

The Correlation between Non-Speech Oral Motor Exercises (NSOME) and Speech Production in Childhood Apraxia of Speech Treatment. A Wide Clinical Retrospective Research

Elad VASHDI¹,
Amit AVRAMOV²,
Špela FALATOV^{3*},
Huang YI-CHEN⁴,
Jiang PEI-RU⁵,
Paula Teodora MAMINA-
CHIRIAC⁶,

¹ DPT, clinician, Yaelcenter institute director, Israel, center@yaelcenter.com

² Senior MDT and VML consultant, Yaelcenter, Israel, amit.avramov@gmail.com

³ Center ZA zdravljenje avtizma Director, Slovenia, info@centerza.com

* Corresponding author

⁴ MSPA-CPSP, Beyond speech pathology clinic director, Taiwan, elaine.y.c.huang@gmail.com

⁵ BSpPath, Sunny Speech Pathology Clinic director, Taiwan, panny320@yahoo.com.tw

⁶ BS-Psych, Psychology Office, Romania, paulachiriac83@yahoo.com

Abstract: *This research shows the relationship between NSOME and speech sounds production, and seems to contradict the common literature findings. However, it, in fact, is just adding another piece of knowledge to the puzzle. The relationship and interaction between NSOME and speech is well demonstrated, and further research should be conducted in order to set guidelines for EBP practice of NSOME.*

Keywords: *childhood apraxia of speech; autism; NSOME; oral motor; phonetics.*

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Introduction

This article aims at taking a different perspective and providing clinical evidence regarding the relationship between Non-Speech Oral Motor Exercises (NSOME) and speech production. The use of NSOME in motor speech sounds disorder treatment has been discussed in the literature in the last three decades, with most of the research discussing the use of NSOME as poorly related to speech production. In fact, no solid evidence has been found in the literature for having the NSOME more efficient in treatment of motor speech sounds disorder. Few researchers argued with passion that using NSOME is not ethical and therapists should "look themselves in mirror" and ask whether they are using non evidence-based practice, and consider their morality and integrity (Kamhi, 2008; Lof, 2007). 75% of the academic instructors, examined in a study conducted in the United States, did not teach NSOME in their classes (Lof & Watson, 2009). However, many clinicians still use the NSOME even though the literature "forbids" it. Few studies have discussed the differences between the clinicians and the researchers on the matter (Muttiah 2008; Muttiah et al., 2011). The relationship between NSOME and speech production should be researched more thoroughly in order to present a possible answer to the above debate.

NSOME is usually practiced with children diagnosed with Childhood Apraxia of Speech (CAS). CAS is a motor speech sounds disorder that involves a deficit in planning and programming of speech sounds on a motor basis (American Speech-Language-Hearing Association, 2007; Burlea et al., 2010). One of the characteristics of that phenomenon is poor control over pre-verbal skills, hence the question of using NSOME in treatment of CAS is crucial. Children with severe CAS have poor control over planning oral movements, whether sound related or not. Using the NSMOE for some of them might be the link for sound production even though NSOME is not speech per se.

What are the NSOME?

The NSOME are a group of exercises targeting oral movement skills. There is no consensus about the type of exercises considered as NSOME, so a general use of the term in research is done, causing inconsistency in results. Some texts will include exercises such as muscle strengthening and coordination to help the development of sound production (Morley 1966, pp. 104-110; Ruscello 2008). Recent research adds breathing control exercises, tongue movement, oral-motor control and

positioning (Bahr 2001; Forrest 2002; Lass & Pannbacker 2008; Lupu et al., 2015). Bahr & Rosenfeld-Johnson (2010) came with a new term called OPT (Oral Placement Therapy), which includes oral motor exercises that are directly related to speech and are to use only if needed for speech purposes. They argue that there is a misunderstanding and misuse of the term NSOME and therefore set a new term to avoid confusion.

