Effects on oral motor skills and speech production using oral vibration in four preschool boys with speech disorder.

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ABSTRACT

Oral motor control has been found to have a relationship with language development by many researchers (Alcock, 2006) and numerous studies have shown that language dysfunction and oral motor dysfunction often occur together. In this intervention study the author investigated the effects of an oral vibration intervention program in four preschool boys with speech disorder. The outcome, after intervention step one and two, was assessed with an oral motor test battery including orofacial motor control, two point discrimination, oral stereognosis, tactile assessment, as well as speech and language tasks as word naming, sentence repetition and non word repetition. A parent questionnaire of benefit was also administered.

Results showed positive outcomes in all areas after the completed intervention period of six months. All four boys made improvements regarding oral stereognostic ability and orofacial motor control and two of four boys improved on speech tasks. All the parents experienced some benefit from the vibration therapy and most of them found it cost-beneficial.

Key words: oral motor control, oral vibration intervention program, oral motor test battery
1. INTRODUCTION

Among speech and language pathologists (SLPs) it has been more and more common to assess the oral sensorimotor ability in children with speech and language disorders. Many clinicians have a group of children with phonological disorders in their case load that falls in between the diagnoses of pure phonological impairment and a clear motor speech disorder e.g. verbal dyspraxia. Some of these children may have failed to benefit from “pure” phonologic intervention approaches where the motor gestures that underlie the phonological development often are addressed in only a cursory or implicit fashion (McCauley & Strand, 1999). Several clinicians also see children with concomitant problems such as drooling or chewing problems. The question that then arises is whether there is a motor component involved in the speech disorder. To help answering that question several test protocols and test batteries have been designed.

Using these test batteries and protocols the SLPs find children with difficulties concerning oral anatomy, orofacial muscle control, oral sensibility, eating related functions and speech. Several intervention programs and techniques have been developed to address these problems throughout the years and many of them consist of an oral motor oriented approach. In Sweden it has become more and more common with orofacial vibration programs using an electric toothbrush as part of speech therapy. Several SLPs get satisfactory results using these oral motor oriented methods in parallel with speech therapy, but few have reported about them. With this thesis the author would like to study the outcome of an oral vibration program in terms of measurable changes in speech, sensory and motor functions using the Stockholm Oral Motor test battery; the STORM (Henningsson, McAllister and Hartstein, 2007) and with a nonword repetition task. The intervention program is divided into two steps; the first step with a daily general orofacial vibration program and step two with the same orofacial vibration program and an added part of guiding towards speech sound targets.

2. BACKGROUND

2.1 Speech motor control versus oral motor control

Speech motor control refers to the systems and strategies that control the production of speech. The input to the system of speech motor control is a phonologic representation of language, especially abstract units such as phonemes. The output of speech motor control is a series of articulatory movements that convey the intended linguistic message through an acoustic signal that can be interpreted by a listener (Kent, 2000). Speech movement production appears to share organizational principles with other motor behaviors, but speech movements probably arise from an interaction of centrally generated command signals with sensory information. Speech movements are ultimately linked to the perception of language and many investigators suggest that speech movement control involves unique features linked to abstract linguistic units (Smith, 1992).

Bunton (2008) elucidates the relation of oromotor nonspeech activities to speech production from contemporary motor theory and neural plasticity. Motor theory suggests that movement control is task specific i.e. that it is tied to unique goals, sources of information and characteristics of varying motor acts. Principles of motor learning also suggest that learning a complex behavior can be facilitated when it is decomposed into smaller units. It is however
important to take two key factors into account when determining if training parts of a task or the task as a whole will be more or less effective, namely task complexity and task organization. For speech production both complexity and organization are high and among three described ways to decompose a motor task to facilitate learning only one was found to provide advantage; segmentation. Segmentation partitions the task into a series of spatial and temporal subcomponents with identifiable start- and endpoints. There is strong preliminary evidence that suggests differences in the underlying neural anatomic substrates for speech production compared with other oral motor behavior (Bunton, 2008).

In two studies by Alcock (2006) results showed that complex oral movements (but not simple oral movements) are closely related to language skills, possible because they are more speech-like than simple oral movements. The differences between speech and nonspeech have been described as an internal model for speech motor control using the relation of vocal tract shapes to their acoustic consequences while oral motor control on the other hand uses an external model of visuo-spatial or proprioceptive target (Perkell et. al, 1997).

In terms of speech motor control it has been postulated that the tongue operates as two quasi-independent articulators (Gibson, 1999). The tongue tip/blade movement can occur relatively independently of tongue body movement and, tongue body activity can occur relatively independently of tongue tip/blade activity. Tongue tip/blade and tongue body activity may also overlap in time; coarticulate, as in a dental-velar sequence. It is also necessary for speakers to be able to “tense the lateral borders of the tongue” (Fletcher, 1992). In children with articulation/phonological disorders there is a high amount of tongue-palate contact. Consonants produced with tongue-palate contact have been referred to as undifferentiated lingual gestures (Gibbon, 1999).

2.2 Oral motor intervention

Speech-language therapy includes many treatment techniques including those designed to facilitate improved oral (jaw, lip, and tongue) motor (sensory, positioning and movement) skills (Marshalla, 2008). Oral motor techniques have been used for at least 100 years and are described in several textbooks and clinical guidebooks within the treatment areas of articulation, phonology, motor speech, feeding, dysphagia, orofacial myology, and oral motor therapy. During the 21st century some researchers have been discussing the use of oral motor treatment within articulation therapy from two different viewpoints. On one hand there is no or little evidence that support the use of oral motor therapy (Lof, 2007; Lof & Watson, 2008) and on the other hand it is widely used by therapists and perceived beneficial (Lof & Watson, 2008; Marshalla, 2008). Marshalla (2008) has reviewed eighty-four textbooks and articles concerning oral motor therapy from the years 1912 to 2007 and she found that these methods have had a prominent role in the speech-language-hearing profession and that professionals of the highest rank have written about and advocated these methods. Marshalla also identified 22 fundamental methods of oral motor facilitation based on the type of sensory and movement technique being employed and not based on what body part, phoneme, or feeding skill being facilitated. These methods overlapped in all treatment areas. Some examples of such methods are to contrast oral movements, to cue oral movements, to develop sensory awareness, to model oral movements or positions and to stabilize oral movements.

Two nationwide surveys were made in the US (Lof & Watson, 2008) and in Canada (Hodge, Salonka & Kollias, 2005) and both found that 85 percent of the SLPs use oral motor exercises to improve speech sound productions. Lof (2007), however, claims that oral motor exercises
should not be used for speech sound disorders because evidence for effectiveness does not exist. Evidence Based Practice (EBP) is a process by which clinicians select assessment and intervention approaches to provide the most effective and efficient services possible (Mutiah, 2008). EBP is the integration of the best current research evidence, clinical experience and client’s values (Lof, 2007, Lass & Pannacker, 2008) and all three aspects of EBP should support any treatment method used. For the best results clinicians should incorporate EBP into their daily practice.

2.2.1 Vibration therapy

Grant (1982) implemented a manual vibrator as an additional method in the speech therapy program of four moderately retarded children with speech problems. The children received daily stimulation for 8 months to the areas of the masseter muscle and around the upper and lower lips. Articulation therapy was provided in parallel with the vibration therapy. The goal was to inhibit tongue thrust, improve tongue tip control and speech production. Results indicated that consistent and carefully supervised application of the manual vibrator together with traditional speech therapy procedures helped these children to develop orofacial muscle control and to improve articulation skills.

