Imitation and Naming in Childhood Apraxia of Speech

Gila Tubul-Lavy*

Ono Academic College, Israel

Abstract: Imitation and object naming are the first steps in language acquisition. While in typical development, imitation is easier than naming, there is a lack of agreement about the role of imitation in language impairment in general, and in Childhood Apraxia of Speech (CAS), in particular. Hence, the aim of this study is to compare imitation and naming in CAS and to analyze the nature of errors according to the complexity of the word and across the three levels of the prosodic hierarchy: the segmental level, the syllabic level and the prosodic word level.

Sixteen children diagnosed with CAS (average age 3;11) participated in the study. The data, collected from each child in the course of eight weekly meetings, are drawn from naming and imitating single words. The results indicate that imitation seems to be an easier task than naming; both tasks are more difficult as the words get longer. Fewer errors are seen on the prosodic level, while most of the errors occur on the segmental and syllabic levels.

Keywords: Childhood apraxia of speech, imitation, naming, segmental level, syllabic level, prosodic level.

INTRODUCTION

Imitation

Imitation seems to be one of the main tools of learning and for social cognition for mankind [1]. Piaget [2] was the first to argue that imitation is a necessary developmental process that must be learned in order to develop symbolic thought and language skills. Recent studies emphasized the role of imitation (motor, vocal, or object use imitation) as a predictor of language acquisition and retention in typical and atypical populations [3, 4]. Immediate imitation following auditory input of the word can help to maintain a temporary phonological representation of the target in short-term memory [5]. Moreover, children who imitate speech had richer phonological systems than children with poor imitation skills [6]. Hence, most researchers agree that imitation can be taken as the basis of child speech and language development.

Picture Naming

A word and its meaning are acquired when the child can name the picture that represents it [7]. Retrieving the name of a picture involves multiple stages: (a) perceptual recognition (i.e., object recognition); (b) activation of the semantic representation (i.e., semantic activation); (c) retrieval of the phonological form (i.e., lexical access); (d) running motor processes; and (e) naming the picture [8].

A picture may generate associated images in multiple modalities (e.g., related objects, sounds, and motor and visceral reactions). The auditory input can help retrieval while activating a group of phonological representations, including the phonologically related picture name [9].

Imitation and Naming

Clinicians usually assess children through picture naming or imitation. This data is analyzed phonologically by comparing the child's productions with accepted adult realizations of the same words [10].

Stackhouse and Wells [11] suggest a developmental model for examining the child's speech processing across a range of speech-production tasks: naming, word imitation (or word repetition) and non-word repetition. According to this model, in the picture-naming task, the child needs to recognize the picture and access an appropriate semantic representation. This will trigger the associated program for the word followed by output processing levels of motor planning and motor execution, which will result in the word being spoken. Picture naming can be used to test the child's vocabulary knowledge or as a measure of speech-production skills (phonological accuracy). For word imitation, there are two processing possibilities: using existing lexical representations to recognize the word and then accessing motor programming for responding or using motor programming skills for output without access to existing lexical representations. The child's performance on these two tasks (naming and imitation) can be compared [12].

Childhood Apraxia of Speech

Childhood apraxia of speech (CAS) was identified by the American Speech-Language-Hearing Association-

*Address correspondence to this author at 4 Pinsker st., Rehovot, 7630804, Israel; Tel: +972549989589; Fax; +97289470481E-mail: gilatu@gmail.com

E-ISSN: 2311-1917/15

ASHA [13] as a "neurological childhood (pediatric) speech sound disorder in which the precision and consistency of movements underlying speech are impaired in the absence of neuromuscular deficits (e.g., abnormal reflexes, abnormal tone). The core impairment in planning and/or programming spatiotemporal parameters of movement sequences results in errors in speech sound production and prosody". CAS may occur as a result of known neurological impairment, in association with complex neurobehavioral disorders of known or unknown origin, or as an idiopathic neurogenic speech sound disorder.

