concurrence of anterior open bite and tongue thrust swallow were 6 times more likely to present with a frontal lisp than participants without an anterior open bite, a tongue thrust swallow or concurrence of these variables. However, there was no evidence that the case group had slower DDK rates than the control group. Thus no further statistical analysis of DDK rates was performed.

5. DISCUSSION

In this section, the findings are discussed in accordance with the aims of the study.

The findings of this study suggested that a structural variable such as an anterior open bite was significantly associated with frontal lisping. In fact, a child with an anterior open bite was six times more likely to present with a frontal lisp than a child who did not present with an anterior open bite. However, the results do not indicate that the anterior open bite should be viewed as a cause of frontal lisping but merely as a variable that may coexist with a frontal lisp. Hence, the presence of an anterior open bite is associated with or may co-occur with frontal lisping.

The results of this study are in agreement with Bernstein (1954), Jann et al. (1964), Mims et al. (1966) and Turvey et al. (1976) who suggested that there was an association between an anterior open bite and frontal lisping. These results seem to indicate that when an individual has an anterior open bite, there is a greater likelihood of there also being a frontal lisp.

According to the theory on coordinative structures (as cited by Levelt, 1989), the participants who presented with anterior open bites and frontal lisps, may have had poor proprioceptive feedback between the two tiers in their executive motor system. The lower command centre may not have been able to send or process accurate messages to the upper command centre, via tactile, proprioceptive and kinesthetic feedback from the tongue, regarding the presence of the anterior open bite. The upper command centre may therefore have not been able to receive or process this information and design and send the appropriate adjusted phonetic plan to the lower centre. The lower centre may then not have been able to execute the necessary adaptions to the altered oral context (Levelt, 1989). This faulty feedback may have resulted in a frontal lisp.

The faulty feedback between the lower and upper centres may be because these participants acquired /s/ and /z/ after the development of the anterior open bite. They may not have had a normal articulatory environment in which to acquire and produce /s/ and /z/, resulting in a frontal lisp. These participants were therefore required to use their existing articulatory milieu to produce /s/ and /z/. Thus their exposure may have only been to tactile, proprioceptive and kinesthetic feedback from the tongue in an irregularly structured oral environment (Konst, Rietveld, Peters & Prahl-Andersen, 2003).

However, in this study, there were participants who presented with an anterior open bite but no frontal lisp. This phenomenon may also be accounted for by the theory of coordinative structures. These participants may have had an intact two-tiered executive motor system. The lower command centre may have been able to send accurate messages to the upper command centre, via tactile, proprioceptive and kinesthetic feedback, regarding the presence of an anterior open bite. The upper command centre may have been able to receive and process this information and send the appropriate context adjusted phonetic plan to the lower centre. The lower centre may then have been able to execute the necessary adaptions or compensatory positioning of the tongue, resulting in the correct production of /s/ and /z/ (Levelt, 1989).

This accurate feedback between the lower and upper centres may be because these participants acquired /s/ and /z/ before the development of the anterior open bite. Thus they may have had a normal articulatory environment in which to acquire and produce /s/ and /z/, resulting in accurate production of these sounds. Their exposure may have only been to tactile, proprioceptive and kinesthetic feedback from the tongue in a regularly structured oral environment (Konst et al., 2003).

Thus it is speculated that if a child developed /s/ and /z/ before the development of the anterior open bite, their experience of producing /s/ and /z/ in a normal structured oral cavity may assist them in maintaining this correct production, despite the later development of an anterior open bite . This maintenance may be reinforced by the auditory, kinesthetic, proprioceptive and tactile feedback that occurred prior to the anterior open bite and which continued despite the later development of the anterior open bite. In other words, the child develops normal production of /s/ and /z/ using multimodality channels such as auditory, kinesthetic and tactile feedback within a normal articulatory environment, and this pattern of articulation is maintained, even in the presence of a developing anterior open bite. However, if the anterior open bite develops before /s/ and /z/ are acquired in speech development, the child may not have been exposed to a normal oral articulatory environment and thus may use the existing articulatory milieu, with an anterior open bite, to produce /s/ and /z/, which could result in a frontal lisp.

However, it was not in the scope of this study to determine whether frontal lisping was more closely associated with an anterior open bite which occurred prior to the production of /s/ and /z/, or more associated with an anterior open bite which occurred after the production of /s/ and /z/. Proffit (1986) reports that most anterior open bites that develop before the production of speech, are genetically determined, whereas anterior open bites that develop after the production of speech, are environmentally determined. However, Larsson (1994) and Moore (1996) suggest that it is very difficult to differentiate an anterior open bite into environmental or genetic, because most anterior open bites develop as a combination of both of these factors. Further research in this area is clearly needed to challenge or strengthen the explanations presented in this study.

Bloomer's theory on adaption (1971), would describe participants with anterior open bites and frontal lisps as having an abnormal oral structure and abnormal oral functioning, whereas participants with anterior open bites and no frontal lisps would be described as having abnormal oral structures but good adaptive tongue function, resulting in normal speech. It could therefore be argued that it is not the anterior open bite itself that is the correlate of a frontal lisp but rather the child's inability to adapt and adjust their articulation to compensate for this oral facial variable.