The prerequisite for a correct articulation is a well coordinated orofacial function (Castillo-Morales, 1998). The goal is to reach a posture and movement pattern as close to normal as possible. The Orofacial regulation therapy (Castillo-Morales, 1998) uses stimulation from the different sensory systems and vibration is one of the most important techniques being executed manually (without any tool) in this therapy. In Sweden Lundeborg & McAllister (2007) and McAllister & Björnström (1995) have been using an electric toothbrush as a vibration tool in combination with palatal plate treatment ad modum Castillo-Morales and electropalatography-aided articulation therapy with good results. Vibration has also been described as a part of treatment programs by Rosenfeld-Johnsson (2005). The exercises suggested are “designed to increase sensory awareness and acceptance of touch within the oral cavity, and improve jaw strength, symmetry and grading as a prerequisite for improved feeding safety and speech clarity”.

2.3 Sensory abilities

The central nervous system requires signals from the orofacial mechanoreceptors involved in the sensorimotor regulation of oral behaviors (Trulsson & Johansson, 2002). Therefore, sensory deficits may contribute to articulatory disorders by limiting kinesthetic and tactile reinforcement of movement sequences, thereby limiting learning of complex movements associated with speech (Forrest, 2002). Forrest (2002) reviewed several studies and found that some of them reported significant correlations between articulatory skill and kinesthetic sensitivity and others did not reveal any relationship. Differences in results may be attributable to methodological variations across studies and additional research is needed.

Oral stereognosis is the ability to recognize and discriminate forms and shape in mouth (Mundin & Norén, 2000). It can be applied as a measure of oral functioning and especially to test oral dysfunction or to evaluate the effect of therapy (Jacobs, Serhal & van Steenberghe, 1998). Some studies referred to in Jacobs et. al. state that knowledge of kinaesthetic feedback in speech behavior could indeed contribute to a better understanding of speech production and perception.
Two-point discrimination is the ability to discriminate smaller differences between two points (Capra, 1995; Linguard & Munters, 2005). Measures of two-point discrimination show that the areas of greatest sensitivity in the mouth are found in the tip of the tongue followed by the lips and the hard palate.

Oral-tactile sensory testing is important as a component of an oral-motor assessment (Rosenfeld-Johnson, 2001). Oral tactile sensory dysfunction may be divided into several categories: tactile hypersensitivity (an overreaction to tactile input i.e. the child is careful with what he puts in his mouth), tactile hyposensitivity (an underreaction to tactile input i.e. the child seeks touch), mixed tactile sensitivity (a combination of hyper, hypo and/or normal), fluctuating sensitivity (change over time), and tactile defensiveness (a tendency to respond negatively or emotionally to tactile input).

There are sensory receptors imbedded in the skin and oral mucosa including the surface of the tongue. Mechanoreceptors in the mucosa serve in a variety of capacities including sensation, composite sensory experiences (e.g. oral kinesthesia and oral stereognosis) and reflex initiation (Capra, 1995). In the orofacial area the mechanoreceptors are responsible for transmitting textural information on food and provide information on the position of food in the mouth and to monitor the tongue position during speech. Mechanoreceptors with high sensitivity are found in the periodontal ligament and on the tip of the tongue.

2.4 Nonword repetition

Adams and Gathercole (2000) concluded that poor nonword repetition is a key feature of hereditary language impairment. Bishop and colleagues propose that nonword repetition could be viewed as a clinical and phenotype marker of language impairment (LI) in children (Bishop, North & Donlan, 1996).

In the early article by Baddeley & Hitch (1974), where their theory of working memory first was presented, non-word repetition was considered to mirror the function of one subcomponent of working memory, ‘the articulatory loop’. Later on the articulatory loop was named ‘the phonological loop’. Many researchers today emphasize the complexity of nonword repetition. The task requires a range of linguistic operations, not only phonological working memory, but phonological processing in a broader sense (perception, production and memory) (Wass et.al, 2000, Coody & Evans, 2008).

The rationales for including a measure of nonword repetition in this study is thus that it is a clinical marker of language impairment and a short, simple and pure task that captures phonological development with minimal involvement of lexical skills, since the items in the test are novel and unknown to the child.

3. AIM

The overall aim of this study was to investigate if children with speech disorder including some oral sensory deficits benefit from an orofacial vibration therapy.

The specific research questions were:

1. Is it possible to see any measurable progress after the completed vibration intervention program concerning
   a. Oral sensory ability

6
b. Oral motor ability
c. Speech and language ability

2. Are there any differences in individual outcome after step one as compared to after step two?

3. What is the parents’ attitude to the intervention?

4. METHOD

4.1 Overall design

The study was made using a systematic case study design (Hedge, 1998). The time period for the intervention study including base-line assessment was January to August 2009 for all participants. An overview of the overall procedure is shown in table 1. The author of this thesis carried out all of the assessments and analyses of data. The author also gave the parents continuous information and instructions about the intervention program. The fact that both assessments and analysis is conducted by the same person has to be taken into account when validating and drawing conclusions about the results.

Table 1. The overall design of the vibration intervention study.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base-line 1</td>
<td>STORM</td>
</tr>
<tr>
<td>1 month</td>
<td></td>
</tr>
<tr>
<td>Base-line 2 / Assessment 1</td>
<td>STORM + Non word repetition</td>
</tr>
<tr>
<td>Therapy for 3 months</td>
<td>General oral vibration program</td>
</tr>
<tr>
<td>Assessment 2</td>
<td>STORM + parent questionnaire</td>
</tr>
<tr>
<td>Therapy for 3 months</td>
<td>General oral vibration program + cuing for speech sound targets</td>
</tr>
<tr>
<td>Assessment 3</td>
<td>STORM + Non word repetition + parent questionnaire</td>
</tr>
</tbody>
</table>

4.2 Participants

4.2.1 Criteria for inclusion

A letter describing the project was sent by the author to colleagues working with speech and language disordered children at the University Hospital in Lund. The children suggested for participation that also matched the criterions were contacted and all accepted to participate.

The inclusion criterions were that the children should have a mild to moderate speech disorder (diagnose code: F 800 A) with no clear difficulties in language comprehension and vocabulary. They should also exhibit difficulties in any of the sensory ability tasks in the STORM assessment and could have a second diagnose code of F 800 B, i.e. oral motor delay. The children should be in the age interval of 4 to 6 years. The study was approved by the local ethical committee at the department of Logopedics, Phoniatrics and Audiology at Lund University and a written consent from parents was collected before inclusion.
4.2.2 Pre-testing

A pre-testing was made by the author, in connection with base-line 1, to collect data about language level. The tests were the Reynell test (Hagvet & Liljestolen, 1990), the Peabody Picture Vocabulary Test, (PPVT) (Dunn & Dunn, 1981) and the Non Word discrimination task from the Sound Information Processing System (SIPS) test battery (Wass et. al. 2008).

The Reynell test is a language comprehension test for children age 1 - 7 years. It is standardized and from the raw score of maximum 67 you get age equivalence and a Stanine score. A four year old child should obtain 53 to 62 points in order to have a result within the normal interval of Stanine 3 to 7. The corresponding interval for a five year old is 56 to 65 points.