The ASHA committee stated that although there is no validated list of diagnostic features of CAS that differentiates this symptom complex from other types of childhood speech sound disorders, three segmental and suprasegmental features were proposed for the assessment of CAS: (a) inconsistent errors on consonants and vowels in repeated productions of syllables or words; (b) lengthened and disrupted co-articulatory transitions between sounds and syllables; and (c) inappropriate prosody, especially in the realization of lexical or phrasal stress. Importantly, these features are not proposed to be the necessary and sufficient signs of CAS. A child with CAS may be at risk for early and persistent problems in speech, expressive language, and the phonological foundations of literacy as well as the possible need for augmentative and alternative communication and assistive technology.

Imitation and Naming in CAS

Not much is known about naming and imitation in CAS, although poor imitation was reported by speech pathologists as a diagnostic marker for this population [14, 15]. Powell [16] suggested that only imitated words entered the phonetic inventory of children diagnosed with speech sound disorders, and three years later, he indicated the added value of imitation purpose in CAS as well [17]. Despite the above, other researchers claimed that imitation on its own is not at all useful for improving production accuracy [15, 18].

Few studies have compared naming and imitation in language impaired children. Single word productions and imitation were examined in Spanish-speaking children with phonological disorders. Comparison of the number of disruption and type errors in both tasks showed that 62% of the children's productions were identical in imitation and naming tasks [19].

Stemming from the claim that the core impairment in CAS is planning and/or programming spatiotemporal parameters of movement sequences [13, 20, 21], we expect difficulties in repeated templates, which require short-term memory, as well as in motor planning. However, in picture naming, the child can choose an easier word; hence, imitation should be more difficult than naming. On the other hand, in imitation a phonological plan for the target is provided, whereas spontaneous naming requires accessing phonological information from the lexicon [22]. Since CAS combines both motoric and phonological disabilities, which task will be easier? Imitation that includes a motoric component or naming that includes language ability as well? Determining this is the aim of this research.

Following studies dealing with CAS motoric and phonological impairment, our hypotheses are as follows:

a. Naming will be a more difficult task than imitation since in naming, the phonological representation needs to be retrieved along with motor programming, as compared to imitation, in which the phonological plan is given [22].

b. Since CAS children exhibit more phonological errors corresponding to phonological processes affected by complexity [23], there will be more phonological errors as the words include more syllables, both for naming and imitation.

c. Since the prosodic word level seems to be the most developed compared to the segmental and syllabic levels [24], there will be more errors on the segmental and syllabic levels, both in imitation and naming.

METHOD

Subjects

Since this research is a continuation of Tubul-Lavy [24], the subjects are the same. Sixteen children, 11 boys and 5 girls, aged 2;7–5;6 (average age 3;11) participated in the study. They were native Hebrew speakers, diagnosed by a speech therapist as children with CAS. All had difficulty in the consecutive articulation of syllables, inconsistent phonological substitutions and increasing difficulty in articulation of longer and more complex words. They all showed inconsistent repeated productions in naming. In addition, each child showed at least three phonological processes relating to the simplification of the syllable or

the alteration of its segments and they all failed the diadochokinesis test (DDK). Fourteen of the sixteen children were in the recursive stage and two children were in the combining stage, all matched the typical stages of language development. Children with cognitive impairments (according to a psychological evaluation), hearing loss (according to a hearing evaluation) or cerebral palsy were excluded from participating in current study.

Procedure

The data, collected from each child at eight weekly meetings, were drawn from the naming of 94 single words, presented in everyday object pictures [25].

The words were balanced in terms of number of syllables, location of the stress (ultimate, penultimate and antepenultimate) and the syllable structure (onset, coda and clusters). The test words included 22 monosyllabic, 35 disyllabic and 37 multisyllabic words. Hebrew is a highly morphologically synthetic language which accounts for the smaller number of monosyllabic words.

For the naming task, a picture was presented to the child and s/he was asked to name it. If s/he succeeded, another picture was shown. If s/he didn't succeed in the naming task, but tried to name again, the clinician waited until s/he finished. If s/he didn't reach the target word, the clinician said the accurate form of the word and asked the child to imitate. For the imitation task, the child was asked to repeat the name of the picture, named by the clinician. The pictures for both tasks were presented randomly throughout the sessions. Once a word was imitated by the child that word was not included for the naming task in that session, but was presented in the following meetings. If the child named the picture or repeated the picture name more than once, the final attempt was scored. If the child showed signs of being tired, the clinician stopped the session and continued the task at the next session. Throughout the 8 sessions, a total of 94 words were transcribed, once for the naming task and once for the imitation task. There were a total of 3,008 productions, 1,504 for each task. No cues were given for either of the tasks.

