REVIEW OF PSYCHOPEDAGOGY
REVISTA DE PSIHOPEDAGOGIE

ISSN 2784 – 3092
ISSN – L 2784 - 3092
psychopedagogy.unibuc.ro

DOI: https://doi.org/10.56663/rop.v12i1.58

Received 04 Sep 2023, Accepted 14 Oct 2023
Published online 22 Dec 2023

The effects of a therapeutic program based on motor learning in the recovery of apraxia of speech in children

Ciobanu Dana Elena, PhD(c)
University of Bucharest
Faculty of Psychology and Educational Sciences

Abstract

The purpose of the present study is to analyze comparatively the effects of some therapeutic interventions to improve the symptoms of apraxia of speech in children (CAS). In this sense, three different therapeutic programs were implemented, each lasting 12 months, in three groups of children. Two measurements were made, before and after the children's participation in the programs. P1 included therapy based on augmentative and alternative communication, P2 included therapy based on the classic speech therapy model and therapeutic speech massage, P3 included therapy based on verbal motor learning, VML. 106 children diagnosed with CAS participated in the study, aged between 5 and 7 years, M = 5.75, SD = .75, of which 81 boys (76%) and 25 girls (24%), were randomly divided into three groups. CAS severity was measured using a grid from the Dynamic Assessment of Motor Speech Skills, measuring articulatory accuracy, vowel scoring, and prosody. Visuomotor accuracy, visuospatial processing, phonemic hearing, narrative memory, and attention were measured with a series of tests from the PEDb and PEDa packages (Cognitrom, 2012). Although all three therapeutic programs registered significant effects on the improvement of CAS symptomatology, the most notable effects were obtained by the VML method. The practical implications of the study are discussed, as well as future research directions.

Keywords: childhood apraxia of speech (CAS), therapy programs, Speech Skills, verbal motor learning

Introduction

The effects of therapeutic programs aimed at apraxia recovery are easily evident in clinical practice, through the results and evolution of children. But unlike other types of language disorders, they are extremely difficult to implement, as therapy programs must be complex, intensive, and long-lasting. Studies on the effects of certain therapeutic programs, although numerous, usually comprise case studies or quasi-experiments with small numbers of participants. Due to the nature of the profession and the expertise of the author of this study, a number of 192 children diagnosed with CAS were identified only within Argeș county and the neighboring ones. Some of them are clients of the author's speech therapy office, which allowed us to follow their evolution over time.

An Australian study of the techniques practiced by CAS recovery specialists highlighted certain characteristics of the most commonly used therapeutic programs. Thus, depending on the sessions' frequency, 61% took place once a week, 17% took place once every two weeks, 9% took place twice a week, 5% took place three times a week. Regarding the sessions' duration, 55% had a duration of 30 – 45 minutes, 21% had a duration of 20 – 29 minutes, 19% had a duration of 46 – 60 minutes, and 4% had lasted less than 20 minutes. Depending on the type of intervention, the first place was the Nuffield Dyspraxia Program (NDP), followed in order by the programs based on augmentative and alternative communication (AAC), by those based on guided articulation and only then by those based on combination of stimulation with increasing core vocabulary (Gomez et al., 2019).

ISSN 2784 – 3092
ISSN – L 2784 - 3092
psychopedagogy.unibuc.ro

Speech therapy in children with CAS focuses on the development of verbal communication and, where the language has reached a certain level of evolution, its reconstruction is considered based on the principle of adopting small steps or "from simple to complex". A large number of repetitions in various situations are required to form the verbal automatisms of new acquisitions. Therapeutic techniques in verbal apraxia increase their efficiency when they are accompanied by various means: articulation by imitating a correct model; following the movements of the phonoarticulatory apparatus during pronunciation; emitting sounds and syllables in a sought-after manner, using melodic intonation therapy; extensive use of gestures that help make sounds (Vashdi, 2014).

In the present study we will compare three types of therapeutic programs, P1 – therapy based on augmentative and alternative communication (AAC), P2 – therapy based on classic speech therapy model and therapeutic speech massage, P3 – therapy based on verbal motor learning (VML).

AAC type models (P1)

Multimodal programs, including AAC, are used for children who are minimally verbal, to teach them to communicate and to reduce frustration associated with their disability. The equipment may include a computer, smartphone, or tablet with applications that help children produce sounds, words, sentences, or phrases. Other methods include specific gestures, sign language, or the use of cue cards. AAC is considered augmentative when it is used to supplement the child's existing speech and alternative when it is used to replace speech that is absent or dysfunctional. The strategies of the AAC model facilitate the improvement of receptive and expressive language skills, these strategies provide augmentative or alternative ways of communicating without the effort associated with natural language production (Branson & Demchak, 2009). Binger (2007) provided an overview of AAC interventions used with children diagnosed with CAS and the specific effects of these techniques on functional communication. AAC strategies help improve specific aspects of communication, such as addressing deficits, initiating conversation, message length, and comprehensiveness.

Classical speech therapy and massage models (P2)

Therapeutic speech massage (TSM) is an active method of mechanical intervention that changes the condition of the muscles, nerves, blood vessels and tissues of the entire phonoarticulatory apparatus. TSM is a technique in speech therapy that normalizes all components of speech: articulation, vocalization, resonance and breathing support, as well as the emotional state of people suffering from speech disorders (Dyakova, 2013). TSM focuses on the muscles of the phonoarticulatory apparatus. The muscles of the tongue, throat, lips and facial expressions, the muscles related to the function of the vocal cords and the muscles of the respiratory system constitute a unified muscle system, which produces speech. TSM covers all the areas mentioned above even when muscle abnormalities are diagnosed for a specific apparently unrelated area (Dyakova, 2013). According to Dyakova (2005), therapeutic speech massage is a component of a comprehensive speech therapy program designed to correct speech disorders. It can be performed at all stages of speech therapy intervention, but its use is especially crucial in the initial stage of treatment. Many years of practical experience working with patients with various speech disorders have shown that the application of TSM will significantly reduce the time required for speech therapy (Dyakova, 2006).