The PPVT is a picture based word comprehension test where the child listens to a word and is asked to indicate the correct picture among four pictures. In a group of normal language developed children age 5:3 – 6:10 years old the mean score was 84.5 (SD 7.5, range 74-93 (max 93 points)). (Reuterståld Wagner, Sahlén, Radeborg & Tideman, 2000).

The Non Word discrimination task is an auditory task where non-words are given in pairs and the child is asked if they are same or different. Every non-word occurs in two versions and the pairs are presented as same; ‘sallotan – sallotan’ or different; ‘sallotan – sallovan’. To get a score the child needs to get two corresponding pairs correct and the maximum is thus 8 points (from the 16 pairs). The SIPS test battery is a computerized platform assessing working memory and language (Wass et. al, 2008).

4.2.3 Description of participants

Four boys between 4;06 and 5;10 years were included in the study. Below follows a description of the children. The information is gathered from their speech and language records written by the SLP. For an overview see table 2.

Boy J

Case history; J was referred to the speech pathologist at 2;11 years of age. He was described as a talkative and socially well functioning boy. Communication with peers was no problem despite his speech problem. His mother had had some speech problems as a child. Breastfeeding and transition to solid food had been working well and eating was normal. When he was one year old he had paracentesis with grommet insertion due to middle ear infections. This operation was repeated on the left side at the age of two. The hearing was documented normal at the age of three. His speech pathologist found a tongue tie and after assessment by a specialized ENT-doctor he had an operation at 3;07. He had a drooling problem as toddler and at the time of the pretest he sometimes still showed some saliva on the lips. He often had an open mouth when playing and sometimes the tongue was visible between his lips. He had a deviant bite with a protruding jaw.

Speech; His first word production came at the expected time and language comprehension developed well but not speech. At play school his teachers were concerned about his articulation. He had speech therapy for a little more than a year before entering the vibration therapy program in this study. At the base-line assessment he wasfronting all his velar sounds [k, g, ng], the liquid sounds / l, r / was substituted by / j/, the fricatives / s / and / f / was
substituted by /s/ and /ʃ/ respectively and he could not produce the sounds /l, k, g, ɳ/ at all in isolation.

**Boy F**

*Case history:* Boy F came to the speech and language pathologist at the age of three. His father and uncle had had speech problems as children. Breastfeeding and transition to solid food was working well and eating was normal. He was drooling until the age of two. He had had a few instances of otitis media with effusion, but hearing was normal. Gross and fine motor control was normal. He was left-handed.

*Speech:* Babbling was normal, but his first words came late, at 2 years of age, and sentences developed at two and a half years. He was unintelligible and his mother had to translate to friends and sometimes to unfamiliar children until he was 4:06. He had speech therapy for 2 years before this study. At the base-line assessment he was fronting velar sounds, but he could produce velar sounds correctly in naming tasks. Stopping of /s/ was sometimes still occurring.

**Boy E**

*Case history:* Boy E came for a first assessment at the age of 3:02. A cousin and uncle had had speech problems. Hearing was tested normal at the 4-years check up at the Child Care Center. Breastfeeding was difficult because of problems with sucking. During transition to solid food he did not want to chew properly and the parents had to mash and cut food into pieces up to the age of 3. He sometimes choked, because of not chewing the food enough. He was habitually breathing through his mouth and had a drooling problem up to one year of age. He seemed to have a lot of saliva in his mouth and his mother often had to remind him to swallow. His mother noted that he was a little poorer than his peers at balance tasks.

*Speech:* Babbling was normal, but his vocabulary development was later than expected. His language comprehension was age appropriate, but understanding him could sometimes be difficult. He had speech therapy for 1½ years before this study. At the base-line assessment he was substituting the fricatives /ʃ/, /g/ and /ʃ/ with [s], /r/ and often /v/ became /l/, and he reduced /s/-clusters (but not completely regularly). His had interdentally /s/-production. He was sometimes a little imprecise in spontaneous speech.

**Boy O**

*Case history:* Boy O was referred for a speech and oral motor assessment at the age of 3:06. A cousin had speech problems. Breastfeeding was normal, but after transition to solid food he was “sloppy” with the food and he seemed to have problems chewing. He used his fingers to move the food in his mouth. He was breathing through his mouth habitually, had continuous drooling, snored at night and was sucking his thumb. He had an anterior open bite. At 3:08 he had a tonsillectomy where both his very large, infected tonsils were removed. The drooling problem and snoring at night then stopped.

*Speech:* Language development was late and he was difficult to understand when starting to talk. At the base-line assessment he was backing the /t, d, n/ sounds to the corresponding /k, g, ɳ/ sounds and had cluster reductions (except some s-clusters). He had a very imprecise, weak articulation and was often unintelligible.
Table 2. An overview of the four participants concerning age, speech, heredity, oral anatomy and eating habits.

<table>
<thead>
<tr>
<th>Child</th>
<th>Age</th>
<th>Heredity</th>
<th>Oral anatomy</th>
<th>Eating Habits</th>
<th>Speech</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boy J</td>
<td>4:09</td>
<td>Mother</td>
<td>Op short frenulum, Prognathism,</td>
<td>Still drooling sometimes, Wet</td>
<td>Fronting, cannot produce velar sounds in isolation, Cluster reduction, Fricative inconstistency</td>
</tr>
<tr>
<td>Boy F</td>
<td>5:10</td>
<td>Father and uncle</td>
<td></td>
<td>Drooling until 2 years</td>
<td>Fronting, but use velar sounds a few times Inconstistency</td>
</tr>
<tr>
<td>Boy E</td>
<td>5:01</td>
<td>Uncle and cousin</td>
<td>Chewing problems as toddler,</td>
<td></td>
<td>Fricative substitutions, S-cluster reduction, Interdental /s/</td>
</tr>
<tr>
<td>Boy O</td>
<td>4:06</td>
<td>Cousin</td>
<td>Tonsillectomy</td>
<td>Chewing problems, Drooling problem</td>
<td>Backing, lateral /s/, Cluster reduction, Imprecise art</td>
</tr>
</tbody>
</table>

4.3 Material

The assessment battery used as a base throughout this study is the STORM (Stockholm Oral Motors assessment) developed by Henningsson, McAllister and Hartstein in 2007. This assessment battery includes tasks/tests concerning body and neck posture, orofacial muscular control, oral anatomy, eating related functions, oral sensibility, speech and dental status. Six of the tests included in the STORM have been used in the present study (see table 3).

Tactile sensibility in the face is assessed in the STORM, but no specified terms for scoring were described in the manual. The terminology used by Rosenfeld-Johnsson (2001) was therefore added in this study. The test Non-word repetition from the SIPS test battery (Wass et al, 2008) was also used before and after completed intervention. The rationale for using non-word repetition in the test battery was, as already mentioned, that it is a quick and simple test mirroring phonological development (production, perception and memory) without lexical involvement. The tests used for scoring and analysis before and after therapy are presented in table 3 and will be described further in chapter 4.5.2 below.

Table 3. Tests used for scoring of sensory, orofacial and speech abilities. A description of the main function they assess.