Each child was tested and recorded individually in a quiet room. The recording was transcribed by two clinicians. A broad transcription was created and only words with the same transcription were included. All the accurate naming and imitation words were analyzed. Each error scored as 1 point. The analysis relates to three levels: the prosodic word level (number of syllables and the stress location), the syllabic level (onset and coda in the syllable) and the segmental level (the segments in the syllable).

RESULTS

The first hypothesis held that imitation will be easier than naming for children with CAS. In order to test this hypothesis, a paired T-test was conducted to compare errors in naming and imitation of the same words. The hypothesis was confirmed ((t 2,113) = 12.801, $p<0.001$). Table **1** presents the means and standard deviations of the errors of the two tasks**.** The results suggest that there is a significant difference in the scores of these two tasks: Imitation is an easier task than naming for children with apraxia.

Table 1: Errors in Imitation and Naming (Means and Standard Deviations)

	Mean	SD
Naming	0.883	0.418
Imitation	0.488	0.519

In order to compare the errors within the same level, the errors were divided according to the three prosodic units: the segmental, the syllabic and the word level. Each of these levels was compared between naming and imitation tasks. Table **2** presents the mean errors in imitation and in naming tasks for the three levels.

Table 2: Mean Errors in Imitation and Naming by Level

	Segmental	Syllabic	Word
Naming	1.12 (0.970)	1.26 (1.065)	0.14 (0.373)
Imitation	0.71 (0.737)	0.71 (0.838)	0.04 (0.206)

The hypothesis that imitation is an easier task than naming was confirmed for all three levels: the segmental level ((z 2,113) = -4.561, $p=0.000$), the syllabic level (z 2, 113) = -6.685, $p=0.000$) and the word level (z 2,113) = -3.317, $p<0.001$). The results suggest that there is a significant difference between naming and imitation on each level.

The second hypothesis dealt with complexity. It was argued that longer words would have more errors in word production, both in naming and imitation, than shorter words. In order to test this hypothesis, a one way ANOVA was conducted. The hypothesis was

confirmed both for naming (F(3,112)=38.13, P<.001)) and imitation (F(3,112)=20.27, P<.001)). The results suggest that for both tasks, there is a difference according to length: shorter words are easier than longer ones. Table **3** shows the percentage of incorrect productions (words which didn't match the target words) according to word length in naming and imitation.

Table 3: Means and Standard Deviations of Incorrect Productions

	Monosyllabic words	Disyllabic words	Tri-syllabic words	Four syllable words
Naming	1.00 (0.63)	1.96 (0.91)	2.44 (0.998)	5.06 (1.81)
Imitation	.00 (.00)	1.22 (0.98)	1.33 (0.98)	3.12 (1.31)

In order to understand the source of the differences between the means, a Bonferroni post-hoc multiple comparison was conducted. In naming, the comparison revealed that in four syllable words, there were significantly more errors than in the other three lengths, while in monosyllabic words there were significantly fewer errors than in words of three and four syllables. Disyllabic and tri-syllabic words were not significantly different from each other.

Similar results were presented in the imitation task: in productions of words of four syllables there were significantly more errors than in the other groups, while in monosyllabic words, there were significantly fewer errors than in words of two, three and four syllables. Disyllabic and tri-syllabic words were not significantly different from each other.

The third hypothesis held that there will be more errors on the segmental and syllabic levels both in imitation and naming. Table **4** presents the mean ranks of each task according to the three prosodic units.

Table 4: Mean Ranks of Naming and Imitation in each Prosodic Unit

	Segmental	Syllabic	Word
Naming	2.29	2.37	1.34
Imitation	2.27	2.22	1.50

In order to test this hypothesis, a Friedman test was conducted. The hypothesis was confirm for naming ($\chi^2$2, 113) = 91.589, p<.001) and for imitation ($\chi^2$2, 113)= 71.963, p<0.001).The results suggest that there is a significant difference between the three prosodic levels in naming as well as in imitation. While the segmental and syllabic levels have almost the same means, the word level showed significantly fewer errors.