Motor learning models (P3)

ISSN 2784 – 3092
ISSN – L 2784 - 3092
psychopedagogy.unibuc.ro

These models use principles of motor learning, such as emphasizing high repetitions of successfully performed tasks, using highly complex stimuli, and a teaching period followed by a practice period where cues and feedback are gradually reduced. This approach seems to facilitate the maintenance and generalization of acquisitions in children with CAS, not only regarding the training of the phonoarticulatory apparatus, but also of the limbs (Maas, 2008, 2014).

Verbal Motor Learning (VML) is a structured method that involves an analysis of the child's condition based on a specific analysis form; an assessment based on an assessment form and a specific protocol; designing and applying a treatment plan specific to the child's needs; manual techniques (hands-on); using motor learning principles (Morgan et al., 2018).

Throughout the algorithmic structure of the method there is great flexibility in structuring the treatment which involves: the goals of the therapy, the therapeutic techniques adopted, the type of therapist, the place where the therapy takes place, the number of weekly sessions planned and their duration, the importance of each micro-objective based on the dynamic needs of the child, adapting the system to the child's preferences, adapting the system to the child's cognitive, linguistic and communication needs. The main indications in the decision-making process are the needs of the child and the method of the therapist (Vashdi, 2013).

Method

In the present study, we aimed to investigate the evolution of three groups of children diagnosed with CAS, who benefited from three different therapy programs: P1 – therapy based on augmentative and alternative communication, P2 – therapy based on the classic speech therapy model and therapeutic massage of speech, P3 – therapy based on verbal motor learning, VML, so we established the following hypotheses:

H1. *The CAS symptoms will decrease to a greater extent in children who benefited from P3 program, compared to the children who benefited from P2 and P1 programs*.

H1a. *The severity of CAS will decrease to a greater extent in children who benefited from P3 program compared to children who benefited from P2 and P1 programs*.

H1b. *Visuomotor accuracy, visuospatial processing, phonematic hearing, narrative memory, and attention will improve to a greater extent in children who benefited from P3 program compared to children who benefited from P2 and P1 programs*.

Participants and procedure

A number of 106 children diagnosed with CAS participated in this study, aged between 5 and 7 years, M = 5.75, SD = .75, of which 81 boys (76%) and 25 girls (24%). They were randomly asigned into three groups. Each group benefited from a different therapeutic program. Group 1 benefited from P1 program and included a number of 34 children, of which 28 boys (82%) and six girls (18%), M = 5.65, SD = .77. Group 2 benefited from P2 program and included 38 children, of which 27 boys (71%) and 11 girls (29%), M = 5.79, SD = .74. Group 3 benefited from P3 program and included 34 children, of which 26 boys (76%) and eight girls (24%), M = 5.75, SD = .75.

All three programs last 12 months. The initial assessment took place at the same time (May 2022) and the final assessment took place in May 2023. For all three programs, there were two weekly sessions for 12 months (June 2022 – May 2023), each session lasting 50 minutes.

Program P1 – Group 1 (AAC)

ISSN 2784 – 3092
ISSN – L 2784 - 3092
psychopedagogy.unibuc.ro

The multimodal AAC variant with moderate technological support was used. The multimodal system consisted of boards with age-appropriate thematic communication cards specific to a preschool or young school age (5-7 years old). The tablets were provided with free spaces where other cards could be added, along the way, to expand the additional symbols needed in communication. The dictionary of images contained approximately the same elements for each child, i.e. images of common objects, toys, food, people, in order to support communication in different situations. The children were asked to choose their favorite themes to build the work kit, but in addition to these, standard cards related to everyday activities were also introduced.

During the therapeutic sessions, verbal stimulation was used simultaneously with the indication of the respective symbol or symbols, giving the child the verbal model of the sound, syllable or word. In the first two months of therapy, sounds and syllables were introduced, later simple words were introduced, then complex words, and in the last three months simple and complex sentences were introduced. Each session was divided into two sub-sessions, one on alternative communication via the tablet and flashcards, and another on speech stimulation. To increase speech intelligibility, the Hodson model was applied, targeting certain groups of sounds (ce, ci, ge, gi, che, chi, ghe, ghi) (Hodson & Paden, 1991). This approach involves using groups of sounds without repeating them, but within natural language, so it maintains the child's attention and interest.

Program P2 – Group 2 (TSM)

This therapeutic program emphasized therapeutic massage, along with classic speech therapy techniques. Therapeutic massage (TSM) contributes to the "preparation" of the child for the production of speech. Thus, it is beneficial for normalizing the muscle tone of the whole body, mimicry, articulation, voice and respiratory muscles; reducing the occurrence of paresis and paralysis of speech muscles; reduction of speech muscle symptoms such as synkinesia, hyperkinetic disorders, spasms, hypersalivation, swallowing reflex and/or biting reflex; stimulation of proprioceptive, kinesthetic sensations to facilitate the organization of movement; activation of speech muscle groups that fail to contract sufficiently and increase oromotor range of motion for articulation; supporting articulatory muscles to form coordinated voluntary movements that produce speech; normalization of children's emotional state (Dyakova, 2013).

The type of massage used was differential (activation and relaxation) based on classical massage methods and techniques. The specific techniques used were: superficial stroking, deep stroking or effleurage, embracing and rake-like stroking, rubbing (floment), kneading (petrissage), vibration and touch, and light pressure.

Not all massage techniques were applied to all children, but only those necessary according to individual characteristics. The therapeutic session was divided into two halves. In the first half, the therapeutic massage was performed, and in the second, classical speech therapy techniques were applied to stimulate speech.

Program P3 – Group 3 (VML)

The VML model benefits from highly accurate techniques. Some examples of these are presented below:

- to pronounce the sound /AH/, it is necessary to go through the following steps: 1. The child opens his mouth wide and says Ahhhhhhh for a long time. 2. The speech therapist presses the child's lower jaw with his thumb. 3. The speech therapist presses the thumb down on the child's

ISSN 2784 – 3092
ISSN – L 2784 - 3092
psychopedagogy.unibuc.ro

lower teeth. 4. The child sticks out his tongue and then imitates Ahhh. 5. The speech therapist inserts a wooden stick into the child's mouth. 6. Short taps are performed on the child's open mouth. 7. A large roller in the form of a megaphone is used. 8. Words starting with Ahhh are used. 9. Guide movements are used for synchronization (Groenen et al., 1996; Vashdi, 2013).