<table>
<thead>
<tr>
<th>Test</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orofacial motor control</td>
<td>Volitional control of mimic-, lip- and tongue muscles</td>
</tr>
<tr>
<td>Two point discrimination</td>
<td>Sensitivity (lips and tongue tip)</td>
</tr>
<tr>
<td>Oral stereognosis</td>
<td>Oral shape recognition</td>
</tr>
<tr>
<td>Tactile assessment</td>
<td>Oral sensibility</td>
</tr>
<tr>
<td>Word naming</td>
<td>Speech production in picture naming</td>
</tr>
<tr>
<td>Sentence repetition</td>
<td>Speech production in sentences</td>
</tr>
<tr>
<td>Non word repetition</td>
<td>Phonological skills (production, perception and memory)</td>
</tr>
</tbody>
</table>

The oral vibration therapy program that was used for intervention was developed by the Oral Motor Centre (OMC) within the Speech and Language Pathology Clinic, Danderyd Hospital, Stockholm (see appendix 1). The parents used an electric vibrating (oscillating) toothbrush executing the therapy at home.
4.4 Recordings

Orofacial muscular control was documented with a digital video camera; Sony Handycam, Digital HD Video Camera Recorder HDR-CX106E and then transferred via Memory stick to a computer where analyzes were made. The films were played back using the program PBM, which was provided with the video camera.

Word naming and sentence repetition was documented in a studio using a computer and the Non word repetition was recorded on Sony Mini disc deck, MDS-JE550. The quality was good and the analysis was made based on the recorded material through the loud speakers.

4.5 Procedure and scoring

4.5.1 Base-line

In order to establish a base-line, two assessments with the STORM were made with an interval of one month in between assessments to ensure that no spontaneous improvement had happened.

4.5.2 Assessments and scoring principles

Seven areas were chosen for scoring and the quantitative analyzes and will be described below.

1. Orofacial muscular control was tested with 26 tasks concerning face, lips, tongue and jaw. This section was scored using a 5 steps deviation scale and a result with a low score equaled a good result; 0 = No remark (the movement was accomplished directly and without associated movements), 1 = Mild (slight divergent from target, one type of associated movement is allowed to occur; a little slow), 2 = Moderate (the movement is moderate divergent from target, but the movement is in the right direction, two types of associated movements may occur; slow and arhythmetrical, 3 = Strong (the movement is groping and/or significantly divergent from target, the movement involves a lot of other muscle groups), 4 = No function (cannot execute the movement/muscle group). The child was assessed sitting opposite the examiner and received the instructions orally and shown by the SLP if needed. Examples of assessed tasks are; “lift your eyebrows” (m. frontalis) and “pout your lips” (m. orbicularis oris).

Oral sensibility was tested by oral stereognosis, two point discrimination and oral-tactile sensory assessment in the mouth. The results were noted in the STORM protocol.

2. Oral stereognosis is the ability to recognize and discriminate different shapes in the mouth. It was examined with four shapes in two sizes made in cobalt chrome. The examiner puts one of the eight pieces (securely tied to a cord) in the mouth of the child. In front of him was a picture of the four shapes. He pointed to the picture matching the shape in his mouth. The child got one point per correct answer. Maximum number of correct responses was eight.

3. Two point discrimination is the ability to discriminate between two tactile points on the skin. A two-point tool, with the distances 3, 5 and 10 millimeter (Henningsson et. al. 2007), was used on the lips’ four quadrants and on the right and left side of the tongue tip. The child was asked to tell if he felt one or two points starting with the 3mm distance.
4. Tactile assessment was assessed with a gloved finger smoothly touching the inside of the child’s mouth. The tongue tip, blade and back of tongue were touched. The results were described in qualitative terms of hyper sensibility if reactions to touch on tongue were excessive and in terms of hyposensibility if reactions to touch on tongue were weaker than expected. Mixed sensibility may also occur if you experience great reactions from one part of the tongue and unexpectedly low from another according to Rosenfeldt-Johnsson (2001).

The speech and language areas single word naming, repetition of sentences and non word repetition were documented with audio recordings (see paragraph 4.4).

5. The word naming task contains of 26 one and two syllable words. All Swedish consonant speech sounds are represented, but not all consonant clusters.

6. The repetition of sentences task contains of eight phrases or sentences and two multisyllabic and complex words. The speech material was transcribed phonetically using the conventions of the International Phonetic Association (http://ipa-lac.org/). Calculations of the percentage of consonants correctly produced (PCC) were made on word naming, repetition of sentences and non word repetition.

7. The words in non word repetition were also analyzed for suprasegmental correctness (the number of non words with correct stress and correct number of syllables) and calculations of the percentage of non words with suprasegmental correctness (PSC) were made.

All video- and tape recordings were scored and transcribed by a second speech language pathologist. Inter-judge reliability for ratings of orofacial muscular control was 87%.

4.5.3 Therapy

The therapy was given in two steps lasting for three months each. The therapy tool used for vibration was an oscillating electric toothbrush. The therapy program was thoroughly explained by the author and practiced in the clinical setting with the child and parent(s) and was then performed by the parents daily at home. No other speech and language therapy was provided during this period.

Therapy period one consisted of pure orofacial sensorimotor therapy with vibration on cheeks, around the mouth, on the tongue and the palate (see appendix 1). The program consisted of eight exercises that were carried out three times each and it took about five minutes to complete the program. The children were given a therapy diary to keep track on training and were asked to mark ‘the happy face’ symbol every day therapy had taken place. Therapy period two consisted of the same oral vibration program as in period one, with an added part of guidance for speech sound targets. The four boys had individual goals depending on their speech status. Boy F had /s/ and /ʃ/, boy J had /l/, boy E had /s/ and /ʃ/ and boy O had dental placement (t, d, l) as targets.

4.5.4 Parent evaluation form

A parent evaluation form was administered by the author to the parents at two occasions; after therapy step one and therapy step two (see appendix 2). The evaluation form was put together by the author and utilized for approximately two years in clinic, when working with oral
motor problems, before using it in the present intervention study. The parents were asked to evaluate the benefit of the vibration therapy using the two scales described below and also by written comments.

Visual analogue scale (VAS) is a subjective measurement used for example to grade experienced pain, but also in other contexts. The scale is often graded from 1 to 10, where 1 in this case stands for no benefit of the vibration therapy program and 10 stands for very much benefit. The other scale was influenced by the ratings described by Campbell (1999) and was developed by the author of this thesis. The scale had four levels from 1 to 4, each with a verbal explanation; Level 1. Not so good, it has been difficult to use. Level 2. Quite good, but not a big improvement in oral motor ability and/or orofacial awareness. Level 3. Good. We notice a positive improvement in oral motor ability and/or orofacial awareness. Level 4. Very good. We notice a considerable improvement in oral motor ability and/or orofacial awareness.

5. RESULTS

The result presentation begins by showing the outcome of the pre-tests and base-line. Descriptive data from assessment 1, 2 and 3 then follow and a description of intrindividual development conclude the presentation.

5.1 Pre-testing and base-line

One inclusion criteria was ‘no major difficulties in language comprehension and vocabulary’. Table 4 shows the results for the four boys on the three pretests, presented in percent, raw scores and for the language comprehension test also as a Stanine value (S). Table 4. Results from the pretests presented in percent, raw scores, and maximum scores. For the language comprehension test also as a Stanine value.