In this research we used the Verbal Motor Learning (VML) method for treating CAS (Vashdi 2013; Vashdi 2014). The VML method uses NSOME as part of the treatment program for children diagnosed with CAS. The use of NSOME is done according to the child's needs in order to help with sound production. The NSOME are divided into four major categories: breathing control, oral sensory regulation, oral imitation (which relates to the mirror neurons system function (Williams et al., 2001) and tongue movements. In sound production, these systems need to work together in high coordination, which can be considered as an additional motor element to control, beyond the single control over each separate system.

The NSOME controversy

Most of the published papers do not support the use of NSOME as a therapeutic tool for speech delay or CAS. Lof and Watson described 5 reasons for not using NSOME in treatment: 1) transference of a part to a whole is not useful, 2) unneeded strength training, 3) specificity of brain organization for performing a specific task, 4) awareness of articulators as not important in speech acquisition and, 5) lack of empirical evidence for NSMOE use (Lof & Watson, 2008). McCauley, Strand, Lof, Schooling, & Frymark (2009) performed a wide survey of the NSOME evidence between 1960 and 2007. They reviewed 899 citations but only 15 passed the inclusion criteria, Thus, their whole analysis was based on 15 articles. The result of the survey did not find any evidence for significant efficacy for using NSOME over speech based speech treatment. Lass & Pannbacker (2008) also reviewed the literature for NSMOE evidence. They reviewed 45 articles between 1981 and 2006 in peer reviewed and non-peer reviewed journals. They could not find evidence to support the use of NSMOE over speech based treatment either. Lof argued against using NSOME, quoting numerous articles that proved NSOME to be non-useful, and advised clinicians not to use non-EBP treatments such as NSOME (Lof, 2007). McCauley & Strand (2008) discussed the use of NSOME in CAS and advised the therapists to carefully consider the techniques they are using due to the lack of evidence.

Braislin & Cascella (2005) conducted a clinical trial regarding the efficacy of NSOME in treating four children with mild articulation deficits, using the “Easy Does it for Articulation: An Oral Motor Approach”. They found slight positive changes which were not significant. Forrest and Iuzzini (2008) compared NSOME and traditional speech treatment for children with phonological/articulatory disorders (PADs). They targeted a single sound for each procedure as the treatment goal. The traditional speech treatment was found significantly more beneficial. Kamhi (2008) wrote about the reasons for the wide use of NSOME by many practitioners and emphasized the false belief as the main reason. He advised the 15% of the practitioners who do not use NSOME to join the battle against the use of NSOME.

Lee and Gibbon (2011) published a research protocol for literature review of the NSOME question. They mentioned the methodology of testing NSOME and speech treatment versus only speech treatment as one aspect they want to review. It is an important research protocol since it changes the way researchers tried to find an answer for this debate. Marshalla (2011) reviewed the tools/objects used in articulation therapy by Van Riper and other traditional therapists. Interestingly, Marshalla points that these exercises were used historically when the direct speech treatment failed to deliver results; consequently, not as the primary tool to treat a speech problem. The manner of using NSOME and the idea behind it are not homogeneous. The basic assumption in most research is that the use of NSOME alone will promote sound acquisition. However, the historical use of NSOME advises that, in case of direct speech intervention failure, NSOME should be introduced. Kolia et al. (2019) showed that 4 weeks of NSOME intervention without speech exercises elicited significant articulatory gains for 7 children with feeding disorder. Finally, Bahr (2008) argues that authors make narrow use of the NSOME term that leads to confusion and misunderstanding. Bahr found that 95% of the speech therapists use NSOME in treatment. These findings are concurrent with Lof and Watson’s (2008) nationwide survey, which reported 85% use of NSOME among SLPs.