A further possible explanation for the higher frequency of anterior open bites in children who present with frontal lisps, is that it is not the anterior open bite per se which is associated with the frontal lisp, but the cause of the anterior open bite (Kellum et al., 1994). Thumb sucking is one of the most common causes of an anterior open bite (Proffit, 1989) and therefore is also associated with frontal lisping (Kellum et al., 1994). It is therefore proposed that a prolonged sucking habit cannot be ignored when attempting to investigate the association between an anterior open bite and a frontal lisp.

Turgeon-O'Brien, Lachapelle, Gagnon, Larocque and Maheu-Robert (1996) reported that the anterior tongue movement patterns associated with a prolonged non-nutritive sucking habit, may influence the interdental tongue placement for /s/ and /z/, which is classified as a frontal lisp. Viewed anatomically, the intrinsic superior longitudinal muscle involved in shortening and curling the tongue tip upwards, may be underutilized during a sucking activity whereas the muscles which flatten the tongue, the inferior longitudinal and vertical muscles, may be overutilized (Kellum et al., 1994). Thus the sucking habit reinforces the same forward, interdental, ungrooved tongue position adopted for a frontal lisp (Kellum, et al., 1994; Turgeon-O'Brien et al., 1996).

It was not in the scope of this study to determine whether frontal lisping was associated with a prolonged sucking habit. Thus further research is clearly needed to determine the nature of the association between a prolonged non-nutritive sucking habit and frontal lisping. However, future methodologies should include both quantitative (the frequency, forcefulness/intensity and duration of the sucking habit) and qualitative (description of the object being sucked, the depth of insertion and position of the object within the oral cavity) measures, as these variables may have different influences on the production of /s/ and /z/ (Luke & Howard, 1983).

There is controversy in orthodontic research over the exact age a non-nutritive sucking habit should stop, to prevent the development of an anterior open bite. Friman (1989), Fukuta, Braham, Yokoi and Kurosu (1996) and Luke and Howard (1983) suggest that the habit should cease at 4 years of age whereas Leung and Robson (1991) and Turgeon-O'Brien et al., (1996) suggest the habit should stop at 6 years of age. Perhaps a conservative approach, in the light of this controversy, would be to encourage the discontinuance of non-nutritive sucking habits from 4 years onwards (V.P. Joseph, personal communication, October 1, 2004). Many parents of "dummy suckers" feel justified in switching their child from a conventional dummy to an orthodontic dummy in the hope that this will prevent an anterior open bite at a later stage (Drane, 1996). However, there is no evidence that orthodontic dummies are more effective in preventing anterior open bites than conventional dummies (Drane, 1996).

Information pertaining to the association between a prolonged non-nutritive sucking habit and the development of an anterior open bite, and the association between an anterior open bite and frontal lisping, could be utilized in preventative counseling. Knowledge of these associations and discouraging a non-nutritive sucking habit from the age of four years could be disseminated in a variety of ways such as pamphlets, informative talks or workshops. Recipients of this information could be other professionals involved with health promotion and disease prevention in young children such as nurses at well-baby clinics, general practitioners and pediatricians.

The speech therapist has a direct therapeutic role when a child presents with a frontal lisp and an anterior open bite (Johnson & Sandy, 2002). This role is necessary because of the child's inability to make the appropriate articulatory adjustments for the correct production of /s/ and /z/. The child is encouraged, through adaptive phonetic placement techniques (Johnson & Sandy, 2002), to experiment and adapt tongue positioning so as to produce the most precise /s/ and /z/ sounds (Ohde & Shaft, 1992). Subtelny et al. (1964) suggest that children with frontal lisps and an anterior open bite should be encouraged to produce /s/ and /z/ with the tongue tip depressed and positioned slightly behind the lower incisor teeth, as in their experience, this tongue position is mostly associated with a precise /s/ and /z/ production, despite the presence of an anterior open bite.

Limitations of this study include the method used to measure the anterior open bite, whereby a binary measure (i.e. absent or present) was used. A binary measurement does not take into account the severity of the anterior open bite (i.e. the size of the gap), which could be precisely determined with instruments (Ngan & Fields, 1997). Future research could measure the degree of an anterior open bite using scientific means to determine whether there is a correlation between the size of an anterior open bite and the production of /s/ and /z/.

Accurate measurement of an anterior open bite is best determined in children who possess a full complement of permanent teeth (Jann et al., 1964). However, the children used as participants in this study were between 5 and 7 years and thus in a stage of mixed dentition. Thus the difficulty of accurately identifying an anterior open bite is an inherent limitation in studies of this age group.

Further findings of this study suggested that a tongue thrust swallow (a functional variable) was significantly associated with frontal lisping. In fact, a child with a tongue thrust swallow was six times more likely to present with a frontal lisp than a child who did not present with a tongue thrust swallow. More specifically, the incorrect interdental tongue position present in participants with frontal lisps, seems to be associated with the incorrect interdental tongue position observed during swallowing, defined as a tongue thrust swallow. However, the results of this study do not indicate that the tongue thrust swallow should be viewed as a cause of frontal lisping but rather as a variable that may coexist with frontal lisping.