/I/ is obtained through the following techniques: 1. Stretch the child's lips as if smiling. 2. The child's mouth is kept almost closed. 3. Push the muscle under the chin up to lift the tongue. 4. Press on the baby's stomach while imitating the sound with a light tap of the fist. 5. Obtaining the vowel /i/ could be easier through /g/ or /k/ (Vashdi, 2013).

/E/ is obtained as follows: 1. Fix the sound according to the wrong control parameter 2. Push the mandible back and down to stabilize it in the middle mouth opening. 3. Work on the vowel /e/ if it does not exist, only after /a/ and /i/ have been obtained (Nijland, 2002; Groenen et al., 1996).

For each child participating in the study, regardless of the therapeutic program he benefited from, a personalized plan was created, in which the objectives and steps were mentioned, as well as the deadline for achieving them.

Instruments

Socio-demographic data were obtained from the records of the speech therapy clinic where the children receive therapy and targeted gender and age.

CAS severity was measured using a grid from the Dynamic Evaluation of Motor Speech Skill (DEMSS) (Strand et al., 2013). The evaluation was done by the author of the study, as experimenter and speech therapist expert, in individual sessions, with each child separately. The child's task is to pronounce certain sounds, syllables, words, according to the experimenter's instructions. The results are noted by an observer in an observation grid. Were measured: articulatory accuracy, vowel scoring, and prosody.

Visuomotor accuracy, visuospatial processing, phonematic hearing, narrative memory, and attention were measured with a series of tests from the PEDb and PEDa packages (Miclea & Bălaj, 2012).

Findings and discussion

Descriptive statistics

Table 1. Descriptive statistics pretest

	M	S	SD pre	PV pre	PZ pre	PVM pre	PV Spre	AFO pre	MEM pre	ATE pre
PApre	3.06	.87	1							
PVpre	1.52	.50	.35**	1						
PZpre	.84	.37	.27**	.30**	1					
PVMpre	42.91	12.70	-.69**	-.08	-.14	1				
PVSpre	39.75	9.74	-.13	.16	.07	.27**	1			
AFOpre	7.92	2.53	-.26**	-.04	-.19	.24*	.55**	1		
MEMpre	11.10	3.66	-.15	.10	.10	.04	.50**	.50**	1	
ATEpre	10.05	3.72	-.21*	-.14	-.14	.01	-.00	.28**	.17	1

**. p < .01, *. p < .05.

PApre – Articulatory accuracy pretest, Pvpre – Vowel scoring pretest, Pzpre – Prosody pretest, PVMpre – Visuomotor accuracy pretest, PVSpre – Visuospatial processing pretest, AFOpre – Phonematic hearing pretest, MEMpre – Narrative memory pretest, ATEpre –Attention pretest

Table 2. Descriptive statistics posttest

ISSN 2784 – 3092
ISSN – L 2784 - 3092
psychopedagogy.unibuc.ro

	M	SD	PA post	PV post	PZ post	PVM post	PVS post	AFO post	MEM post	ATE post
PApost	2.25	.74	1							
PVpost	.82	.63	.40**	1						
PZpost	.57	.50	.11	.24*	1					
PVMpost	50.69	9.86	-.39**	-.16	-.07	1				
PVSpost	43.52	8.34	-.21*	.02	.10	.14	1			
AFOpost	9.72	2.26	-.37**	-.18	-.07	.11	.53**	1		
MEMpost	12.36	4.21	-.07	.17	.12	-.01	.50**	.31**	1	
ATEpost	11.96	2.90	-.08	-.10	.05	-.02	.07	.17	.33**	1

**. p < .01, *. p < .05.
PApost – Articulatory accuracy posttest, PVpost – Vowel scoring posttest, PZpost – Prosody posttest, PVMpost – Visuomotor accuracy posttest, PVSpost – Visuospatial processing posttest, AFOpost – Phonematic hearing posttest, MEMpost – Narrative memory posttest, ATEpost – Attention posttest

Hypotheses testing

H1. *The CAS symptoms will decrease to a greater extent in children who benefited from P3 program, compared to the children who benefited from P2 and P1 programs*.

H1a. *The severity of CAS will decrease to a greater extent in children who benefited from P3 program compared to children who benefited from P2 and P1 programs*.

H1b. *Visuomotor accuracy, visuospatial processing, phonematic hearing, narrative memory, and attention will improve to a greater extent in children who benefited from P3 program compared to children who benefited from P2 and P1 programs*.

To test this hypothesis, a one-way ANCOVA analysis of variance was performed, controlling for the pretest levels of the analyzed variables.

Multivariate tests show that the resulting differences are statistically significant, Wilks lambda = .16, F(16, 176) = 16.78, $p < .01$, $\eta^2 = .60$.

Table 3. Estimation of posttest differences according to the pretest values of the analyzed variables

				95% CI	
Dependent variable	Group	M	SE	Lower	Upper
PApost	Program P1	2.61	.09	2.43	2.80
	Program P2	2.49	.10	2.30	2.69
	Program P3	1.60	.09	1.41	1.78
PVpost	Program P1	1.16	.09	.98	1.33
	Program P2	1.00	.09	.81	1.18
	Program P3	.29	.09	.11	.46
PZpost	Program P1	.78	.07	.64	.92
	Program P2	.64	.07	.49	.78
	Program P3	.27	.07	.14	.41
PVMpost	Program P1	51.86	.87	50.14	53.57
	Program P2	47.32	.91	45.52	49.12
	Program P3	53.29	.88	51.55	55.03
PVSpost	Program P1	43.29	.69	41.92	44.65
	Program P2	41.40	.72	39.97	42.83
	Program P3	46.13	.69	44.75	47.50
AFOpost	Program P1	8.64	.24	8.16	9.12
	Program P2	9.13	.25	8.62	9.63
	Program P3	11.46	.25	10.97	11.94
MEMpost	Program P1	13.53	.29	12.96	14.09
	Program P2	11.36	.30	10.77	11.95
	Program P3	12.30	.29	11.73	12.87
ATEpost	Program P1	11.48	.35	10.77	12.18
	Program P2	11.16	.37	10.43	11.90
	Program P3	13.34	.36	12.63	14.05