The debate is between two main groups: a specific group of researchers versus practitioners. Most of the researchers advise not to use NSOME since there is no supportive evidence. Most of the practitioners, however, do use NSOME (Kamhi 2008). The discrepancy between these two groups is not presented equally in the literature as most of the practitioners cannot perform research nor represent their knowledge in the literature. Since researchers and practitioners in this field are representing

usually separate groups, the overlapping between the clinical work and research is low. Muttiah, Georges and Brackenbury (2011) explored how clinicians and researchers incorporate EBP (Evidence Based Practice) into their decision-making processes in relation to these approaches. They have interviewed 11 clinicians and 11 researchers and found 5 themes: 1) NSOME's are effective, 2) EBP is useful, 3) There is no published research supporting NSOME's, 4) Research evidence may change clinical use of NSOME, and 5) Researchers and clinicians have separate but shared roles in clinical decision making. The last theme represents the basis for professional collaboration and might help in solving this debate and others to come.

The current literature does not provide an answer to this gap between theory and practice. While the review articles presented above were not in favour of NSOME, McCauley, Strand, Lof, Schooling, & Frymark (2009) discuss a few problems in such research: 1) lack of homogeneity in terms of NSOME definition and use, target population and research protocols, 2) the basic assumption for most of the protocols is that the use of NSOME alone will improve speech, 3) most of the research structures were of single subject design or small groups, 4) some of the researches had methodological problems. For example, Braislin & Cascella (2005) chose children with very mild articulation problem and no oral-motor deficits, while inspecting the influence of NSOME on speech. These methodological problems may provide reasons for the gap between theory and practice on this matter.

One of the questions in line is whether a change in preverbal skill is correlated with a change in SSP (single syllable production) and multi-syllabic structures pronunciation. Therefore, cases with good pre-verbal skill at the beginning of the treatment process should be excluded, since a good preverbal skill is not expected to improve it and might affect the results of the correlation. Therefore, measuring the correlation between the change in pre-verbal skill and speech should consider a potential to change in both variables. In this research, two measurements were taken: a change in SSP for all the children and a change in SSP just for the children who had poor preverbal skills.

The main purpose of this research was to learn about the relationship between the oral-motor skills and sound production among CAS population, through a wide cross sectional and longitudinal retrospective research. A secondary purpose is to clarify the term "NSOME" for adequate clinical use. The results might add knowledge regarding the use of NSOME in treatment and will suggest directions for

future research in terms of NSOME definition, target population, basic assumption of usefulness and research methodology.

Method

A retrospective study was conducted, analysing 256 entry evaluations and 89 long term treatment protocols of children diagnosed with CAS or suspected CAS. The data was collected over the years 2006 and 2012 and regarded children evaluated at a private clinic in Israel in the Hebrew language. A set of variables based on the VML method assessment was established for the retrospective data collection. Each evaluation was examined thoroughly, and the data was extracted according to a detailed index. Inter-rater agreement for the VML assessment tool was found to be 81% while correlation was 0.79.

Evaluations inclusion criteria were: 1. Suspected CAS or CAS diagnosis. 2. At least 80% of needed data is extractable. Data that was not clear enough to fit the variables criteria was not used. 3. Evaluations in the Hebrew language only. Evaluations were examined regardless of any other criteria so no deliberate sorting was made.

Subjects

Entry evaluations: 256 evaluations were used. Gender distribution - 76.6% boys, 23.4% girls. Average age was 5 years old. Age range was 1;7 – 19 years old. All subjects were diagnosed with speech delay or suspected CAS. 65% of them were diagnosed with Autism as well.

Long term treatment: 89 processes were used in which the child was evaluated 3 times on average. Gender distribution - 83.1% boys, 16.9% girls (typical prevalence). Average age at first evaluation was 6.5 years old. Age range on first evaluation was 3 – 14.5 years old. All subjects were diagnosed with suspected CAS or CAS. 69.6% of them were diagnosed with Autism as well.

Variables

Speech Variables

The ability to pronounce every single sound (vowels, consonants with all the vowels and consonants without vowel) in the Hebrew language was scored. Every sound got a score between 0-3. The data was collected mainly through a single sound imitation and by listening to spontaneous sounds production by the child during the two hours of evaluation. New variables were created out of the raw data:

1. The percentage of each consonant group pronounced (ba +bo + bu+ bi+ beh+bb,).
2. Fricatives –the sum score of the /f/, /v/, /sh/, /s/, /ts/ , /z/ consonants.
3. Sum score of single syllables pronunciation (SSP) –Maximum score of 360 points.