<table>
<thead>
<tr>
<th>Child</th>
<th>Reynell</th>
<th>PPVT</th>
<th>Non word discrimination</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% max 67 Stanine</td>
<td>% max 93</td>
<td>% max 8</td>
</tr>
<tr>
<td>J</td>
<td>92 62</td>
<td>St 7</td>
<td>76 71</td>
</tr>
<tr>
<td>F</td>
<td>97 65</td>
<td>St 7</td>
<td>80 74</td>
</tr>
<tr>
<td>E</td>
<td>94 63</td>
<td>St 6</td>
<td>77 72</td>
</tr>
<tr>
<td>O</td>
<td>84 56</td>
<td>St 4</td>
<td>70 65</td>
</tr>
</tbody>
</table>

Three of the boys received high points on the Reynell language comprehension test and the fourth boy a little lower, but converting the score to Stanine we can conclude that they all fall within the normal range on this test. The results on the PPVT show that, according to the age reference in Reuterskiöld et. al. (2000), the word comprehension is normal, but within the lower range. The Non Word discrimination test shows five to eight correct pairs and according to Höorman and Kring (2001) it is a result within the normal range for this age group.

There was no significant spontaneous development between the two base-line assessments. As an example Boy E, F and J scored the same number correct identified oral stereognostic shapes in base-line one as in base-line two, and Boy O made three correct responses in base-line one and two correct responses in base-line two. The speech task word naming, calculated in PCC, showed the exact same percent in base-line one and two for Boy J (57/57), Boy F
(91/91) and Boy E (79/79). Boy O had an improvement in PCC (45/52), but since he was stable in sentence repetition and in sensory abilities he was included in the study.

5.2 Descriptive data of assessment areas

The results from the three assessments with the STORM are presented below, one ability at a time. The speech and language tasks are shown in percent change from assessment 1 to 3. The other assessed abilities are presented in raw scores or as descriptive data because it was not reasonable or possible to calculate percent on these results.

<table>
<thead>
<tr>
<th>Oral stereognosis</th>
<th>Orofacial</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Graph" /></td>
<td><img src="image" alt="Graph" /></td>
</tr>
</tbody>
</table>

Figure 1 and 2. Development of oral stereognostic ability and orofacial control from assessment one to three for each individual. Orofacial control is measured in points where the higher the score the larger the difficulties.

When looking at the results on oral stereognosis and orofacial motor control tasks some improvement for all subjects are evident, see Figure 1. As for oral stereognosis the most obvious improvements were made by Boy O and E. They increased their number of correct responses from 2 to 5 and from 3 to 5 respectively (out of 8). Boy O progressed well on the orofacial motor tasks after 6 months of vibration therapy although he started out with great difficulties. His orofacial score was improved by 14 points, see Figure 2.

Table 5. Results from oral two point discrimination at assessment 1 to 3. A plus (+) indicates that the child was able to discriminate two points with 3 millimeter’s distance. L is short for left side and R is short for right side.

<table>
<thead>
<tr>
<th>Child</th>
<th>Two point discrimination</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ass 1 tongue/lips</td>
</tr>
<tr>
<td>J</td>
<td>+/+/</td>
</tr>
<tr>
<td>F</td>
<td>+/+</td>
</tr>
<tr>
<td>E</td>
<td>+/+/</td>
</tr>
<tr>
<td>O</td>
<td>No results, he guesses</td>
</tr>
</tbody>
</table>

Two point discrimination gave a normal result for Boy J and Boy F, i.e. full score on both tongue and lips. Boy E also reached a good result, but got a little uncertain concerning touch on the tongue tip at assessments two and three. Boy O could not manage to give any reliable scores at all at assessment 1 and 2, but after the full intervention period his performance was somewhat improved.
Table 6. Results from tactile sensitivity test at assessments one to three.

<table>
<thead>
<tr>
<th>Child</th>
<th>STORM Ass 1</th>
<th>Tactile Ass 2</th>
<th>sensitivity Ass 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>J</td>
<td>hyper</td>
<td>hyper</td>
<td>hyper</td>
</tr>
<tr>
<td>F</td>
<td>hyper</td>
<td>hyper</td>
<td>Normal</td>
</tr>
<tr>
<td>E</td>
<td>hyper</td>
<td>hyper</td>
<td>Hyper</td>
</tr>
<tr>
<td>O</td>
<td>hypo</td>
<td>hypo</td>
<td>Mixed with hypo</td>
</tr>
</tbody>
</table>

Three boys were hypersensitive in their mouth at assessment one and one boy was hyposensitive. After step one no change was noted, but after step two, i.e. after three more months with intraoral vibration, two boys made improvements. Boy F now reacted normally to touch on his tongue and Boy O with hyposensitivity had developed his oral sensitivity.

![Graphs showing changes in words, sentences, and non-word repetition over assessments.]

Figure 3, 4 and 5. Change from assessment one to three on speech and language tasks; word naming, sentence repetition and non word repetition.

Looking closer at all the speech tasks a clear pattern of boy J and boy F making the greatest percent improvement is shown. See figure 3 to 5. At assessment three they improved 18 and 10 percent respectively for word naming, 15 and 17 percent for sentence repetition and 38 and 34 percent for non word repetition. Boy E made progress on sentence repetition with 9 percent, but no improvements regarding word naming and non word repetition was noted. Repetition of non words was the most difficult task. The lowest PCC for the group was found on this task (compared to PCC for the other two speech tasks). None of the boys had any suprasegmental problems as measured by syllable length and stress.
5.3 Descriptive data of individuals

Boy J.

Table 7. Test results for boy J. Orofacial motor control tasks were measured in points from 0 to 4, where 0 represents the best result.

<table>
<thead>
<tr>
<th></th>
<th>STORM stereognosis max 8</th>
<th>STORM 2p disc tongue/lips</th>
<th>STORM orofacial Points</th>
<th>STORM tactile sensibility</th>
<th>STORM words PCC</th>
<th>STORM Sentence PCC</th>
<th>Non-word PCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ass 1</td>
<td>5</td>
<td>+/+</td>
<td>8</td>
<td>Hyper</td>
<td>57</td>
<td>52</td>
<td>45</td>
</tr>
<tr>
<td>Ass 2</td>
<td>5</td>
<td>+/+</td>
<td>8</td>
<td>Hyper</td>
<td>59</td>
<td>55</td>
<td></td>
</tr>
<tr>
<td>Ass 3</td>
<td>6</td>
<td>+/+</td>
<td>2</td>
<td>Hyper</td>
<td>67</td>
<td>60</td>
<td>62</td>
</tr>
</tbody>
</table>

J reacted with discomfort having the oral stereognosis forms in mouth and handled the forms only with his tongue-tip and alveolar ridge. The wrong responses decreased from three to two and they were at assessment three within form category (rounded/spiny). He gave clear and correct responses to two point discrimination on all assessments. Orofacial motor control gave a low score and after the two vibration therapy steps he improved his /l/-sound which further lowered the points. Tactile hypersensitivity was persistent throughout the intervention period. Word naming, sentence repetition and non word repetition improved from assessment one to three as measured with PPC. This was despite the fact that the fronting persisted throughout the intervention period. See table 7.

Boy F.

Table 8. Test results for boy F. Orofacial motor control tasks were measured in points from 0 to 4, where 0 represents the best result.