The results of this study support the findings of an association between a tongue thrust swallow and a frontal lisp, reported by researchers (Fletcher et al., 1961; Jann et al., 1964; Mason & Profitt, 1974; Subtelny et al., 1964; Ward et al., 1961). These results indicate that when there is a tongue thrust during swallowing, there is a greater likelihood of the individual also demonstrating a frontal lisp.

The results of this study may be explained by the different levels of demand required from the tongue for the functions of swallowing and the precise production of /s/ and /z/ (Levelt, 1989). It is possible that speech production requires an increased precision of movement and co-ordination than swallowing (Levelt, 1989). Thus swallowing and speech may require different levels of demand in terms of tongue coordination and therefore different degrees of freedom to attain the goal (Levelt, 1989).

The possible differences in degrees of freedom for speech and swallowing, suggest that if an articulatory structure such as the tongue, does not function adequately for swallowing (which may have a lower precision requirement than speech), then there is a greater likelihood of there being a lack of adequate performance of this articulator for the production of /s/ and /z/ (which has a higher precision requirement than swallowing). In other words, if the tongue appears not to adapt its functioning during swallowing, it may also be likely that it would not be able to adapt its function for the production of /s/ and /z/. The results of this study seem to support this notion.

In this study, participants with tongue thrust swallows did not present with errors on other tongue tip phonemes, such as /t/ and /d/. Thus no potential participants had to be excluded from the study because they presented with errors on /t/. The fact that /s/ and /z/ were affected by a tongue thrust swallow and not other tongue tip phonemes such as /t/ and /d/, may relate to the degree of difficulty associated with the production of individual sounds, since the sounds acquired last in developmental sequence are those most often affected by structural or functional variation (Johnson & Sandy, 1999). /s/ and /z/ are more complex sounds than /t/ and /d/, require greater precision of articulatory movement and are acquired later in developmental sequence (Kent, 1998). In addition, the productions of /s/ and /z/ have fewer contact markers than /t/ and /d/ (where the tongue is in direct contact with the mucous lining of the oral cavity) and therefore there may be less proprioceptive feedback, in particular sensory feedback, to assist with the correct production of these sounds (Levelt, 1989).

The association between a tongue thrust swallow and frontal lisping has clinical implications. According to Barnes (1994), Christensen and Hanson (1981) and Netsell (1986), children receiving therapy for a frontal lisp, with an associated tongue thrust swallow, would begin speech therapy with an unnecessary disadvantage if they did not initially receive myofunctional therapy to address the tongue thrust swallow. Thus myofunctional therapy may need to be initiated before place-feature oriented articulation therapy for the frontal lisp (Christensen & Hanson, 1981). This approach implies that the more basic lingual function in swallowing should be addressed prior to remediating lingual function in a speech production task.

However, this approach to speech therapy for a child who presents with a tongue thrust swallow and a frontal lisp suggests that speech is a behaviour which emerges from earlier appearing oromotor behaviours such as swallowing (Moore & Ruark, 1996; 1997). Yet according to the coordinative structures theory (cited by Levelt, 1989) and investigations from prominent researchers in the field such as Moore and Ruark, speech develops independently from swallowing and the movements for speech and swallowing are task specific and unrelated. Thus according to the coordinative structures theory, myofunctional therapy can be provided to address a tongue thrust swallow but not in the hope that the correct tongue movements for swallowing will carry-over into the correct movements for the production of /s/ and /z/. The treatment for swallowing (myofunctional therapy) and the treatment for a frontal lisp (place-feature oriented articulation therapy) may be unrelated because the physiological movements for speech and swallowing are task specific (Moore & Ruark, 1996; 1997).

The speech therapist needs to be aware that the presence of a tongue thrust swallow may require additional specialist referral (Mason, 1988). For instance, referral to an Ear, Nose and Throat (ENT) Specialist is recommended when tonsils or adenoids are enlarged, occupy more space in the throat and thus obstruct the breathing passageway (Mason, 1988). This enlargement forces the tongue to adopt a more forward position so as to increase the size of the oral cavity for breathing (Mason, 1988). This forward tongue position may be carried over into swallowing (Mason, 1988).

Further findings of this study suggested that the concurrence of an anterior open bite and a tongue thrust swallow was significantly associated with frontal lisping. This result was not surprising in light of this study's reported findings that an anterior open bite and a tongue thrust swallow, without concurrence, were also associated with frontal lisping. In addition, this study's results suggested that a participant with concurrence of anterior open bite and tongue thrust swallow was six times more likely to present with a frontal lisp than a participant who did not present with concurrence of these variables. The likelihood of presenting with a frontal lisp was similarly influenced (i.e. also six times more likely to occur) by the presence of an anterior open bite (a structural variable) and by the presence of a tongue thrust swallow (a functional variable).