NSOME variables

Breathing control (blowing) was measured on a scale from 1 to 5. The scale was set according to the VML assessment scale. According to this hierarchal scale, progressing in the scale means that the former stages are acquired. The analysis of the raw data shows that in 98.8% (250 of 253) of the cases the order of the breathing control scale was kept. The tongue movement variable was measured on a 1-4 scale. The scale was set according to the VML assessment tool. Analysis of the raw data shows that in all the cases the order of the tongue movement control scale was kept. Oral motor imitation was measured on a 1-4 scale. The scale was set according to the VML assessment tool. Analysis of the raw data shows that in all the cases the order of the Oral motor control scale was kept.

Other variables

- change in breathing control, tongue movements and oral imitation variables for long term group;
- the score difference between the first and last evaluation for each one of the variables per participant;
- the change in sum score of single syllable pronunciation for the long-term group;
- the success percentage difference between first and last evaluation for SSP sum score of the long-term group.

Analysis

Correlations were calculated between the NSOME group of variables and speech production variables for the first evaluation group. For the long-term group, correlations were calculated between changes in sum score of SSP variable and the score change in breathing control, tongue movement and oral imitation variables. The correlations were calculated twice. Once, between any two variables for all participants in this group, and second, only for the group of children that started from change score of 3 and above in the NSOME variables (SSP2).

Results

The correlations between blowing, tongue movements and oral imitation with SSP and other sound variables are presented in Table 1. High correlations were found between the oral-motor variables (blowing, tongue movement and oral imitation) and SSP (-0.62 , -0.65 and -0.64 respectively). Blowing was significantly correlated with the Hebrew fricative consonants group, the /sh/ consonant ([ʃ]) and the /f/ consonant ([f]) (-0.52, -0.50 and -0.51 respectively).

Table 1 – First evaluations' correlations

Source: authors'own contribution

Pearson Correlation Coefficients Prob > r under H0: Rho=0 Number of Observations										
	BLOW ING	TONGUE MOVE	ORAL IMITAT ION	SSP	SUM FRICATI VES	SU M SH	SU M L	SU M F	SU M T	SU M D
TONGU E MOVEM ENT	0.66 <.0001 225									
ORAL IMITATI ON	0.67 <.0001 227	0.94 <.0001 227								

Pearson Correlation Coefficients Prob > r under H0: Rho=0 Number of Observations										
	BLOW ING	TONGUE MOVE	ORAL IMITAT ION	SSP	SUM FRICATI VES	SU M SH	SU M L	SU M F	SU M T	SU M D
SSP	-0.62 <.0001 253	-0.65 <.0001 227	-0.64 <.0001 229							
SUM FRICATI VES	-0.52 <.0001 253	-0.54 <.0001 227	-0.53 <.0001 229	0.90 <.00 01 256						
SUM SH	-0.50 <.0001 253	-0.49 <.0001 227	-0.49 <.0001 229	0.85 <.00 01 256	0.93 <.0001 256					
SUM L	-0.49 <.0001 253	-0.55 <.0001 227	-0.54 <.0001 229	0.77 <.00 01 256	0.64 <.0001 256	0.61 <.00 01 256				
SUM F	-0.51 <.0001 253	-0.56 <.0001 227	-0.54 <.0001 229	0.86 <.00 01 256	0.93 <.0001 256	0.82 <.00 01 256	0.64 <.00 01 256			
SUM T	-0.55 <.0001 253	-0.63 <.0001 227	-0.61 <.0001 229	0.87 <.00 01 256	0.72 <.0001 256	0.68 <.00 01 256	0.66 <.00 01 256	0.66 <.00 01 256		
SUM D	-0.52 <.0001 253	-0.61 <.0001 227	-0.58 <.0001 229	0.85 <.00 01 256	0.70 <.0001 256	0.65 <.00 01 256	0.65 <.00 01 256	0.62 <.00 01 256	0.96 <.00 01 256	
SUM N	-0.54 <.0001 253	-0.57 <.0001 227	-0.55 <.0001 229	0.86 <.00 01 256	0.71 <.0001 256	0.67 <.00 01 256	0.70 <.00 01 256	0.68 <.00 01 256	0.80 <.00 01 256	0.78 <.00 01 256