ISSN 2784 – 3092
ISSN – L 2784 - 3092
psychopedagogy.unibuc.ro

Covariates in the model are evaluated at the following values; PApre = 3.06, PVpre = 1.52, PZpre = .84, PVMpre = 42.91, PVSpre = 39.75, AFOpre = 7.92, MEMpre = 11.10, ATEpre = 10.05.
PApost – Articulatory accuracy posttest, PVpost – Vowel scoring posttest, PZpost – Prosody posttest, PVMpost – Visuomotor accuracy posttest, PVSpost – Visuospatial processing posttest, AFOpost – Phonematic hearing posttest, MEMpost – Narrative memory posttest, ATEpost – Attention posttest
PApre – Articulatory accuracy pretest, Pvpre – Vowel scoring pretest, Pzpre – Prosody pretest, PVMpre – Visuomotor accuracy pretest, PVSpre – Visuospatial processing pretest, AFOpre – Phonematic hearing pretest, MEMpre – Narrative memory pretest, ATEpre –Attention pretest

In Table 4, it can be seen that all differences are statistically significant. Thus, for articulatory accuracy $F(2, 106) = 35.19$, $p < .01$, $\eta^2 = .43$, for vowel scoring $F(2, 106) = 27.37$, $p < .01$, $\eta^2 = .37$, for prosody $F(2, 106) = 14.51$, $p < .01$, $\eta^2 = .23$, for visuomotor accuracy $F(2, 106) = 9.73$, $p < .01$, $\eta^2 = .17$, for visuospatial processing $F(2, 106) = 9.96$, $p < .01$, $\eta^2 = .17$, for phonematic hearing $F(2, 106) = 37.73$, $p < .01$, $\eta^2 = .44$, for narrative memory $F(2, 106) = 12.32$, $p < .01$, $\eta^2 = .21$ and for attention $F(2, 106) = 10.07$, $p < .01$, $\eta^2 = .18$.

Table 4. Test of between-subjects effects according to the treatment program they received

Sourse	Variable	Sum of Squares Tip III	df	SM	F	Sig.	partial η^2
Group	PApost	16.70	2	8.35	35.19	.00	.43
	PVpost	11.75	2	5.87	27.37	.00	.37
	PZpost	3.81	2	1.90	14.51	.00	.23
	PVMpost	407.03	2	203.51	9.73	.00	.17
	PVSpost	262.59	2	131.30	9.96	.00	.17
	AFOpost	124.26	2	62.13	37.73	.00	.44
	MEMpost	55.71	2	27.85	12.32	.00	.21
	ATEpost	70.28	2	35.14	10.07	.00	.18

PApost – Articulatory accuracy posttest, PVpost – Vowel scoring posttest, PZpost – Prosody posttest, PVMpost – Visuomotor accuracy posttest, PVSpost – Visuospatial processing posttest, AFOpost – Phonematic hearing posttest, MEMpost – Narrative memory posttest, ATEpost – Attention posttest

Table 5. Bonferroni post hoc test for multiple comparisons, differences between the effects of the three therapeutic programs

Dependent variable	(I) Group	(J) Group	MD (I-J)	SE	Sig.	95% CI Lower	95% CI Upper
PApost	Program P3	Program P1	-1.02*	.13	.00	-1.33	-.70
		Program P2	-.90*	.15	.00	-1.25	-.54
PVpost	Program P3	Program P1	-.87*	.12	.00	-1.17	-.57
		Program P2	-.71*	.14	.00	-1.05	-.37
PZpost	Program P3	Program P1	-.51*	.10	.00	-.74	-.27
		Program P2	-.36*	.11	.00	-.63	-.10
PVMpost	Program P1	Program P2	4.54*	1.36	.00	1.21	7.86
	Program P3	Program P2	5.97*	1.38	.00	2.61	9.33
PVSpost	Program P3	Program P1	2.84*	.96	.01	.50	5.18
		Program P2	4.73*	1.10	.00	2.06	7.40
AFOpost	Program P3	Program P1	2.82*	.34	.00	1.99	3.64
		Program P2	2.33*	.39	.00	1.39	3.27
MEMpost	Program P1	Program P2	2.17*	.45	.00	1.07	3.26
		Program P3	1.23*	.40	.01	.26	2.20
ATEpost	Program P3	Program P1	1.87*	.49	.00	.66	3.07
		Program P2	2.18*	.56	.00	.80	3.55

PApost – Articulatory accuracy posttest, PVpost – Vowel scoring posttest, PZpost – Prosody posttest, PVMpost – Visuomotor accuracy posttest, PVSpost – Visuospatial processing posttest, AFOpost – Phonematic hearing posttest, MEMpost – Narrative memory posttest, ATEpost – Attention posttest

Regarding articulatory accuracy, it can be seen that Program P3 has stronger effects than Program P1, DM = -1.02, CI95%(-1.33, -.70), $p < .01$ and than Program P2, DM = -. 90, CI95%

ISSN 2784 – 3092
ISSN – L 2784 - 3092
psychopedagogy.unibuc.ro

(-1.25, -.54), p < .01. For vowel scores, program P3 has stronger effects than program P1, DM = -.87, CI95%(-1.17, -.57), p < .01 and than Program P2, DM = -.71, CI95%(- 1.05, -.37), p < .01. For prosody, program P3 has stronger effects than Program P1, DM = -.51, CI95%(-.74, -.27), p < .01 and than program P2, DM = -.36, CI95%(- .63, -.10), p < .01.