The results of this study thus support the findings of an association between the concurrence of an anterior open bite and a tongue thrust swallow, and frontal lisping, reported by researchers Jann et al. (1964). These results suggest that if children cannot adapt their tongue positioning for the precise production of /s/ and /z/ in the presence of a changed or altered structure such as an anterior open bite (perhaps related to poor proprioceptive feedback from the tongue) and they have imprecise tongue positioning during swallowing (which may require less precision of tongue movement than speech production), they are more inclined to present with a frontal lisp than if these variables did not co-occur.

The clinical implications of a child presenting with a frontal lisp and the concurrence of an anterior open bite and a tongue thrust swallow, are the same as if each of these variables occurred on their own. The reason for this is that adaption of motor behaviour is task-specific (Hadders-Algra, 2000). Thus the tongue thrust swallow may be treated with myofunctional techniques (Barnes, 1994; Christensen & Hanson, 1981) and the frontal lisp may be treated with adaptive or compensatory strategies (Mason & Proffit, 1974; Subtelny et al., 1964). These compensation strategies would be introduced in speech therapy so that the child could achieve the correct production of /s/ and /z/, despite the presence of the anterior open bite (Mason & Proffit, 1974; Subtelny et al., 1964).

It was noted in this study that not all participants who presented with a tongue thrust swallow presented with an anterior open bite. Thus an anterior open bite is not necessarily associated with a tongue thrust swallow (Bankson & Bernthal, 1998a; Proffit, 1986). However, each participant who presented with an anterior open bite also presented with a tongue thrust swallow. This association could have occurred because these participants used their tongues to seal off the front of their mouths during swallowing (Proffit, 1986). Thus, according to Proffit, the tongue thrust swallow may be a necessary physiological adaption in the presence of an anterior open bite. A tongue thrust swallow may therefore be considered the result of an anterior open bite, but not its cause (Proffit, 1986).

This observation has clinical implications. For instance, if a tongue thrust swallow is an adaption to the anterior open bite, then therapy to alter a tongue thrust swallow in the presence of an anterior open bite is unwarranted (Proffit, 1986). However, correcting the anterior open bite with orthodontic treatment should cause a change in the swallow pattern (Proffit, 1986). Thus the effect of orthodontic surgery (to close an anterior open bite) on a tongue thrust swallow, would be an interesting phenomenon to explore in future research.

Further results of this study suggested that slower DDK rates for */t∂/*, */k∂/* and */t∂k∂/* were not significantly associated with frontal lisping. These findings suggest that the ability to rapidly coordinate speech musculature, which is required in DDK rate, is no different in children who present with frontal lisps than in children who do not. Thus, the inability to rapidly coordinate the speech musculature was not associated with frontal lisping.

The results of this study support the findings of Dworkin and Culatta (1985) that suggested that there was no association between slower DDK rates and frontal lisping. However, the results of this study do not support Dworkin's earlier research (1978; 1980), which proposed that there was an association. The fact that this study supported Dworkin's later research could be because both this study and the research by Dworkin and Calutta (1985) included more participants in the case and control groups. A larger number of participants increases the power of statistical analysis and therefore strengthens the reliability of the findings (Collett, 1991).

Although the role of DDK rate may be diagnostic for motor speech disorders (Cohen et al., 1998), the results of this study indicate that frontal lisping is not associated with a neuromuscular impairment that is characteristic of dysarthria. Thus children with frontal lisps are not slower, weaker or more incoordinated in their articulation of sounds than children who do not have frontal lisps (Bankson & Bernthal, 1998a). In addition, frontal lisping did not seem to be associated with an impairment of motor speech programming, that is characteristic of apraxia of speech (Bankson & Bernthal, 1998a).

Clinically, oral motor exercises have been recommended for the treatment of a frontal lisp, when the frontal lisp has been associated with slow DDK rate (Bahr, 2001; Forrest, 2002; Mackie, 1996). The application of oral motor exercises is based on the philosophy that speech is a motor behaviour and thus by alleviating underlying motor impairments such as a slow rate of articulator movement, there will also be an improvement in speech production (Clark, 2005). However, the fact that in this study, frontal lisping was not associated with slow DDK rate, indicates that oral motor exercises may not be appropriate for the treatment of a frontal lisp. In addition, there is little evidence to support that improvement in speech production can be attained through the use of non-speech activities (Clark, 2005; Forrest, 2002). Further research is therefore warranted to determine the efficacy of the continued use of oral motor exercises for the treatment of speech disorders such as a frontal lisp.

6. CONCLUSIONS

This study set out to determine whether there was a higher frequency of anterior open bites, tongue thrust swallows and the concurrence of anterior open bites and tongue thrust swallows in a group of children aged between 5 and 7 years who presented with frontal lisps compared to a group of children in the same age range who did not. In addition, this study aimed to determine the probability of a frontal lisp occurring if an anterior open bite, a tongue thrust swallow or concurrence of an anterior open bite and a tongue thrust swallow was also present. Furthermore, these two groups of children were compared to see whether children with frontal lisps had slower DDK rate than children without frontal lisps.