Tongue movement was correlated with all the alveolar ridge consonants. As seen in Table 1, change in oral imitation and tongue movements had good correlation with change in SSP (R=0.32, <0.0028, R=0.35, <0.001 respectively). The correlation between change in blowing

and change in SSP was not significant ($R=0.17$, <0.1005). When correlated with SSP2, all the variables showed significant correlation. Oral imitation correlation with SSP2 was $R=0.52$ ($N=54$, $<.0001$), Tongue movements correlation was $R=0.55$ ($N=62$, $<.0001$), and blowing correlation was $R=0.29$ ($N=57$, $<.0026$).

Discussion

The NSOME use in the treatment of motor speech sounds disorder is controversial between researchers and clinicians. There is no empirical evidence for its significant usefulness over the solely speech exercises practice (Lof, & Watson 2008), therefore the use of NSOME is considered in most of the academic world as mal-practice and not evidence based. This article suggests a new attitude towards the use of NSOME, by bringing new empirical evidence and set the way for empirical research that will answer the question.

The high correlations between NSOME level of skill and SSP level of skill in the cross-sectional analysis suggest a connection between these fields. The high correlations between the change in NSOME variables and the SSP2 emphasize the connection between the fields, especially when there is a place for a significant change in the pre-verbal skills. Not only is it a cross sectional relationship, but when changes occur in one of the sectors, a consistent change will occur in the other. We cannot determine the direction of influence only by these results, but we can suggest possible theoretical explanations regarding the nature of the relationship between these two skill systems:

Oral-motor skills are developed earlier than speech skills while enabling the sensory-motor base for the development of speech. Even though oral-motor skill and speech sounds do not have the exact motor patterns, since they are not the same movement (Lof 2007), the same sensory-motor pathways are involved in both systems.

If these sensory-motor pathways are basically impaired due to different reasons, both systems will be possibly affected. In medical conditions where sensory-motor oral function is compromised, speech was found to be delayed (such as esophageal atresia). Only after resolving the medical problem, the oral sensory-motor condition improves rapidly, and speech follows (Nath et al., 2018; Sankaran et al., 1983; Wieczorek et al., 2007).

While there is poor significant evidence for the superior usefulness of NSOME, it was not found to be not useful. In all the research it did not present lesser results, hence, not to be treated as malpractice.

Some researchers claim against using NSOME until more solid evidence emerges, but on the other hand do not conduct the research needed for a proof. In addition, randomised control trial (RCT - considered to be the highest EBP criteria) is not the only criteria for EBP or beneficial practice, hence, one should not exclude a very common clinical tool solely by the absence of an RCT. Most clinicians use NSOME (Lof & Watson 2008) since they believe, according to their experience, that it works and is beneficial. Their professional opinion cannot be dismissed so easily.

The guidelines towards NSOME use in speech treatment are not clear due to inconsistency in definitions of NSOME (Bahr, 2001), target population (McCauley et al., 2009), and the way of using the NSOME in speech treatment. Without these definitions, it will be hard to come to accurate conclusions, conduct a reliable and valid research, or give clinical guidelines. Some of the NSOME presented in the literature will never be practiced in the clinical field as presented, since practicing NSOME is done according to the speech sounds needs and only if it contributes to the practice.

Producing speech sounds requires a complicated motor planning at higher level than oral-motor exercises. Each oral task is just one part in the speech sound production hence much easier to achieve. Logically, in order to perform a complicated task a good control over its basic elements will be achieved earlier.