Regarding visuomotor accuracy, it is observed that Program P1 has stronger effects than Program P2, DM = 4.54, CI95%(1.21, 7.86), p < .01, and Program P3 has stronger effects than Program P2, DM = 5.97, CI95% (2.61, 9.33), p < .01. For visuospatial processing, Program P3 has stronger effects than Program P1, DM = 2.84, CI95%(.50, 5.18), p < .05 and than Program P2, DM = 4.73, CI95%(2.06, 7.40), p < .01. For phonematic hearing, Program P3 has stronger effects than Program P1, DM = 2.82, CI95%(1.99, 3.64), p < .01 and than Program P2, DM = 2.33, CI95%(1.39, 3.27), p < . 01, for narrative memory, Program P1 has stronger effects than Program P2, DM = 2.17, CI95%(1.07, 3.26), p < .01 and than Program P2 program, DM = 1.23, CI95%(.26, 2.20), p < .05, and for attention, Program P3 has stronger effects than Program P1, DM = 1.87, CI95%(.66, 3.07), p < .01 and than Program P2, DM = 2.18, CI95%(.80 , 3.55), p < .01.

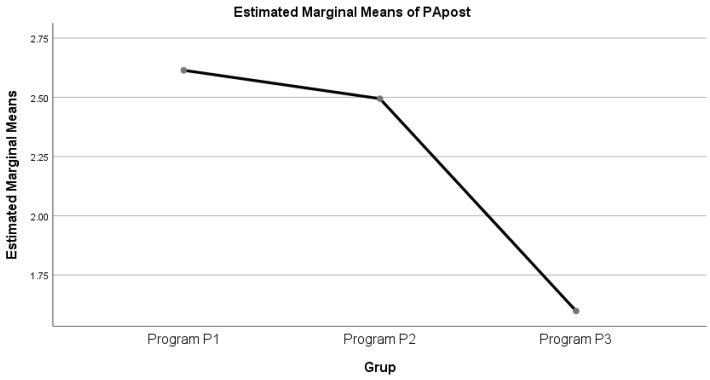

Figure 1. Estimated posttest marginal means for articulatory accuracy by therapeutic program

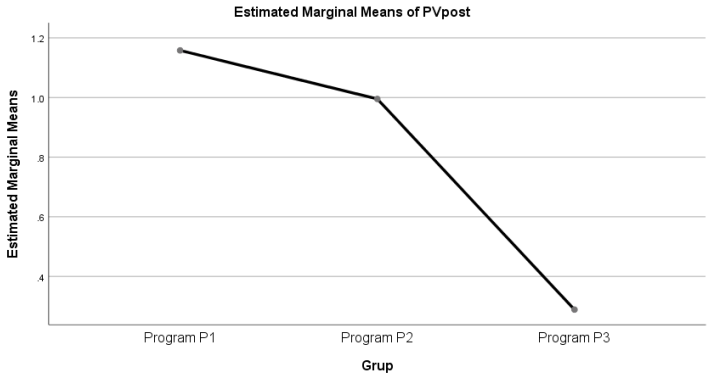

Figure 2. Estimated posttest marginal means for vowel score by therapeutic program

ISSN 2784 – 3092
ISSN – L 2784 - 3092
psychopedagogy.unibuc.ro

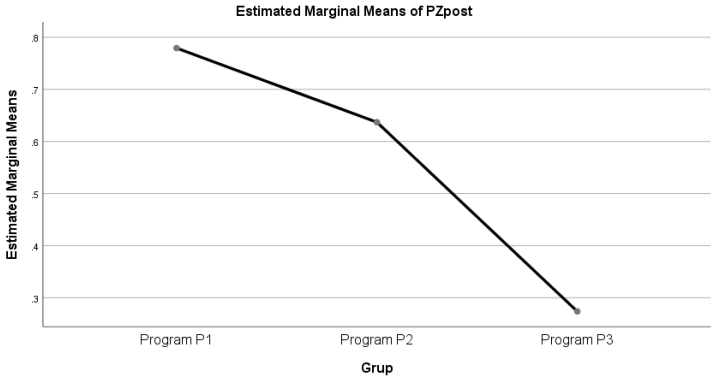

Figure 3. Estimated posttest marginal means for prosody by therapeutic program

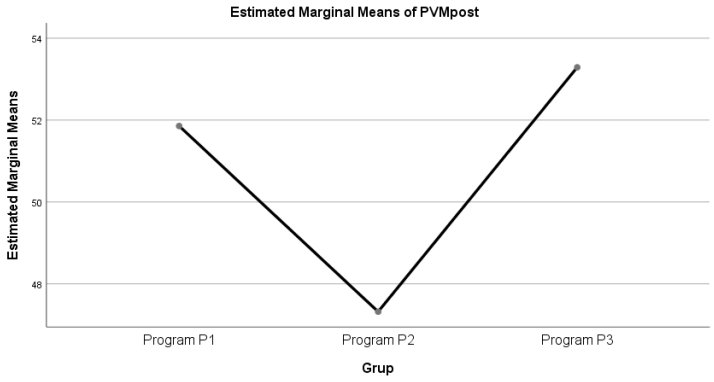

Figure 4. Estimated posttest marginal means for visuomotor accuracy by therapeutic program

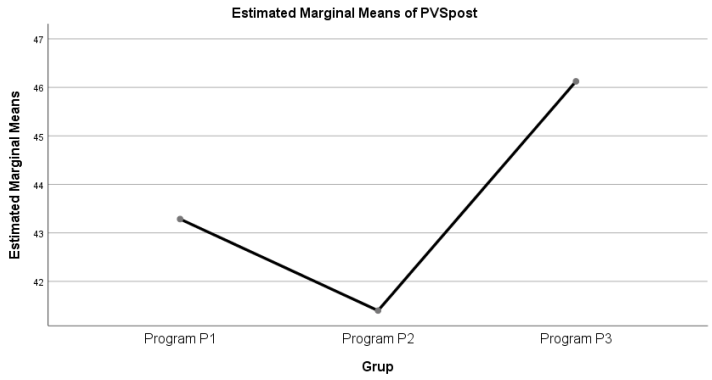

Figure 5. Estimated posttest marginal means for visuospatial processing by therapeutic program