The main findings of this study indicated that an anterior open bite, a tongue thrust swallow and concurrence of an anterior open bite and a tongue thrust swallow were more frequent in participants who presented with a frontal lisp than in those who did not. In addition, the probability of a participant presenting with a frontal lisp increased six times when either an anterior open bite, or a tongue thrust swallow, or concurrence of these variables was present. Furthermore, slow DDK rates were not found to be significantly different in children with frontal lisps than in children without frontal lisps.

Some theoretical and clinical implications emerged from this study. It may be that it is not so much the anterior open bite that affects the production of /s/ and /z/ resulting in a frontal lisp, but perhaps an inability to adapt tongue placement to compensate for this structural oral facial variable. Thus according to the theory of coordinative structures (Levelt, 1989), the inability to adapt tongue position for the production of /s/ and /z/, in the presence of an anterior open bite, may be related to absent or faulty proprioceptive feedback from the tongue regarding the changed or irregular structure of the oral cavity. This faulty feedback may be related to the development of /s/ and /z/ after the formation of the anterior open bite. Children with frontal lisps may therefore not have had a normal articulatory environment in which to acquire /s/ and /z/. Thus the child has only been exposed to proprioceptive feedback from the tongue in an irregularily structured oral environment.

The association between a tongue thrust swallow and a frontal lisp could be related to the different degrees of freedom, or the different levels of demand, required for speech and swallowing (Levelt, 1989). Speech production may require more precise articulatory movement than swallowing. Thus, if the tongue is impaired for the function of swallowing, which has a lower level of demand for preciseness than speech production, there is a greater likelihood that it may be impaired for speech production, which has a higher level of demand for precision than swallowing. In addition, the sounds /s/ and /z/ may be more affected by imprecise tongue movement than other tongue tip sounds, because /s/ and /z/ are more complex sounds and require greater precision of articulatory movement (Kent, 1998).

The association between a frontal lisp and the concurrence of an anterior open bite and a tongue thrust swallow, was expected because of the association between frontal lisping and each of these variables in isolation. Thus the combined effect of faulty feedback from the tongue, in relation to the presence of an anterior open bite, and the tongue's inability to position itself correctly, even in a behaviour that requires low level of precision of movement such as swallowing, influences the production of /s/ and /z/. However, the fact that concurrence of a structural variable such as an anterior open bite and a functional variable such as a tongue thrust swallow, does not increase the likelihood of a frontal lisp, than if these variables occurred on their own, indicates that each of these variables and their concurrence have the same influence on frontal lisping.

Slow DDK rate has often been associated with underlying oral motor disorders such as dysarthria (Cohen et al., 1998). Thus as a frontal lisp was not associated with slow DDK rate in this study, it can be presumed that a frontal lisp is not indicative of an underlying oral motor speech disorder. Children with frontal lisps have the same abilities with regard to rate of lingual movement as children without frontal lisps.

These theoretical implications have a direct effect on treatment strategy. Clinically, if a child presents with a frontal lisp and an anterior open bite, speech therapy may include adaptive tongue placement techniques (Johnson & Sandy, 2002). These techniques may be introduced to assist the child in producing an accurate /s/ and /z/ sound, despite the presence of an anterior open bite (Sandy & Johnson, 2002). In addition, the speech therapist also has a role in preventative counseling. This counseling may involve educating parents and professionals on the effect a prolonged non-nutrient sucking habit may have on bite formation and how this structural variable, namely an anterior open bite, has been associated with frontal lisping.

The treatment of a tongue thrust swallow may include the application of myofunctional therapy techniques (Barnes, 1994). However, these techniques should not be applied in the hope that, by correcting the incorrect tongue positioning in swallowing, there would be a carry-over effect into the correct positioning of the tongue for /s/ and /z/ production. According to coordinative structures theory (cited by Levelt, 1989), speech develops independently from swallowing and the movements for speech and swallowing are task specific. Thus the treatment for a tongue thrust swallow and a frontal lisp, should also be task specific. In other words, myofunctional techniques are recommended for the treatment of a tongue thrust swallow and techniques such as place-feature oriented articulation therapy, is recommended for the treatment of the frontal lisp (Bankson & Bernthal, 1998c). Future research would have to document whether improvement in a tongue thrust swallow from myofunctional therapy has any impact on a frontal lisp.

The same therapeutic principles would apply if a frontal lisp was associated with the concurrence of an anterior open bite and a tongue thrust swallow. In other words, the tongue thrust swallow may be treated with myofunctional techniques but the anterior open bite would be accommodated during speech therapy for the frontal lisp, through adaptive phonetic placement techniques. However, the tongue thrust swallow may be a necessary physiological adaption by the tongue to form an anterior seal when an anterior open bite is present (Proffit, 1986). If this suggestion is true, then it could be argued that therapy to alter the tongue thrust swallow would be unwarranted (Proffit, 1996). However, more research is needed in this area.

The fact that the results of this study found no association between DDK rate and frontal lisping, raises a question regarding the purpose of employing oral motor exercises in any treatment program for a child presenting with a frontal lisp (Clark, 2005). In addition, according to the theory on coordinative structures, there is no evidence to suggest that non-speech activities will improve speech production (Forrest, 2002).

