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Original Research

Diadochokinetic Rate Quantification in 5 to 14 Year Old Children

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ABSTRACT

Background: *Diadochokinetic Rate (DDK) is an ability of repeating a series of sounds quickly and repeatedly. This ability is one of variables to measure speaking ability. The need for normative data is important to provide prediction appropriately in order to establish speaking disorder diagnosis. This research aims to find quantitative data (DDK) in 5 to 14 year old children.*

Methods: *The research employed observational approach. Data was collection was conducted through face-to-face examination with students as enumerator. Each of enumerators has been trained on how to examine and to document data, as indicated with audiovisual recording. Data was collected on January 2020. A total of 100 respondents were included into analysis criteria. Respondents were 5-14 year old normal children. Data analysis was conducted using descriptive analysis.*

Results: *The research found data of Diadochokinetic Rate quantification at syllable and word levels. Quantification data shows the difference between nonsense syllable words and words. There was a difference of quantitative data in each of age groups. Analysis on examination result was carried out using mean and standard deviation scores.*

Conclusion: *The finding of research showed recent data of DDK in 5 to 14 year old year children. Data can be used as the material of speech therapy examination analysis. Further researchers are required to see DDK ability broadly in each of age groups.*

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INTRODUCTION

Diadochokinetic Rate (DDK) is an ability of spelling syllables sequentially and quickly. This ability is divided into *Sequencing Motion Rate* and *Alternating Motion Rate* (AMR). This ability indicates speaking planning and programming process (Ben-David & Icht, 2018; Duffy, 2013; Lowit et al., 2018; Padovani et al., 2009). The failure in doing DDK task informs the putative speaking problems. Speaking problem includes DDK examination as one of compulsory examinations is motor-speech disorder. Some literatures have mentioned normative data on DKK (Fletcher, 1972; Prathanee et al., 2003; Seifpanahi et al., 2008; Tiffany, 1980). The data provides clinical guidelines on the reference for children's ability compared with normative data.

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Fletcher (1972) provided clear guidelines on DDK quantification. It informs the parameter of DKK for 6 to 13 year old children. The material used as non sense words. A similar study has been conducted by Seifpanahi et al., (2008). Just like the previous studies, the use of non sense words is the primary choice in doing DDK. A research is required to explore data of DDK quantification before 5-year and after 13-year age more broadly (Fletcher, 1972). Including the real words is the choice compatible to the examination need. It builds on contextual examination of client needs. Without DDK norm, clinicians will find difficulty in establishing speech disorder diagnosis accurately, particularly dysarthria and verbal apraxia (Redstone & KowalskI, 2011; Shakibayi et al., 2019).

The need for data of DDK quantification is crucially required by clinicians in Indonesia. Data of DDK quantification based on ethnocultural background will provide better and more functional analysis result (Shipley & McAfee, 2021). In addition, data on children's speaking ability is uncertainly the same between one language and another, despite normative data on each speaking ability aspect elaborated (Kent et al., 1987). Unfound data on DDK quantification in Indonesia is a problem needing to answer immediately. The norms resulting from this research can be used as reference in assessing the speech planning and programming ability of 5-14 year old children.

The search on data on DDK quantification at single and double syllables and word level is very important (Alshahwan et al., 2020). In addition to providing syllable- and word-based information, the fulfilment of information on DKK in syllables with voiced and voiceless consonant becomes important. This quantification data will give the clinicians a guideline to perform assessment and intervention processes. The ethnocultural-based assessment and intervention processes exert more significant effect on its management. Word and material choices in ethnocultural-based DDK activity play an important role in handling speech disorder related to motor-speech process. Studies have been conducted to see DDK across languages (Alshahwan et al., 2020; Icht & Ben-David, 2014), but none to see DDK ability in Indonesian language speakers.

The objective of research is to find out the DDK quantification at single and double syllables, and words. This data selection is important, because there is a process of comparing real words with non sense word. Data of quantification result will give more objective description on client's diagnosis and need limited to motor-speech area.