The following tables show examples of differences on the segmental level (Table **5a**), the syllabic level (**5b**), the word prosodic level (**5c**) and productions which differed on more than one level (**5d**) for naming and imitation. The tables show that for most of the words, imitation is closer to the target word than naming.

Table 5a: Differences between Naming and Imitation on the Segmental Level

Imitation	Naming	Target word (translation)
pa.'a	ta.'a	pa.'ra (cow)
sam.'po	pam.'po	ʃam.'po (shampoo)
mi.'ta	ti.'ta	mi.'ta (bed)
xa.ru.'zim	ta.ru.'zim	xa.ru.'zim (beads)
ta.'ti.ax	ka.'ti.ax	a.'ti.ax ʃ (carpet)
dag	dak	dag (fish)
'ze.ba	'be.ba	'zeb.ra (zebra)
gi.'ca.ra	gi.'sa.ya	gi.'ta.ra (guitar)
ma.'de	da.'ye	maz.'leg (fork)
'te.le.so	'xe.xe.so	'te.le.fon (telephone)

Table 5b: Differences between Naming and Imitation on the Syllabic Level

Imitation	Naming	Target word (translation)
pa.'pa	a.'pa	par.'par (butterfly)
pa.'non	a.'non	ba.'lon (balloon)
ka.'me.ax	ka.'me.a	sa.'me.ax (happy)
a.bi.'on	a.bi.'o	a.vi.'ron (airplane)
ji.'a.fa	i.'a.fa	dzi.'ra.fa (giraffe)
ba.lo.'nim	ba.lo.'ni	ba.lo.'nim (balloons)
'na.al	'a.a	'na.al (shoe)
te.na.'ti.na	e. a.'ti.na	kle.man.'ti.na (clementine)
mig.'dal	i.'dal	mig.'dal (tower)
kaf	ka	kaf (tablespoon)
maf.'te.yax	ma.'te.yax	maf.'te. ax (key)

Table 5c: Differences between Naming and Imitation on the Word Prosodic Level

Imitation	Naming	Target word (translation)
be.'ta	.ta	bei.'ca (egg)
ʃi.mi.'xa	mi.'xa	smi.'xa (blanket)
ef.'o.ax	.'o.ax	ef.'ro.ax (chick)
ko.'dot	kot	ne.ku.'dot (points)
e.e.'ma	e.'ma	mac.le.'ma (camera)
mi.ta.'fa.im	ta.'fa.im	mi.ʃ.ka.'fa.im (glasses)

Table 5d: Differences between Naming and Imitation on more than One Level

Imitation	Naming	Target word (translation)
mas.'lek	ka.'leg	maz.'leg (fork)
am.'bat.ya	a.'bag.ya	am.'bat.ya (bathroom)
su.ka.'yot	su.ku.'yu	su.kar.'yot (candies)
'ʃmo.ne	ʃ o.me'	'ʃ mo.ne (eight)
ag.'la.im	a_'ya.im	rag.'la.im (feet)
te.le.'di.da	e.'di.da	te.le.'viz.ya (television)
pa.'ti ʃ	a.'pi ʃ	pa.'ti ʃ (hammer)
te.re.'zi.za	a.ra.'ti.za	te.le.'viz.ya (television)
a.si.'son	a.ra.'so	a.fi.'fon (kite)
a.ma.'ti.ax	me.'ti.ax	a.va.'ti.ax (watermelon)
mi.xa.'sa.im	si.'sa.i	mix.na.'sa.im (pants)

DISCUSSION

The aim of this study was to compare naming and word imitation of 16 Israeli Hebrew-speaking children with CAS. The results show that there is a significant difference between these two tasks. Moreover, significant differences were also found when comparing errors according to prosodic units: the segmental, the syllabic and the word level. Both in naming and imitation tasks, more errors were produced on the segmental and syllabic levels compared to the word prosodic level.

The first assumption, that imitation will be easier than naming in CAS, was confirmed. Comparison of these two tasks in whole words as well as comparison of each of the prosodic levels of these words reveals that in the naming task, there are more errors than in imitation; hence, naming is a harder task than imitation. Stackhouse and Wells' developmental model of speech processing showing routes for naming and word repetition [11], supports the claim that access to appropriate semantic representation is needed for naming while imitation can be performed without this prerequisite: repetition can use motor programming skills for output without access existing lexical representations.