The three stages of learning a new motor task are acquisition, retention and transfer (Rose & Christina 2006; Magill 2007). During the first stage the learner acquires knowledge regarding the new task. Acquiring the knowledge is not necessarily a conscious process but involves unconscious processes without the learner awareness of the specific parts of the task (Explicit and Implicit learning). During the retention stage, the learner is required to re-perform the task under the same conditions, and, during the transfer stage, the learner is required to perform the task under different conditions. Only then a full control of task is achieved. The more complicated the task, the longer it takes to go through the acquisition phase. If the learner's ability in learning a new task level is low, then the acquisition of knowledge will be more gradual.

NSOME skills are used in treatment as a tool for getting new sounds implicitly. For example, the clinician can use the ability to blow in order to teach the sound /sh/ or /p/. The learner will engage with blowing while

being manipulated into the target sound. Targeting NSOME is not done only as a physiological basis for sound production, but also in order to create tools which can help in teaching new sounds.

Other theoretical explanations for the use of NSOME in speech sound treatment

One of the basic motor learning principles is part and whole practice. Part practice is practicing the separate parts of the task, one at a time, while whole practice refers to practicing the whole skill on all its components (Magill 2007). Fontana, Mazzardo, Furtado & Gallaghe (2009) found that a task with high complexity (more than 8 parts per task) and low organization (parts are not dependent one on the other) is better practiced through part practice. A task performed by special needs subjects was recorded with high complexity regardless of the number of parts. Since each part in the speech sound task is dependent on another part, and the speech task is performed by a child with speech sound disorder, the task can be considered with high complexity and high organization task. Therefore, part practice should be considered in practicing speech and will include NSOME. Part practice is divided into three strategies; segmentation, simplification and fractionization. In speech treatment we use all strategies, especially the fractionization, where tasks practiced simultaneously are separated into part practice, and then put back together. In single syllable production the oral movements, tongue movements, blowing, sensory condition and vocal cord activity happen at once. Separating them to single part practice and then re-grouping them, follows the fractionization principle, and justify the use of NSOME in speech practice.

Variable practice was found more beneficial in learning a novel task due to better retention and transfer results (Shea & Kohl 1990). Wulf & Schmidt (1997) found that variability of practice in pursuit tracking task had enhanced result in transfer in comparison to a constant practice. NSOME can be considered as variable practice in the speech treatment. The non-similar use of the oral muscles for speech and oral motor exercises is not a problem when considering the variability of practice theory. In this case, practicing the NSOME along with the speech sounds might be more beneficial than practicing speech sounds alone.

Vashdi (2019) defined new interpretation for on-and-off task motor learning principles. The concept “on task exercises” was defined as part of the skills set being used in the target activity, while “off task exercises” was defined as activities which are not part of the specific target activity, such as stretching, weightlifting or rope skipping for soccer players. Off task

exercises are very common in every sport field and are a major part of training (Vashdi 2019). The NSOME can be considered as the off-task exercises in speech practice, hence an essential part of speech treatment.

Definition and role of NSOME

Researchers use different definitions for NSOME. Some of them use wide definitions (Bahr 2008) and some narrower (Forrest & Iuzzini 2008). There are many oral motor techniques and we can pursue new techniques and instruments. We believe that there is a variance in the influence of different oral-motor exercises on treatment results which is depended on the level of oral-motor condition, child motivation, specific target sound, and therapist expertise. Therefore, we cannot treat these exercises as a group but rather per technique and goal. NSOME are used to achieve different goals of treatment such as swallowing, feeding, sensory diet, oral strengthening or speech. The role of these exercises is different for each type of intervention. It is important to determine the role and type of NSOME in the treatment of motor speech disorder since we believe it is misunderstood.

Limitations

A retrospective study, wide and thorough as it can be, cannot replace a prospective random controlled study. These kind of studies will be able to deeply uncover the essence of the question and get more accurate answers. Therefore, we suggest a protocol that will include three months of intensive speech treatment followed by three months of speech and NSOME treatment in a random order with a control group. An international collaboration will help in getting large groups. Definition of the NSOME, target population and level of severity will be crucial.

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