ISSN 2784 – 3092
ISSN – L 2784 - 3092
psychopedagogy.unibuc.ro

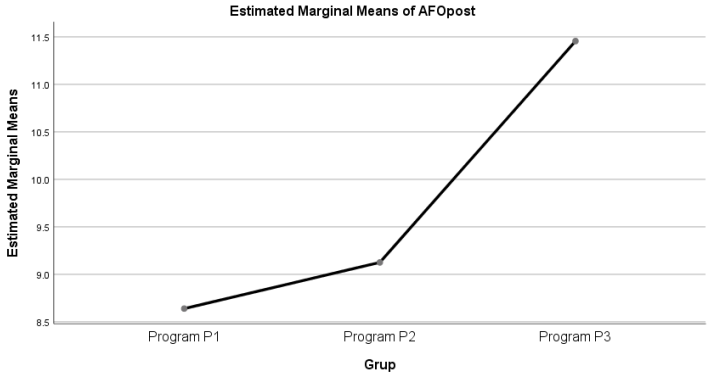

Figure 6. Estimated posttest marginal means for phonematic hearing by therapeutic program

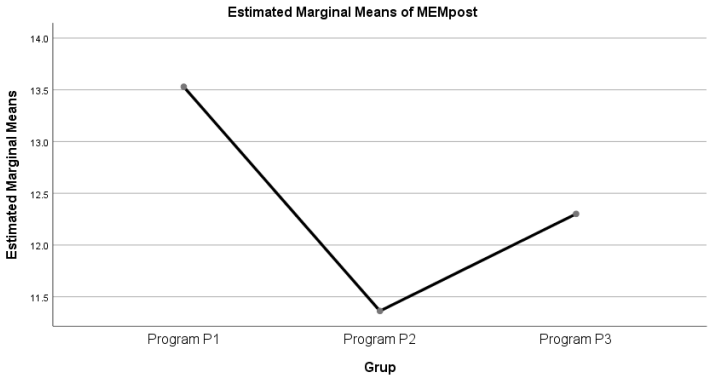

Figure 7. Estimated posttest marginal means for narrative memory by therapeutic program

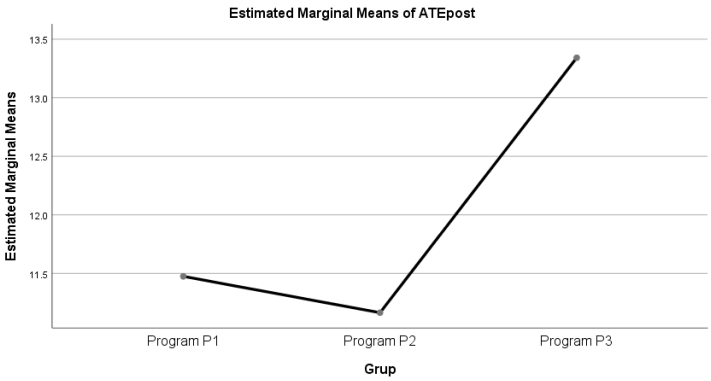

Figure 8. Estimated posttest marginal means for attention by therapeutic program

Conclusion

Through our hypotheses we wanted to test the effectiveness of the three programs, our results showing that the best performance was obtained through the P3 – VML program. Although all three programs constitute established models of therapy for children with CAS, the individual differences, and particular characteristics of the children, as well as the specifics of the programs, determined the emergence of substantial differences.

Program P1 has its benefits especially for non-verbal children and is used in conjunction with classical speech therapy. It is mainly based on augmentative techniques, in our intervention plans we reduce the technology to a moderate level. However, children were encouraged to use natural speech and supplementary materials were used only in very severe cases. Although

ISSN 2784 – 3092
ISSN – L 2784 - 3092
psychopedagogy.unibuc.ro

significant results have been observed following children's participation in this program, more intensive training is required to improve articulation and prosody.

Program P2 is a program for which the therapist needs specific training and many of the children consider it to be "too technical". Therapeutic massage is less engaging for children, unlike the P1 program which involves interactive materials and the P3 program which involves direct interaction with the therapist through games, colored boards, and stories. Thus, Program P2 can be considered restrictive, despite the fact that it was accompanied by classic speech therapy techniques, the sessions being equally divided.

Program P3 is extremely complex and involves training the production of each affected sound, depending on the degree of CAS severity and the child's particularities. A reason to which we can attribute the differences obtained is that P1 and P3 programs aim to provide feedback that the child enjoys and on the basis of which, not only corrects his articulation and speech rhythm, but also motivates him to train further.

Also, although the therapeutic programs fell into the three categories, P1, P2, and P3, each child benefited from an individualized intervention plan according to his personal needs and the aspects considered essential in the therapy. It is therefore possible that some differences are not statistically significant because some therapeutic elements partially coincided. However, the advantages of the P3 therapeutic program, through verbal motor learning, are indisputable, with literature in the field often stating that this type of therapy for children with CAS is among the most effective when implemented long-term and in a consistent and sustained rhythm. An important aspect of the P3 program, more precisely VML, is the specificity of the tasks by selecting common words from the child's real world and training their production, so that the child can later use them in as many different contexts as possible (Rochet-Capellan er al., 2012). At the same time, because CAS is a disorder of speech sequencing, the production of non-words and the transition between sounds and between syllables can be trained. Thus, practicing different types of sequencing, with or without meaning, will allow the child to focus on pronunciation skills, which he can then generalize in other contexts. It is clear that word generalization depends on the severity of the disorder and may be more appropriate for older children. For younger children, words with meaning are more indicated because it will increase their level of motivation for learning them, assimilating them with objects and phenomena in their lives, and being able to practice and use them outside the speech therapy office as well (Ballard et al., 2010). In any case, experts believe that task specificity must be respected, suggesting that the movements to be learned and practiced must be "speech" movements and not lip or tongue movements in the absence of speech (Clark, 2003).

There is evidence in the literature to support the advantages of VML therapy in the recovery of children with CAS. Language improvements have been observed through the application of non-word production techniques that pique children's interest and imagination but also manage their attention span, with studies suggesting that learning motor skills can be affected by too much attention and too much inwardly oriented (Freedman et al., 2007; Wulf & Prinz, 2001).

With regard to feedback, the child is asked to self-assess the quality of the verbal production and to self-correct if necessary, so that the focus can be on the result and not on the movement itself. Thus a link is created between the auditory output and the verbal production itself, producing an internal auditory-kinesthetic model that can be extremely useful in motor learning (Vihman, 2004). The essential challenge of motor learning is the management and adaptation of sensorimotor transformations. After acquiring a series of nonwords, children are

ISSN 2784 – 3092
ISSN – L 2784 - 3092
psychopedagogy.unibuc.ro

trained to increase their pronunciation rate until they reach a level considered normal. This process also involves adaptation to spatial and temporal parameters (Van der Merwe, 2009).