This study presented with both strengths and limitations. The strengths of this study involve the fact that the researcher took cognisance of the limitations in previous methods of investigation and tried to improve on them. Thus the strengths of this study involved the large sample size employed, which increased the power of the statistical analysis, and which in turn strengthened the reliability of the findings. Furthermore, this reliability was enhanced by high inter-rater reliability. In addition, participants were only included in this study if they did not have errors on any of the sounds used for DDK purposes, as a /t/ for /k/ substitution affects production and timing of DDK rate (Cohen et al., 1998). In addition, instructions given to each participant were included in the protocol of the study, so that inconsistent instructions did not become a variable that could affect performance in the young child (Cohen et al., 1998; Lushei, 1991). This study also differed from past studies in that three oral facial variables were investigated. It is believed that the investigation of more than one variable provided greater insight into the relatedness between variables.

A general limitation of this study involves the lack of formal instrumentation that would have allowed for more objective and precise measures. Thus the assessment of each of the oral facial variables, namely an anterior open bite, a tongue thrust swallow and DDK rate, were subjective and thus subject to human error. Thus future research should focus on introducing more formal and precise measures for these oral facial variables.

However, research should continue to focus on the oral facial variables associated with frontal lisping, to add to the existing body of knowledge in this area. In addition, continued research regarding frontal lisping is necessary in order to enhance our knowledge regarding the theoretical underpinnings of this speech disorder, resulting in appropriate remediation.

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Appendix A

Information Sheet For Parents/Guardians of Potential Participants.

My name is Linda Thompson and I am currently studying to complete a Masters Degree in Speech Therapy at the University of Cape Town. I am presently conducting a research project into certain oral facial variables that may be associated with frontal lisping in children aged 5-7 years.

I would appreciate your child's participation in this study as I require children who present with frontal lisps and children who do not. Your child will be tested by me and possibly simultaneously by another private speech therapist, to ensure accuracy of results. The test procedure will take approximately 20 minutes and will involve the following:

- a speech test to confirm whether your child does or does not present with a frontal lisp
- the repeating of a few syllables
- the request for your child to swallow, while his/her lips are parted
- the request for your child to bite his/her teeth together

Your child will be tested at his/her school during school hours or at my private practice in Rondebosch. None of these tests will harm your child in any way. The participation of your child in this study is entirely voluntary, and he/she is under no obligation to participate. If you choose not to allow your child to participate, or you or your child want to withdraw at any time during the testing procedure, you and your child will not be disadvantaged in any way. Your child's results will be available to you but otherwise will be strictly confidential.

Your consent and your child's participation in this study will be much appreciated. If you have any questions please do not hesitate to phone me on 021- 6892679.

Regards

Linda Thompson

Appendix B

Consent Form For Parents/Guardians

CONSENT FORM OF PARENT/GUARDIAN

I have been fully informed as to the procedures being followed with my child and have been given a description of their purpose. In signing this consent form, I agree to let my child participate in this study although I understand that it will not necessarily provide personal benefit. I understand that I can refuse to allow my child to participate in this study or discontinue my child's participation in this study at any time. I also understand that if I have any questions at any time, they will be answered.

Name of Child: ____________________

Parent/ Guardian's Signature: ______________________

Date: __________________

Appendix C

Assessment Form

ASSESSMENT FORM

A. GENERAL INFORMATION:

Name of Subject:....................................Race:.........Grade:...........

Date of the assessment:...

Age of subject at time of assessment:..

Contact phone number for subject:...

B. INFORMATION ON THE PRESENCE OF A FRONTAL LISP:

1. Does this subject present with a frontal lisp?...

1. What other articulation errors did this subject present with?

....

C. ANTERIOR OPEN BITE: (indicate with a tick)

Present:......................

Absent:.......................

D. TONGUE THRUST SWALLOW: (indicate with a tick)

Present:___________

Absent:____________

E. THE COUNT-BY-TIME MEASUREMENT OF DIADOCHOKINETIC RATE

(The number of syllables per 15 seconds)

/t∂/:......................
/k∂/............... ....
/t∂k∂/ ....

Appendix D

Consent Form For Principals At Barkly House Preprimary

CONSENT FORM OF PRINCIPALS AT BARKLY HOUSE PREPRIMARY

I, the principal of Barkly House Preprimary School (Molteno Road) do hereby give permission to Linda Thompson to assess the children aged 5-7 years who are attending our school. I understand that she requires these children for her research into the oral facial variables associated with frontal lisping and that participation in her research is entirely voluntary.

I also understand that she will test these children on school premises after she has obtained written consent from the parent/guardian.

Date: ____________________

Principal (Molteno Road): ______________________

I, the principal of Barkly House Preprimary School (Harfield Road) do hereby give permission to Linda Thompson to assess the children aged 5-7 years who are attending our school. I understand that she requires these children for her research into the oral facial variables associated with frontal lisping and that participation in her research is entirely voluntary.

I also understand she will test these children on school premises after she has obtained written consent from the parent/guardian.