<table>
<thead>
<tr>
<th></th>
<th>STORM stereognosis max 8</th>
<th>STORM 2p disc tongue/lips</th>
<th>STORM orofacial Points</th>
<th>STORM tactile sensibility</th>
<th>STORM words PCC</th>
<th>STORM Sentence PCC</th>
<th>Non-word repetition PCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ass 1</td>
<td>5</td>
<td>+/+</td>
<td>3</td>
<td>Hyper</td>
<td>91</td>
<td>72</td>
<td>41</td>
</tr>
<tr>
<td>Ass 2</td>
<td>6</td>
<td>+/+</td>
<td>1</td>
<td>Hyper</td>
<td>98</td>
<td>78</td>
<td></td>
</tr>
<tr>
<td>Ass 3</td>
<td>6</td>
<td>+/+</td>
<td>0</td>
<td>Normal</td>
<td>100</td>
<td>84</td>
<td>55</td>
</tr>
</tbody>
</table>

F participated well in the oral stereognosis test but could not handle the forms between his tongue blade and the palate but instead used the front part of the tongue and alveolar ridge. After therapy the wrong responses decreased to two and those were then also within form category (assessment three). He gave clear and correct responses to two point discrimination. Orofacial muscular control was normal with only 3 points in first assessment but dropped even further to a maximum score (0 points) in assessment three. After both intervention periods he showed normal tactile sensibility in mouth. Speech parameters improved and Word Naming showed increased consonants correct and he got them all accurate after both therapy periods. Sentence repetition improved with 12 PCC and non-word repetition with 14 PCC. See table 8.
Boy E.

Table 9. Test results for boy E. L is short for left side and R is short for right side. Orofacial motor control tasks were measured in points from 0 to 4, where 0 represents the best result.

<table>
<thead>
<tr>
<th></th>
<th>STORM stereognosis max 8</th>
<th>STORM 2p disc tongue/lips</th>
<th>STORM orofacial Points</th>
<th>STORM tactile sensibility</th>
<th>STORM words PCC</th>
<th>STORM Sentence PCC</th>
<th>Non-word repetition PCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ass 1</td>
<td>3</td>
<td>+/+</td>
<td>9</td>
<td>Hyper</td>
<td>79</td>
<td>70</td>
<td>55</td>
</tr>
<tr>
<td>Ass 2</td>
<td>5</td>
<td>L+R 5mm/+</td>
<td>8</td>
<td>Hyper</td>
<td>79</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>Ass 3</td>
<td>5</td>
<td>L3mm, R5mm/+</td>
<td>6</td>
<td>Hyper</td>
<td>77</td>
<td>76</td>
<td>57</td>
</tr>
</tbody>
</table>

E. recognized and identified shapes in the oral stereognosis task only with tongue tip and alveolar ridge. He increased the amount of correct answers from 3 to 5 after using the sensorimotor vibration program for 3 months (step one), but used the same way of handling the forms throughout the study. He gave clear and correct responses to two point discrimination on the first occasion on both tongue and lips but only on the lips on the second and third assessment, when he showed an uncertainty regarding the narrow distance of 3 mm on the tongue tip.

Orofacial motor control gave few points and there was a small development in the motor control, for example concerning the movement and placement of the tongue tip on the alveolar ridge. Tactile sensitivity on the tongue was classified as hypersensitive with a strong reaction when touched on the tongue blade and back. After six months he was still hypersensitive.

As for the speech parameters word naming and non-word repetition he did not improve concerning percent consonants correct, but for sentence repetition there was an improvement from 70 to 76 percent. Looking at individual speech sounds there was occurrence of the /l/ sound from a /j/ after the second step of vibration therapy. See table 9.

Boy O.

Table 10. Test results for boy O. L is short for left side and R is short for right side. Orofacial motor control tasks were measured in points from 0 to 4, where 0 represents the best result.

<table>
<thead>
<tr>
<th></th>
<th>STORM stereognosis max 8</th>
<th>STORM 2p disc tongue/lips</th>
<th>STORM orofacial Points</th>
<th>STORM tactile sensibility</th>
<th>STORM words PCC</th>
<th>STORM Sentence PCC</th>
<th>Non-word Repetition PCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ass 1</td>
<td>2</td>
<td>No result</td>
<td>37</td>
<td>Hypo</td>
<td>52</td>
<td>48</td>
<td>51</td>
</tr>
<tr>
<td>Ass 2</td>
<td>4</td>
<td>No result</td>
<td>38</td>
<td>Hypo</td>
<td>54</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>Ass 3</td>
<td>5</td>
<td>L10mm, R5mm/guesses</td>
<td>23</td>
<td>Mixed (hypo)</td>
<td>52</td>
<td>46</td>
<td>55</td>
</tr>
</tbody>
</table>

Boy O was uncertain regarding the oral stereognosis shapes and made groping gestures when trying to identify the shapes. The shapes were mostly handled in the front of the mouth and at a periodontal location and they were sometimes almost pushed out of the mouth. The results increased from 2 to 5 correct answers and he also got a little more certain in handling the objects between assessment one and three. He still had to feel in the periodontal region and he
only used the tongue tip. The two point discrimination task was difficult for him to perform. He did not understand the task and guessed. In the third assessment, however, it was clear that he felt the difference between one point and two points regarding a distance of 10 mm on the left side of the tongue and 5 mm on the right. On all four places on the lips he was not sure at all and guessed.

Orofacial muscular control was difficult. He reached high points on the mimic muscle tasks and on movements with the tongue. The results had not improved after step one, but after step two he had increased his awareness and control and made a better result. Tactile sensitivity on the tongue was hyposensitive from start and after the intervention step one, but after 6 months of vibration he responded to touch on his tongue.

There was no obvious change regarding the results on the speech and language tasks; word naming, sentence repetition and non word repetition. See table 10.

5.4 Parents evaluation

The results from the parent questionnaire are shown in tables 11 and 12. The scales used and the written comments are presented.

Table 11. Parents’ evaluation after therapy step one. VAS 1 = no benefit, 10 = very much benefit. Level 1 = not very good, level 4 = very good.

<table>
<thead>
<tr>
<th>Child</th>
<th>VAS (0-10)</th>
<th>Level (1-4)</th>
<th>Parents comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>J</td>
<td>2</td>
<td>2</td>
<td>&quot;He is not fond of the vibration therapy, but has participated every day&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&quot;We cannot see any positive changes in oral motor ability, but some days speech is more clear and other days not.&quot;</td>
</tr>
<tr>
<td>F</td>
<td>9</td>
<td>3</td>
<td>&quot;His speech has improved and he is thinking about his pronunciation and is trying to find more correct placements of the tongue when talking&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&quot;he can control his tongue much better when brushing teeth&quot;</td>
</tr>
<tr>
<td>E</td>
<td>4</td>
<td>3</td>
<td>&quot;His oral awareness has improved a lot and he is now able to find the speech sounds /l/ and /s/ more easily when we train at home and we sometimes notice these sounds in his spontaneous speech.&quot;</td>
</tr>
<tr>
<td>O</td>
<td>7</td>
<td>3</td>
<td>&quot;He has gained tactile sensitivity around the lips. He did not feel the vibration here from the beginning, but now he thinks it tickles. He is more aware of his tongue movements and is beginning to understand how to produce speech sound /l/, but there is no change in his spontaneous speech.&quot;</td>
</tr>
</tbody>
</table>
Table 12. Parents’ evaluation after therapy step two. VAS 1 = no benefit, 10 = very much benefit. Level 1 = not very good, level 4 = very good.