Picture naming was investigated with auditory distractor [9]. The children were asked to name each picture and to ignore the auditory distractor. Among the six types of distractors, the initial consonant-vowel that was the same as the beginning of the picture name significantly facilitated naming performance for both accuracy and speed. The authors claimed that the auditory input activates phonological representations (section (d) in Ellis and Young's model [8]), including the phonologically related picture name which supports retrieval. The connection between naming and phonology was also seen by Dockrell, Messer, & George [26]. They found that children with word founding disabilities made proportionally more phonological errors on object naming than their typical age-matched peers. Yet, some researchers claimed the opposite. For example, Dodd, Holm, Crosbie, & McCormack [27] suggest that in comparison to children with an inconsistent phonological disorder who are more successful in word imitation than spontaneous production, in children with CAS, word production can be poorer for imitation than spontaneous production.

Since the phonological representation of CAS is impaired [28, 29], we expect difficulties in retrieving the accurate name of the picture, as we have seen.

Children with typical development received higher scores on word repetition than on naming task [12]. Hence; the authors concluded that in the imitation task, children make use of the spoken model of the word, and can imitate some words more accurately than they can name them. This suggests that existing motor programs (accessed in naming) may be inaccurate or incomplete.

In addition, Tealman and Gillis [30] claim that in a typical population, there should be fewer omissions and substitutions in imitating than in naming; i.e., imitation enables production of the target words. Imitation gives the child phonological cues, which lead to better production than naming with no such clues. Is this the case in children with speech and language impairment? A case study of a child with both CAS and oral apraxia who had intensive speech treatments was reported [17]. The treatment focused on improving the imitation of the consonants which were missing in the child's inventory. The child's phonetic repertoire increased from 11 to 17 phonemes. Although the present study is only a case study with no control

group, it shows the need to use imitation in CAS populations as a tool to improve their phonetic inventory.

When imitation skills are not present in young children, speech and language skills typically fail to emerge. Thus, imitation is the first step toward understanding the meaning of the words and using the imitative pattern in everyday conversations.

The next question is whether imitation serves for learning the specific word only or improves learning of new words. Imitation therapy was used to examine whether it helps a variety of speech and language impairments [31]. Novel names with imitation were taught to four groups of young children:(a) children with consistently non-developmental errors; (b) children with inconsistent errors; (c) children diagnosed as having CAS; and (d) a typically speaking age-matched control group. Unlike all other groups, none of the phonological and phonetics cues provided were helpful and in particular imitation didn't improve the accurate production in children with CAS. The imitation therapy method was repeated [32]: five children aged 18 months were treated to determine if imitative behavior in the form of sound production could be initiated and increased. After two months of treatment, all five children were able to use consistent imitative sound productions and exhibited significant increases in both the number of vocalizations and the variety of phonemes produced. In addition, these children showed regular spontaneous verbal imitation. The study demonstrated that imitation therapy appears to be a promising practice but further investigation is needed. Our results support these findings. Although some productions of imitation were similar to naming, most of the children benefit from imitation and came closer to the target word, and sometimes even produced the phonological and phonetic format of the target word.

The second assumption that in CAS, there would be more phonological errors as the word includes more syllables both for naming and imitation, was confirmed. Monosyllabic words had significantly fewer mistakes compared to longer words both in naming and imitation. Moreover, four syllable words seemed to be most difficult for the children in both naming and imitation tasks, and had more mistakes than tri-syllabic, disyllabic and monosyllabic words.

In section (d) in Ellis and Young's model [8], the lexical data processes into the phonological lexicon. One way of increasing phonological complexity is increasing the number of syllables in the word. Monosyllabic words should be easier than disyllabic words, while the multi-syllabic word is the most complex form. Hence, we expected that more phonological errors will occur as the word included more syllables. Our results support previous researches [23, 33] that found more phonological errors corresponding to phonological processes affected by complexity. Shorter words had fewer phonological errors while multi-syllabic words predicted lower consonant accuracy.