Date: ____________________

Principal (Harfield Road): _________________________

Appendix E

Reasons Given For Not Returning Control Group Consent Forms.

Number of Respondents	Reasons given
1	had no time to complete the form
15	forgot to return the form
1	felt her child was too shy to participate in the investigation
1	thought there would be an overwhelming response and therefore the researcher would not need her child
2	stated that by the time they had signed the consent form the testing had been completed
1	thought the notice said that her child had to have a speech problem
1	didn't want to sign because her child would not directly benefit from the investigation
1	said it just slipped her mind
1	the child was away at the time

Appendix F

Raw Data Collected From The Case Group.

Number participants	SEX M/F	AGE Yr/Mo	AGE Mo	AOB a/p	TTSwallow a/p	T∂ reps	K∂ reps	T∂ K∂ reps
1	M	6.2	74	a	a	64	64	33
2	F	6.0	72	p	p	60	53	28
3	F	6.0	72	a	a	56	53	28
4	M	6.8	80	a	a	51	44	36
5	M	5.6	66	a	a	46	47	30
6	M	6.4	76	a	a	41	41	24
7	M	6.1	73	a	p	48	45	26
8	M	6.8	80	a	a	49	59	26
9	M	6.8	80	a	a	50	58	35
10	M	5.2	62	a	a	52	54	28
10	M	5.2	62	a	a	53	54	28
11	F	6.3	75	a	a	51	45	25
12	M	6.3	75	a	p	59	52	35
13	F	6.1	73	a	a	50	53	41
14	M	6.9	81	p	p	51	50	28
15	M	6.11	83	a	a	51	48	21
16	M	6.4	76	a	a	41	41	22
17	F	6.1	73	a	a	43	33	19
18	F	6.4	76	a	a	52	41	30
19	F	5.3	63	a	a	39	35	26
20	F	5.4	64	a	a	61	56	32
20	F	5.4	64	a	a	62	56	32
21	M	6.8	70	a	a	42	42	28
22	M	5.0	60	a	a	57	46	27
23	F	5.1	61	a	a	54	41	24
24	M	6.6	78	a	a	53	35	30
25	M	5.1	61	a	a	49	46	28
26	F	5.8	68	a	a	53	50	22
27	M	5.8	68	p	p	34	38	27
28	M	6.1	73	a	a	54	52	31
29	M	6.0	72	p	p	58	55	41
30	F	6.4	76	a	a	39	32	26
30	F	6.4	76	a	a	39	32	27
31	F	6.7	79	p	p	52	44	26
32	F	6.3	75	p	p	53	49	28
33	M	6.2	74	a	a	51	44	37
34	F	5.1	61	a	p	41	42	25

Appendix F

Raw Data Collected From The Case Group.

35	F	6.2	74	a	a	59	53	39
36	M	5.6	66	a	a	37	35	22
37	M	6.2	74	a	a	54	40	26
38	F	6.1	73	a	a	55	48	31
39	F	6.11	83	p	p	50	43	30
40	F	6.5	77	a	a	33	27	23
40	F	6.5	77	a	a	33	26	24
41	F	6.1	73	p	p	45	42	25
42	F	6.7	79	a	a	43	50	16
43	F	6.7	79	a	a	24	36	42
44	F	6.3	75	a	a	36	32	17
45	F	6.11	83	p	p	51	44	24
46	M	6.7	79	p	p	57	52	30
47	M	6.9	81	a	a	58	43	31
48	F	6.11	83	p	p	61	41	34
49	F	5.1	61	a	a	33	40	24
50	M	6.4	76	a	a	50	52	28
50	M	6.4	76	a	a	50	52	28
51	M	6.3	75	p	p	38	40	23
52	M	6.1	73	a	a	61	43	33
53	M	6.7	79	a	a	48	46	31
54	M	6.8	80	p	a	58	49	28
55	M	6.4	76	a	p	52	40	30
56	F	5.11	71	a	a	52	47	27
57	M	6.4	76	a	a	56	54	30
58	M	6.11	83	a	p	41	39	24
59	M	5.5	65	a	a	42	38	25
60	M	5.5	65	a	a	54	57	32
60	M	5.5	65	a	a	54	56	32
61	M	6.6	78	a	a	52	48	22
62	F	6.7	79	a	a	50	48	50
63	M	6.3	75	a	p	65	59	35
64	M	6.1	73	a	a	55	51	28
65	M	6.11	83	a	a	67	53	33
66	M	6.1	73	a	a	53	52	32
67	M	6.11	83	a	a	57	43	22
68	M	6.3	75	p	p	48	46	26
69	M	6.4	76	a	a	58	52	32
70	M	6.6	78	p	p	44	41	18
70	M	6.6	78	p	p	44	40	18

Appendix F

Raw Data Collected From The Case Group.