<table>
<thead>
<tr>
<th>Child</th>
<th>VAS (0-10)</th>
<th>Level (1-4)</th>
<th>Parents comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>J</td>
<td>2</td>
<td>2</td>
<td>“There are some words that he pronounces better now, and /l/ is sometimes heard in spontaneous speech. He does use a more retracted position for the velar sounds /k/ and /g/ sometimes, but cannot find the right placement. We think he still is a bit sensitive on the back of his tongue.”</td>
</tr>
<tr>
<td>F</td>
<td>10</td>
<td>4</td>
<td>“His motivation has been great; he was the one who initiated practice for a long time. It is so positive that he has got an increased awareness of his mouth and speech movements. He recently learned how to pronounce the end of his name.”</td>
</tr>
<tr>
<td>E</td>
<td>6</td>
<td>3</td>
<td>“The vibration program has been really helpful and we think he would benefit from continuing it. Before he had big problems knowing how to move his tongue when working with speech but now he is more aware and finds the sounds in words when practice.”</td>
</tr>
<tr>
<td>O</td>
<td>8</td>
<td>3</td>
<td>” We think he is now talking a little better, his articulation is more distinct. He has now learned how to pronounce /l/ correct in practice. The vibration intervention program has been a way to achieve better awareness about tongue movement and placement.”</td>
</tr>
</tbody>
</table>

6. DISCUSSION OF RESULTS

6.1 Does oral vibration therapy affect oral sensory abilities?

Looking at the outcome concerning oral stereognosis after the completed intervention program we find a positive effect for all four children in this study. See figure 5. Boy O, who had the most pervasive oral sensory and motor deficits, is the one with the most obvious improvements. He had pronounced difficulties handling the objects in his mouth and at the third assessment he had reached a higher level of certainty. Since oral stereognostic ability is used daily in eating (Mundin & Norén, 2000) it might be that boy O’s difficulties with chewing were affected by his poor stereognostic ability. Boy O’s parents reported an increased oral awareness after both therapy step one and therapy step two and they were very positive about the exercises.

Regarding the data on two point discrimination it is evident that the task was quite easy for three of the boys. The author has observed that most of the speech disordered children tested in the clinic obtain full scores on this test. In a study of oral sensory ability in typically language developed children it was found that 73 of 103 children reached a full score on a test of two-point discrimination (Andersson & Buhr, 2009). The remaining children’s scores were also consistently high. Boy O had difficulties with the discrimination during the baseline assessment, but after six month of tactile stimulation with the vibration tool he was able to give some correct answers when tested.

Concerning tactile sensitivity, Boy F is normalizing his oral sensitivity after six months of vibration therapy and Boy O, with hyposensitivity becomes more sensitive in and around his mouth. The parents of the latter boy reported that his sensibility around and in the mouth
increased already after three months; he now felt the vibration and said it tickled a little. From the beginning he had not felt anything. Several SLP’s use oral-motor intervention programs including tasks concerning touch. (Bahar, 2009; Rosenfeld-Johnson, 200). The latter author described several children who were hyposensitive and a vibration tool was used to massage lips, tongue and buccal cavity (Rosenfeld-Johnson, 2005).

As for the oral motor techniques defined by Marshalla (2008) some of them are addressed when using a vibrating tool. To ‘develop sensory awareness and discrimination for oral movements’ and ‘normalize tactile sensitivity for oral movements’, are techniques that are at the core in the present study.

6.2 Does oral vibration therapy affect oral motor ability?

All the boys improved according to the orofacial assessment in the STORM after 6 months i.e. step one plus two, see figure 2. In this multiple case study it is evident that Boy O had the most severe difficulties with orofacial motor control. The test results after six months vibration intervention indicated great improvements, from 37 points down to 23 (lower points represent better performance), and positive functional result was also reported by his parents.

It may be that the oral vibration was a means for him and the other boys to develop an awareness and discrimination of orofacial movements (Marshalla, 2008) which in turn affected the ability to perform volitional mimic expressions. The mimic muscles form a highly complex functional network and some children need a lot of support and different approaches to be able to develop their orofacial motor control. Based on the results of the present study the author believes that oral vibration could be one such approach.

6.3 Does oral vibration therapy affect speech and language?

There was a measurable and clear progress of the results on the speech tasks for two of the boys (Boy J and Boy F) in this study, figure 3 to 5. The speech tasks including real words; word naming and sentence repetition, improved at or above 15 percent for these two boys after the completed intervention. The analysis of phoneme production showed improvements regarding the speech sound production for all four boys.

The most obvious improvements were demonstrated on the nonword repetition task (an increase of 34 and 38 percent). Researchers have consistently acknowledged that the non word repetition task tap into many language processes, including speech perception, phonological encoding, phonological memory and articulation (Coady & Evans, 2008). They have also found evidence that children with LI often exhibit impairments in all these supporting skills. The non-word repetition task has gained wide acceptance in indexing language acquisition in both children with normal language development and children with language impairments (Botting & Conti-Ramsden, 2001). One example is Stark and Blackwell (1997), who found that non word repetition was associated with oral motor skills and phoneme identification in children with LI.

Taking the present results into account it is assumed that these children improved oral awareness and oral motor control after oral vibration therapy. Better and more automatized oral motor control may have freed resources for auditory analysis needed for more efficient phonological processing in the non word repetition task.
It is important to keep in mind that transfer of training occurs when learning of a response in one situation or domain facilitates learning of a response in a different, novel situation (Forrest, 2002). In the clinic we have several different techniques to facilitate this process of transfer. When dealing with a child with a sensorimotor deficit underlying poor phonological development we need to add more motor and sensory oriented techniques to our speech and language intervention program. This could for instance be tactile cues, palatal plates or a vibrating tool. The technique used could help cueing articulatory targets within the speech intervention program focusing on speech and lingual movement. The cues could help the child to find, establish and, with specific speech therapy, transfer the improved speech movement to speech. If the child has both speech problems and orofacial problems like drooling and poor orofacial muscle control the difficulties should be addressed in the treatment plan. It is also important to be aware of the goals with each technique and to explain these goals clearly to the parents and to the child.

6.4 Are there any differences in individual outcome after step one compared to step two?

The greatest gains were seen after the completion of the whole training program even if some gains were obvious already after step one.

Therapy step one consisted of pure oral sensorimotor exercises with vibration. Despite this boy F already after this first step showed significant improvements in spontaneous speech and naming/repetition, as well as regarding the distinction between velar and dental speech sounds. Boy J was from the start not able to imitate and produce the speech sound /l/ at all, but at the assessment after step one he was able to find the correct articulatory target and even to coarticulate syllables with a vowel using the correct speech movements if guided by the therapist. He also had acquired s-clusters and devoicing had ceased. Boy E and O showed no change in speech after therapy step one.

Therapy step two consisted of the same oral vibration program as in period one with an added part of guidance for lingual placement. All four children showed improvement, but to different degrees. Boy F had /g/ and /ʃ/ as target sounds and learned to produce them in words when working with his parents. Boy J had /l/ as his target sound and after therapy step two he had started to frequently use it in words and sentences. Furthermore the /r/, /ɹ/ and /ʃ/ sounds appeared in some words. Boy E had /g/ and /ʃ/ as his targets in intervention step two and learnt how to produce them and used them in words when reminded. Boy O had the dental consonants (t, d, n, l) as his target sounds and the assessment after therapy showed a more active tongue tip, /l/ was used frequently in speech and /s/ was more distinct with a more anterior air flow (he had lateral produced /ʃ/ in his spontaneous speech).