Some claim that complexity is influenced by motor control [34]. The relationship between speech motor and phonological deficits in suspected CAS was examined in a series of three studies [35]. Inappropriate stress was the only domain which differentiated this population from children with speech delay of unknown origin. The authors claimed that the stress deficit occurs within linguistic representational levels of phonology, rather than within pre-articulatory sequencing. Hence, because the disorder is more consistent with a phonological as opposed to a speech-motor deficit, CAS may not be the appropriate term for the group of children identified in these studies because they show a phonological deficit but not praxic deficits. The authors emphasize the need for further research relating phonological deficits to motor speech deficits.

Another attempt to answer this question compared typical children to children with CAS using brain activation in response to phonemic speech-sound contrast [29]. If a strictly motor planning deficit is at the core of CAS, the typical children and children with CAS would not show different brain activations in response to phonemic speech-sound contrasts. But, if phonological involvement is a core of CAS, there will be differences in the brain activation responses as compared with age-matched peers. The findings revealed that the second option was confirmed: children with CAS showed different brain activation responses to phonemic and allophonic contrasts when compared with typical children, leading to the conclusion that children with CAS have phonological deficits. These findings do not provide support for a view of CAS as a pure motor planning deficit.

Dynamic Evaluation of Motor Speech Skill (DEMSS), dealt with the assessment of CAS. Cluster analysis showed that total DEMSS scores can differentiate clusters of children with CAS vs. mild CAS

vs. other speech disorders, but sometimes fails to identify children with CAS [36]. Although DEMSS is a motoric assessment, the authors stated that children with motor speech impairment probably exhibit errors in phonology given that the motoric deficit almost certainly makes phonologic acquisition more difficult.

The results of our study show that imitation helps children with CAS to come closer to the target word. If the difficulty was only in pre-articulatory sequencing, imitation should be more difficult, but this is not the case. Imitation of words seems to be an easier task than naming in CAS. Hence, the difficulty lies not only on the motor-speech level, but also on the phonological level. Since children with CAS have difficulty in organizing the word semantically and phonologically (steps c+d in Ellis & Young's model [8]), they will have more difficulty when the template in not displayed.

The third assumption dealt with the frequency of the three prosodic levels in CAS errors: the segmental, the syllabic and the word prosodic levels. The results of our study demonstrated fewer errors on the prosodic word level than on the syllabic and the segmental levels. Children with CAS have difficulty perceiving and processing syllable structure (for example, identification of the number of syllables in the word, and judging intrasyllabic sound position within monosyllabic frames) [28]. Children with CAS displayed impaired performance on all tasks compared to typical children. The conclusion was that CAS is a disability to perceive syllable representation. Another study of Hebrew-speaking children with CAS showed that there is a-synchronization between the acquisition of the prosodic word and the acquisition of syllable structure and segments [24]. While children with CAS added more and more syllables to the word, syllable structure and segments were not acquired as expected. The syllabic structure sometimes included a consonantal onset followed by a vowel or even syllables with vowels only [37]. Consonant accuracy is highly linked with syllable construction errors and patterns of syllable production. The relationship between the syllable structure and consonant accuracy was investigated in three children with CAS [33]. Results show the relations between these two levels: complex syllable shape predicted low consonant accuracy and vice versa. A longitudinal follow up study showed little improvement: irregular patterns of consonant and syllable-level errors persisted across the period.

The children in our study showed many segmental errors. In 5 year old children with typical development, there should not be any segmental inconsistency; however, it persisted in children with CAS, suggesting that for a child of this age, inconsistency is a feature of a speech disorder rather than typical development [24, 38, 39].

CONCLUSION

The aim of this study was to compare imitation and naming in children with CAS and to analyze the nature of their errors according to the complexity of the word and across the three levels of the prosodic hierarchy: the segmental level, the syllabic level and the prosodic word level.

Results indicate that naming is a more complex task than imitation and includes more errors than imitation. Moreover, as the word length increases there are more errors in both tasks. In addition, more errors appear on the segmental and syllabic levels compared to the word prosodic level, i.e. the word prosodic level is the first to be acquired while the two other levels stay behind. From these results we conclude that imitation is acquired in CAS before naming as in typical children. In imitation, children are given the pattern of the word and they need to repeat it, while in naming they have to retrieve the phonological pattern of the word.

Although intra variability was shown, the differences were significant. Yet, additional studies need to be done with more CAS children in order to determine whether different productions made by the children in naming and imitation can help to divide CAS into various subgroups.