The positive effects of VML have also been supported by the fact that it offers the opportunity to extract generalizable and adaptable rules to diverse speech contexts, for the motor planning of articulation (Jaric et al., 1993), but also by the transfer of motor learning to actual movements (Wolpert et al., 2001).

Another positive effect of the VML program was that many of the children in the group improved their verbal production also for words that were not the primary target of the therapy. Since one of the principles of VML is to work from the simplest to the most complex problems, it is possible that certain articulatory "formulas" have been generalized over time, which the child later uses on his own and for other words and phrases. Rvachew and Bernhardt (2010) showed that those children who were trained on simpler target words also made progress on more complex words, while children who were trained on more complex target words made less progress.

Although most specialists are of the opinion that the most suitable therapeutic plan for language disorders must be consistent with a certain theoretical current, with a certain approach to the understanding and interpretation of the causes and symptomatology of CAS, it is imperative that the therapeutic plan is first and foremost adapted to the child's requirements and his level of development, more precisely to the volume of language he can naturally produce at the beginning of therapy. Through such a combination of premises, the best therapeutic program for each child can be developed and planned. With regard to verbal motor learning, the *per se* characteristics of apraxia of speech must be taken into account, following three essential phases: motor planning of speech, motor programming and execution. These three phases are consistent with the hierarchy of motor control for voluntary movements at high, medium, and low levels (Magill, 2007). Thus, speech production in the context of language must constitute the planning unit. Motor planning of speech involves the basic plans of movements, which determine the selection of motor goals for all speech structures involved in the production of sounds, syllables, and words. To these are added the spatial specifications for updating the place and manner of articulation, as well as the temporal ones. Planning is viewed as generative and plastic, to cover the influence of different phonetic contexts on speech parameters. Speech parameters must in turn be adapted to speech rate, segmentation duration, and interarticulatory synchronization requirements.

The purpose of this study was not necessarily to put any of the therapeutic programs in a positive or negative light, but rather to verify their effectiveness and to evaluate the extent to which 12 months of therapy make significant contributions to the recovery of children with CAS. The ages of the children in this study were initially between 5 and 7 years. At the end of the program, some of them enrolled in school, showing much reduced language problems compared to the moment before the therapy. We believe that these results outweigh the critical analysis of therapeutic programs and that the advantage of children's participation in such programs is to successfully adjust to school, peer groups, and society in general.

Practical implications

The present study contributes to the general knowledge regarding the recovery of children with CAS and draws attention to the fact that this therapy-resistant disorder can be ameliorated by means of well-dosed and consistent therapeutic programs. The stimuli used for each child were personalized and adapted to their individual requirements and needs. However, the therapeutic programs were distinguished by the specificity of the intervention itself. This mix

ISSN 2784 – 3092
ISSN – L 2784 - 3092
psychopedagogy.unibuc.ro

of techniques and procedures has been shown to ameliorate the symptoms of CAS in the sense of improving word production and prosody. Also, the target stimuli or sounds/syllables/words that the children were able to learn, more specifically could only produce in certain contexts, were chosen at first. For example, each stimulus item contained a difficult phoneme for the child, placed between the phonemes he could produce in the pretest, so a small-step approach was used. At the same time, the type of priming and feedback offered to the child were among the most diverse, including through their visual image. This distraction from the presentation of the purely verbal form of the item encouraged children to process each item with increased focus and much more independently.

One of the practical implications of this study is therefore to emphasize the importance of personalizing therapy sessions. Beyond choosing one therapeutic approach or another, we recommend shaping each session in such a way that the child is primed and encouraged to progress and gain curiosity and a desire to move forward by analyzing their own progress. We thus arrive at the second implication, namely the need to provide adapted and constructive feedback. Beyond letting the child know that his answer was correct or incorrect, it seems imperative to give him explanations about the details of his verbal production, analyzing together every micro-movement involved in the pronunciation process.

Beyond the VML program, the other two programs also proved significant positive effects, which leads to a third practical implication, namely alternating or combining the elements of different programs, at least in the first sessions, to be able to observe which aspects the child reacts better.

Limitations and future research directions

A limitation of this study is the large number of participants. If most of the studies in this field were case studies, with at most five participants, our effort was to collect data from the majority of children with CAS from Argeș County and its surroundings. Also taking into account the fact that each child is unique, and the characteristics of the speech disorder are different, very different baseline (pretest) levels resulted. In addition, beyond the specific nature of the therapeutic program, the children benefited from personalized plans. All of these have the potential to reduce the generalizability of our results.

Another limitation is the fact that the therapeutic programs were carried out by a team of specialists and not by the same speech therapist. The rhythm, personal style or simply the individual characteristics of the therapist, as well as the relationship between the therapist and the child, could have influenced in one way or another the nature of the results. We can add here the involvement of parents. Some of them, living at a greater distance from the speech therapy clinic, may be absent from certain sessions. Also, here we can mention the fact that a perfectly randomized division of the children into the three groups was not achieved, because we had to make the distribution by groups according to the availability and decision of the parents.

A third limitation of the study is that more elements specific to CAS were not analyzed, despite the fact that this information exists in the archives of the speech therapy office (for example, the exact sounds affected). We have chosen to simplify the procedure in order not to unnecessarily extend this paper. However, the benefits of the three programs, especially the VML program, are higher than those presented in the present study.

ISSN 2784 – 3092
ISSN – L 2784 - 3092
psychopedagogy.unibuc.ro

In our future studies, we will focus on a smaller number of children and aim to analyze children with severe CAS and those with associated disorders. We also aim to carry out a series of longitudinal studies to analyze the persistence over time of the children's progress.