The speech assessments show positive results for all boys in this study after therapy period two. Grant (1982) describes the positive effects of using a manual vibrator in speech therapy in terms of increasing proprioceptive input to the oral region and reports that it will develop orofacial musculature control and improve articulation skills. He states that a manual vibrator may be a useful supplement to the speech therapy program. Marshalla (2008) has several oral motor techniques amongst her twenty-two fundamental methods that have specific phonemes or group of phonemes as targets. Some of them are addressed in the extended vibration
intervention program in phase two; cue oral movement, mark the target of oral movement and model oral movements or positions.

Looking at the results from all the oral (jaw, lip, and tongue) motor (sensory, movement, and positioning) skills (Marshalla, 2008) as a group it seems to be important for the boys to have enough time to practice and develop. Most improvements concerning oral stereognosis, orofacial motor control and tactile sensibility was not made after first step, but after step two i.e. six months. If you for instance look at boy F he was still hypersensitive after step one, but after step two his tactile sensitivity was normal. Thus, the complete program is recommended in order to make sure for skills to become stable and automatized in all children.

6.5 What is the parents' attitude to this intervention?

The effects of treatment can be measured in three different ways including the measurement of treatment outcomes, functional treatment outcomes and treatment efficacy (Campbell, 1999). Treatment outcomes are the change of communication behaviors measured at some point in the intervention process and the presented results in this study would belong to this category. Functional treatment outcomes on the other hand are the change seen in real-life communicative situations and we often need to collect the information about these outcomes from parents using questions or a questionnaire with a rating scale or a scoring system.

From the questionnaire of therapy benefit that was administered after intervention steps one and two it was obvious that the parents' opinions do not always match treatment outcome. Boy J had the greatest speech improvement of all the boys measured in percent, but the parents did not notice the change concerning the velar sounds that they had hoped for. Consequently their scoring (on both scales) was low on both occasions. Despite this they made some positive written comments. The parents of boys F, E and O were positive and gave the intervention method good and increasing grades between intervention step one and two. They all associated the results of the vibration treatment with the phoneme production and speech improvement they noticed. In the clinic it is important to take parents' views into account when planning for further treatment. Using a single source of data, i.e. the clinicians observations, will often give an invalid estimate of the child's communication abilities. Multiple observations and different sources of information can provide rich and valid data for documenting both treatment outcome and functional change in communication.

6.6 Methodological considerations and future studies

There are some shortcomings as to the present study.

1. It would have been interesting to have assessed non word repetition after therapy step one to see if the improvements were already present after step one.

2. Reliability checks could have been done on more tasks than on the orofacial motor control tasks.

3. The vibration intervention program was performed by parents at home and there were no checking up of the parent's instructions in-between assessments. The parents may not have instructed their children in the same way.

4. The entire process in this intervention study was made by one person, the author of this thesis, and there may be effects on the therapy results presented according to
the Hawthorne effect (Dollaghan, 2007). This is a form of reactivity where subjects improve or modify an aspect of their behavior being experimentally measured simply in response to the fact that they are being studied. There is also a possibility that spontaneous development of the areas assessed occurred during the intervention period of six months.

Future studies call for an inclusion of more children in order to strengthen the support for the method. This is necessary if the goal is Evidence Based Practice.

6.7 Conclusions

- All four boys made improvements in oral stereognostic ability after six months of oral vibration therapy.
- All four boys made improvements in orofacial motor control after six months of oral vibration therapy.
- The oral vibration therapy affected the tactile sensibility for two of the boys in a positive direction.
- Three of four boys made improvements in sentence repetition (between 9 and 17 percent).
- Two of four boys made great improvements in speech and language tasks; word naming, sentence repetition and non-word repetition.
- The vibration intervention program is a nonspeech oral motor technique and the nonspeech abilities oral stereognostic and orofacial motor control improved in all four boys.
- All boys learnt how to produce the target lingual placement or sounds, the placement of which was added as a goal in step two. Some phonemes were managed only in practice; others were appearing at some extent in spontaneous speech.
- It seems to be important to administer the vibration intervention program for more than one three-month period, because some children need more time to be able to benefit from it.
- The general impression is that parents experience the vibration intervention program as cost-beneficial.

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Appendix 1: The vibration intervention program

ORALMOTORISK STIMULANS MED ELTANDBORSTE

Övningarna måste göras varje dag för att resultatet ska bli bra. För att öka medvetenheten och rörligheten är det lagom att utföra varje övning tre gånger. Använd en vibrerande el tandborste.

1. För el tandborsten från muninnhals mot frams och tillbaka.

2. För el tandborsten runt munnen utifrån det läpppröda. Gör samma sak på det läpppröda. (Syfte: att öka aktiviteten i läpparna.)

3. För el tandborsten som "voterar" ut från läpparna. (Syfte: att stimulera läpp保姆.)

4. För el tandborsten boxfynt och framåt på munnen. Stäng sedan munnen och svälj en gång. Upprepa procedurerna ett par gånger till. (Syfte: att stimulera tungan att röra sig bakåt.)

5. Börja bak på tungan och för el tandborsten diagonalit fram mot tungan. Gör likadant från andra sidan. (Syfte: att öka sensorn och aktiviteten i tungan.)

6. För el tandborsten långs tungan sidor bakåt och framåt. (Syfte: att öka sensorn och aktiviteten i tungan.)

7. Stricka tungan och vibrera på tungan. Patenta el tandborsten med tungan. (Syfte: att hitta tungan - många barn använder för stor del av tungan vid articulation.)

8. Vibrera omväntande på tungan mota och bokarnas framdelarna i övningar. (Syfte: att hitta de mest artikulationsställen.)
Appendix 2: The parent questionnaire of benefit

Utvärdering

Dagens datum: ...........Namn: ............................................Född: ......................

Oralmotoriskt träningsprogram

Du/ditt barn har tränt med (sätt kryss vid det som stämmer)

...........*eltehandtröskvajprogrammet ...........*finger-dent massage
...........*spatelträmning för läpparna ...........*gompflatta
...........*munskärm ...........*Hummingbird
...........*munmotoriska övningar ...........*artikulatoriska övningar

Tidsperiod

Vi har nu använt detta program i ...... månader. Datum: ..................till ..........

...........*varje dag (med få undantag) ...........*flera gånger i veckan
...........*någon gång varje vecka ...........*några få gånger under perioden

Nytt

Träningsprogrammet är en del i min/mitt barns talträning och det har varit

...........*mycket bra och vi märker en tydlig förbättring av oralmotoriken och/eller ökad medvetenhet i och kring munnen
Kommentar__________________________________________________________________________

...........*bra och vi märker en förbättring av oralmotoriken och/eller ökad medvetenhet i och kring munnen
Kommentar__________________________________________________________________________

...........*ganska bra, men vi märker inte så stor förbättring av oralmotoriken och/eller ökad medvetenhet i och kring munnen
Kommentar__________________________________________________________________________

...........*mindre bra, det har varit svårt att genomföra på grund av att ____________________________

1 2 3 4 5 6 7 8 9 10 VAS-skala (sätt kryss)

I...................................................................................................................................I

Liten nyttan..............................................mycket stor nyttan

Tack för hjälp!
/Susanne Rex, leg. logoped