REFERENCES

[1] Meltzoff AN. The human infant as homo imitans. In: Zentall TR, Galef JR BG, Eds. Social learning: Psychological and biological. Hillsdale, NJ: Erlbaum1988; pp. 319-341.

[2] Piaget J. The origins of intelligence in children. New York: International Universities Press 1952.

[3] Gaines R, Leaper C, Monahan C, Weickgenant A. Language learning and retention in young language disordered children. J Autism Dev Disord 1988; 18: 281-96. http://dx.doi.org/10.1007/BF02211953

[4] Miniscalco C, Rudling M, Råstam M, Gillberg C, Johnels JA. Imitation (rather than core language) predicts pragmatic development in young children with ASD: A preliminary longitudinal study using CDI parental reports. Int J Lang & Commun Disabil 2014; 49: 369-75. http://dx.doi.org/10.1111/1460-6984.12085

[5] Gathercole SE, Baddeley AD. Working memory and language. Hove, England: Lawrence Erlbaum Associates 1993.

[6] Snow CE. Imitativeness: A trait or skill? In: Speidel GE, Nelson KE, Eds. The many faces of imitation in language learning. New York: Springer-Verlag 1989; pp. 73-90. http://dx.doi.org/10.1007/978-1-4612-1011-5_4

[7] Morrison CM, Chappell TD, Ellis AW. Age of acquisition norms for a large set of object names and their relation to adult estimates and other variables. Q J Exp Psychol 1997; 50: 528-59. http://dx.doi.org/10.1080/027249897392017

[8] Ellis A, Young A. Human cognitive neuropsychology. London: Erlbaum 1988.

[9] Jerger S, Martin R, Damian M. Semantic and phonological influences on picture naming by children and teenagers. J Mem Lang 2002; 47: 229-49. http://dx.doi.org/10.1016/S0749-596X(02)00002-5

[10] Grunwell P. Phonological assessment of child speech. Windsor: NFER Nelson 2005.

[11] Stackhouse J, Wells B. Children's speech and literacy difficulties: A psycholinguistic framework. London: Whurr 1997.

[12] Vance M, Stackhouse J, Wells B. Speech-production skills in children aged 3-7 years. Int Lang Commun Disord 2005; 40: 29-48. http://dx.doi.org/10.1080/13682820410001716172

[13] American Speech-Language-Hearing Association. Childhood apraxia of speech [Technical Report] 2007.

[14] Forrest K. Diagnostic criteria of developmental apraxia of speech used by clinical speech-language pathologists. Am J Speech Lang Pathol 2003; 12: 376-80. http://dx.doi.org/10.1044/1058-0360(2003/083)

[15] Bradford A, Dodd B. Do all speech disordered children have motor deficits? Clin Linguistics Phonetics 1996; 10: 77-101. http://dx.doi.org/10.3109/02699209608985164

[16] Powell TW. Phonetic inventory constraints in young children: Factors affecting acquisition patterns during treatment. Clin Linguistics Phonetics 1993; 7: 45-57. http://dx.doi.org/10.3109/02699209308985543

[17] Powell TW. Stimulability considerations in the phonological treatment of a child with a persistent disorder of speech-sound production. J Commun Disord 1996; 29: 315-33. http://dx.doi.org/10.1016/0021-9924(96)00015-9

[18] Ozanne A. The search for developmental verbal dyspraxia. In: B. Dodd B, Ed. Differential diagnosis and treatment of children with speech disorder. San Diego, CA: Singular. 1995; pp. 91-101.

[19] Goldstein B, Fabiano L, Iglesias A. Spontaneous and imitated productions in Spanish-speaking children with phonological disorders. Lang, Speech, and Hear Serv Sch 2004; 35: 5-15. http://dx.doi.org/10.1044/0161-1461(2004/002)

[20] Aram D. Assessment and treatment of developmental apraxia. New York: Thieme-Stratton 1984.

[21] Kent RD. Research on speech motor control and its disorders: A review and prospective. J Commun Disord 2000; 33: 391-428. http://dx.doi.org/10.1016/S0021-9924(00)00023-X

[22] Dodd B, McCormack P. A model of speech processing for differential diagnosis of phonological disorders. In: Dodd B, Ed. Differential diagnosis and treatment of children with speech disorders. John Wiley & Sons 2013; pp. 71-82.