References

Ballard, K. J., Robin, D. A., McCabe, P., & McDonald, J. (2010). A treatment for dysprosody in childhood apraxia of speech. *Journal of Speech, Language, and Hearing Research*, *53*, 1227–1245. https://doi.org/10.1044/1092-4388(2010/09-0130)

Binger, C., & Light, J. (2007). The effect of aided AAC modeling on the expression of multi-symbol messages by preschoolers who use AAC. *Augmentative and alternative communication*, *23*(1), 30–43. https://doi.org/10.1080/07434610600807470

Branson , D. , & Demchak , M . (2009) . The use of augmentative and alternative communication methods with infants and toddlers with disabilities: A research review. *Augmentative and Alternative Communication*, *25*, 274 – 286. doi:10.3109/07434610903384529

Clark, H. M. (2003). Neuromuscular treatments for speech and swallowing: A tutorial. *American Journal of Speech-Language Pathology*, *12*, 400–415.

Dyakova, E. A. (2005). Main Principles for the Application of Therapeutic Speech Massage in the seech therapy practice. The Speech Therapist in Pre – school. *Academia Press, 5-6*, 102-112.

Dyakova, E. A. (2006). Main Principles for the Application of Therapeutic Speech Massage in the Prevention and Treatment of Speech Disturbances. Public Health and prevention of diseases. *Academia Press, 2*, 53-58.

Dyakova, E. A. (2012). *Therapeutic Speech Massage: A Manual for Practitioners and Students*. Academia Press.

Freedman, S. E., Maas, E., Caligiuri, M. P., Wulf, G., & Robin, D. A. (2007). Internal versus external: Oral-motor performance as a function of attentional focus. *Journal of Speech, Language, and Hearing Research, 50*, 131-136.

Gomez, M., McCabe, P., & Purcell, A. (2019). Clinical management of childhood apraxia of s peech: A survey of speech-language pathologists in Australia and New Zealand. *International Journal of Speech-Language Pathology*, 1–10. doi:10.1080/17549507.2019.1608301

Groenen, P., Maassen, B., Crul, T., & Thoonen, G. (1996). The specific relation between perception and production errors for place of articulation in developmental apraxia of speech. *Journal of speech and hearing research*, *39*(3), 468–482. https://doi.org/10.1044/jshr.3903.468

Hodson, B. W., Paden, E. P. (1991). *A phonological approach to remediation: Targeting intelligible speech* (2nd ed.).TX.

Jaric, S., Corcos, D. M., Agarwal, G. C., & Gottlieb, G. L. (1993). Principles for learning single-joint movements. II. Generalizing a learned behavior. *Experimental Brain Research*, *94*, 514-521.

Maas, E., Gildersleeve-Neumann, C., Jakielski, K. J., & Stoeckel, R. (2014). Motor-based intervention protocols in treatment of childhood apraxia of speech (CAS). *Current developmental disorders reports*, *1*(3), 197–206. https://doi.org/10.1007/s40474-014-0016-4

Maas, E., Robin, D. A., Austermann Hula, S. N., Freedman, S. E., Wulf, G., Ballard, K. J., & Schmidt, R. A. (2008). Principles of motor learning in treatment of motor speech disorders. *American Journal of Speech-Language Pathology, 17*, 277-298. https://doi.org/10.1044/1058-0360(2008/025)

Magill, R. A. (2007). *Motor learning and control: Concepts and applications*. (8th ed.). McGraw-Hill.

Miclea, M., Bălaj, A. (2012). *Platforma de Evaluare a Dezvoltării. Evaluarea aptitudinilor cognitive*. ASCR.

Morgan, A., T., Haaften, L., V., van Hulst, K., Edley, C., Mei, C., Tan, T., Y., Amor, D., Fisher, S., E., & Koolen, D. A. (2018). Early speech development in Koolen de Vries syndrome limited by oral praxis and hypotonia. *European journal of human genetics:EJHG*, *26*(1), 75–84. https://doi.org/10.1038/s41431-017-0035-9

Nijland, L., Maassen, B., Van der Meulen, S., Gabreels, F., Kraaimaat, F. W., & Schreuder, R. (2002).

Coarticulation patterns in children with developmental apraxia of speech. *Clinical linguistics & phonetics*, *16*(6), 461–483. https://doi.org/10.1080/02699200210159103

Rochet-Capellan, A., Richer, L., Ostry, D. J. (2012). Nonhomogeneous transfer reveals specificity in speech motor learning. *Journal of Neurophysiology*, *107*, 1711–1717.

ISSN 2784 – 3092
ISSN – L 2784 - 3092
psychopedagogy.unibuc.ro

Rvachew, S., & Bernhardt, B. M. (2010). Clinical implications of dynamic systems theory for phonological development. *American Journal of Speech-Language Pathology, 19*, 34-50.

Strand, E. A., McCauley, R. J., Weigand, S. D., Stoeckel, R. E., & Baas, B. S. (2013). A motor speech assessment for children with severe speech disorders: reliability and validity evidence. *Journal of speech, language, and hearing research : JSLHR, 56*(2), 505–520. https://doi.org/10.1044/1092-4388(2012/12-0094)

Van der Merwe, A. (2009). A theoretical framework for the characterization of pathological speech sensorimotor control. In M. R. McNeil (Ed.), *Clinical management of sensorimotor speech disorders* (2nd ed.). Thieme.

Vashdi, E. (2013). Using VML (verbal motor learning) method techniques in treatment of prosody disorder due to childhood apraxia of speech: A case study. *International Journal of Child Health and Human Development, 6*(2), 255-260. https://doi.org/10.18662/brain/11.3Sup1/126

Vashdi, E. (2014). The influence of Initial Phoneme Cue technique according to the VML method on word formation with a child who has apraxia of speech and autism - A case study. *International Journal Child Health Human Development, 7*(2), 197-203. https://doi.org/10.18662/brain/11.3Sup1/122

Vihman, M. M. (2004). Early phonological development. In J. E. Bernthal & N. W. Bankson (Eds.), *Articulation and phonological disorders* (pp 63-85). Pearson.

Wolpert, D. M., Ghahramani, Z., & Flanagan, J. R. (2001). Perspectives and problems in motor learning. *Trends in Cognitive Sciences, 5*(11), 487-494.

Wulf, G., & Prinz, W. (2001). Directing attention to movement effects enhances learning: A review. *Psychonomic Bulletin & Review, 8*(4), 648-660.