71	M	6.7	79	a	a	51	53	18
72	M	6.11	83	a	a	57	56	31
73	F	6.3	75	a	a	45	42	22
74	F	5.4	64	a	p	51	46	28
75	M	6.4	76	a	a	59	51	25
76	F	5.6	66	a	a	60	58	33
77	M	5.1	61	p	p	47	47	29
78	M	6.4	76	a	p	36	35	22
79	F	5.4	64	a	a	51	43	24
80	M	5.9	69	a	a	38	48	21
80	M	5.9	69	a	a	40	50	21

Appendix G

A Table For The Collection Of Raw Data From The Control Group.

Number participants	SEX M/F	AGE Yr/Mo	AGE Mo	AOB a/p	TTSwallow a/p	t∂ reps	K∂ reps	T∂ K∂ reps
1	F	6.0	72	a	a	53	44	28
2	M	6.5	77	a	a	58	53	40
3	M	6.9	81	a	a	62	56	27
4	M	6.9	81	a	a	45	46	25
5	M	6.8	80	a	a	32	27	23
6	M	6.11	83	a	a	50	49	31
7	F	6.9	81	a	a	45	44	30
8	M	6.7	79	a	a	51	48	23
9	F	6.4	76	a	a	53	51	30
10	M	6.1	73	a	a	56	54	32
10	M	6.1	73	a	a	60	57	30
11	F	6.2	74	a	a	54	47	32
12	M	6.11	83	a	a	42	41	23
13	F	6.8	80	a	a	58	53	32
14	F	6.2	74	a	a	52	39	26
15	F	6.3	75	a	a	55	40	33
16	F	6.4	76	a	a	58	50	35
17	M	6.1	73	a	a	58	52	34
18	F	6.8	80	a	a	45	43	29
19	M	6.11	83	p	p	42	33	23
20	M	6.2	74	a	p	44	40	25
20	M	6.2	74	a	p	46	40	24
21	F	6.6	78	a	a	45	44	27
22	M	5.1	61	a	a	41	42	25
23	M	6.6	78	a	a	43	39	25
24	M	6.7	79	a	a	54	53	39
25	F	6.7	79	a	a	45	53	35
26	M	6.5	77	a	a	43	40	26
27	F	6.11	83	a	a	43	41	24
28	F	6.7	79	a	a	42	43	29
29	F	5.4	64	a	a	48	41	21
30	F	5.5	65	a	a	34	35	25
30	F	5.5	65	a	a	35	37	22
31	M	5.7	67	a	a	46	44	20
32	M	5.5	65	a	a	36	40	23
33	M	6.8	80	a	a	54	49	28
34	M	5.0	60	a	a	44	46	24
35	M	5.6	66	a	a	44	43	28
36	M	5.0	60	a	a	52	50	27

Appendix G

A Table For The Collection Of Raw Data From The Control Group.

37	M	5.1	61	a	a	57	56	27
38	M	5.3	63	a	a	50	43	25
39	F	5.9	69	a	a	39	46	25
40	M	5.4	64	a	a	47	47	32
40	M	5.4	64	a	a	46	46	30
41	M	5.9	69	a	a	43	42	20
42	F	5.8	68	a	a	60	54	36
43	M	5.2	62	a	a	59	51	28
44	M	5.11	71	a	p	53	50	25
45	M	5.6	66	a	a	43	49	31
46	M	5.7	67	a	a	40	43	23
47	F	5.2	62	a	a	47	46	27
48	M	5.6	66	a	a	59	44	27
49	M	5.11	71	a	a	51	47	28
50	F	5.4	64	a	a	56	50	27
50	F	5.4	64	a	a	56	50	28
51	M	5.11	71	a	a	52	49	34
52	M	5.1	61	a	a	38	27	24
53	M	5.7	67	a	a	36	43	27
54	F	5.0	60	p	p	44	36	28
55	M	5.1	61	a	a	53	50	29
56	F	5.1	61	a	a	50	42	24
57	F	5.2	62	a	a	42	40	26
58	M	5.3	63	a	a	58	56	21
59	M	5.7	67	a	a	41	35	19
60	M	5.11	71	a	a	55	42	26
60	M	5.11	71	a	a	55	42	27
61	M	5.2	62	a	a	59	48	30
62	F	5.8	68	a	a	61	47	31
63	M	5.6	66	a	a	53	39	28
64	M	5.5	65	a	a	55	44	31
65	F	5.1	61	a	a	46	50	27
66	M	5.7	67	p	p	50	50	33
67	F	6.10	82	a	a	47	46	31
68	M	6.4	76	a	a	58	53	24
69	M	6.9	81	a	a	57	43	35
70	F	6.6	78	a	a	57	56	37
70	F	6.6	78	a	a	60	57	40
71	M	6.7	79	a	a	48	46	34
72	F	6.7	79	a	a	55	53	38

Appendix G

A Table For The Collection Of Raw Data From The Control Group.

73	F	6.9	81	a	a	53	43	23
74	M	5.11	71	a	a	44	43	26
75	M	6.6	78	a	a	51	45	23
76	F	6.4	76	a	a	46	44	38
77	M	6.9	81	a	a	48	38	30
78	F	6.8	80	a	a	42	42	26
79	F	6.11	83	a	a	44	38	25
80	M	6.8	80	a	a	46	58	33
80	M	6.8	80	a	a	46	56	33