[23] Thoonen G, Maassen B, Wit J, Gabreëls F, Schreuder R. The integrated use of maximum performance tasks in differential diagnostic evaluations among children with motor speech disorders. Clin Linguistics Phonetics 1996; 10: 311-36. http://dx.doi.org/10.3109/02699209608985178

[24] Tubul-Lavy G. Intra-word inconsistency in apraxic Hebrew-speaking children, ClinLinguistics Phonetics 2012; 26: 502-17. http://dx.doi.org/10.3109/02699206.2012.663050

[25] Ben-David A. Language acquisition and phonological theory: Universal and variable processes across children and across languages. Doctoral dissertation, Tel-Aviv University 2001; Israel [in Hebrew].

[26] Dockrell J, Messer D, George R. Patterns of naming objects and actions in children with word-finding difficulties. Lang Cog Processes 2001; 16: 261-86. http://dx.doi.org/10.1080/01690960042000030

[27] Dodd B, Holm A, Crosbie S, McCormack P. Differential diagnosis of phonological disorders. In Dodd B Ed. Differential diagnosis and treatment of children with speech disorders London: Whurr 2005; pp. 44-70.

[28] Marquardt T, Sussman HM, Snow T, Jacks A. The integrity of the syllable in developmental apraxia of speech. J Commun Disord 2002; 35: 31-49. http://dx.doi.org/10.1016/S0021-9924(01)00068-5

[29] Froud K, Khamis-Dakwar R. Mismatch negativity responses in children with a diagnosis of childhood apraxia of speech (CAS). Am J speech Lang Pathol 2012; 21: 302-312. http://dx.doi.org/10.1044/1058-0360(2012/11-0003)

[30] Taelman H, Gillis S. Variation and consistency in children's truncation patterns. In Proc. of the gala 2001 CLA 2002; pp. 263-270.

[31] Bradford-Heit A, Dodd B. Learning new words using imitation andadditional cues: differences between children with disordered speech. Lang Teach Therapy 1988; 14: 159-80. http://dx.doi.org/10.1191/026565998674298897

[32] Gill C, Mehta J, Fredenburg K, Bartlett K. Imitation therapy for non-verbal toddlers. Child Lang Teach Ther 2001; 27: 97-108. http://dx.doi.org/10.1177/0265659010375179

[33] Jacks A, Marquardt TP, Davis BL. Consonant and syllable structure patterns in childhood apraxia of speech: Developmental change in three children. J Commun Disord 2006; 39: 424-41. http://dx.doi.org/10.1016/j.jcomdis.2005.12.005

[34] Williams P, Stackhouse J. Rate, accuracy and Consistency: Diadochokinetic performance of young normally developing children. Clin Linguistics Phonetics 2000; 14: 267-29. http://dx.doi.org/10.1080/02699200050023985

[35] Shriberg LD, Aram DM, Kwiatkowski J. Developmental apraxia of speech: III. A subtype marked by inappropriate stress. J Speech Lang Hear Res 1997; 40: 313-37. http://dx.doi.org/10.1044/jslhr.4002.313

[36] McCauley RJ, Weigand SD, Stoeckel RE, Baas BS. A motor speech assessment for children with severe speech disorders: Reliability and validity evidence. J Speech Lang and Hear Res 2013; 56: 505-20. http://dx.doi.org/10.1044/1092-4388(2012/12-0094)

[37] Adi-Bensaid L, Tubul-Lavy G. Consonant-free words: Evidence from Hebrew speaking children with cochlear implants. Clin Linguistics Phonetics 2009; 23: 122-32. http://dx.doi.org/10.1080/02699200802564961

[38] Holm A, Crosbie S, Dodd B. Differentiating normal variability from inconsistency in children's speech: Normative data. Int J Lang Commun Disord 2007; 42: 467-86. http://dx.doi.org/10.1080/13682820600988967

[39] Iuzzini J. Inconsistency of speech in children with childhood apraxia of speech, phonological disorders, and typical speech. Doctoral dissertation, Indiana University 2012.

Received on 05-04-2015 Accepted on 27-04-2015 Published on 30-04-2015

DOI: http://dx.doi.org/10.12970/2311-1917.2015.03.01.5