MATERIALS AND METHOD

Data collection was carried out using a purposive sampling. The assessment was calculated based on the length of time needed to repeat syllable or word. Each of syllables has different repetition number in one repetition period. A single syllable needs 20 repetitions. More than one syllable needs 10 repetitions for each repetition period. Word needs 10 repetitions for each group. Word repetition group consists of one syllable, word with two syllables and word with three syllables.

DDK is conducted by repeating one syllable and word. There are two syllable groups: voiceless and voiced consonants. The list of syllables with voiceless consonant repeated includes /pʌ/, /tʌ/, /kʌ/, /pʌtʌ/, /pʌkʌ/, /tʌkʌ/, and /pʌtʌkʌ/. The list of syllables with voiced consonant repeated includes /bʌ/, /dʌ/, /gʌ/, /bʌdʌ/, /bʌgʌ/, /dʌgʌ/, and /bʌdʌgʌ/. The word group with single syllable has CVC pattern. The word group with double syllable has CVCV pattern. The word group with two syllables has CVCVCV pattern. Each of word groups consists of 10 words. Analysis was conducted on word level using mean score of respective word groups consisting of one, two, and three syllables.

DDK activity was conducted using procedure of collecting DDK data with modified count-by-time procedure (Fletcher, 1972). The detail of data collection procedure is elaborated as follows: (a) *I want you spell a syllable/a word",* (b) "*I will show you how to do*

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so", (c) *"Now you can try it with me"*, (d) *"Try it by yourself now"* (e) "*I want you do it once more time, do it as quickly as possible until I give you an order" and* (f) "*Next….."*

Data was taken by a trained enumerator. The enumerators in this case were the 5th-semester students of Speech Therapy Undergraduate program in Academic year of 2019/2020. Before collecting data, each of enumerators has been training on how to conduct test and documentation. Test was documented in paper based and audiovisual recording to ensure that the data collection has been appropriate. Each of enumerator collected data for one male respondent and one female respondent. The instruments used were assessment sheet, stopwatch, and stationery.

The research was conducted on the schools existing in Surakarta City's work area. The data collecting process was carried out on January 2020. The research was carried out based on Director of Health Polytechnic of Ministry of Health Surakarta's recommendation No. LB.02.02/ I.3/ 6510/ 2019 on July 30, 2019 about the Application for Research Permission and the Permission given by Surakarta City's Local Planning and Development Agency (Bappeda) No. 070/ 1587/ XII/ 2019 on December 12, 2019 about Research Permission. The respondents of research consisted of 100 students.

RESULTS

Descriptive data of research's respondents consists of sex and age. Statistic descriptive analysis was conducted using mean, standard deviation, maximum, and minimum values. Analysis is distributed by word or non word type and data complexity. The distribution of respondent data is explained in Table 1.

Table 1. Data Distribution

Data	**n**	**%**
Sex		
Male	50	50
Female	50	50
Age		
60 – 71 months	10	10
72 – 83 months	10	10
84 – 95 months	10	10
96 – 107 months	10	10
108 – 119 months	10	10
120 – 131 months	10	10
132 – 143 months	10	10
144 – 155 months	10	10
156 – 167 months	10	10
168 – 179 months	10	10
Total	**100**	**100**

n= respondent number, %= percentages

Table above shows the distribution of respondents' data by children's sex and age. Table 1 shows that the ratio of male to female respondent is 1:1. There is no difference in the proportion of each age group for both male and female respondents. Each of age groups consists of 5 girls and 5 boys.

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DDK Quantification at the single syllable with voiceless consonant level

The list of syllable with voiceless consonant used as DDK material includes pʌ/, /tʌ/, /kʌ/, /pʌtʌ/, /pʌkʌ/, /tʌkʌ/, and /pʌtʌkʌ/. The table below presents the detail of mean and standard deviation values. The data also shows the detailed data indicating DDK abilities of both male and female respondents. Table 2 shows data of DDK at one-syllable level.

Table 2. DDK at one-syllable level

Age (mo)		pʌ			tʌ			kʌ		
		M	F	#	M	F	#	M	F	#
60 – 71	m	6.1	8.5	7.3	6.1	8.6	7.3	6	8.5	7.3
	SD	0.4	1.7	1.7	0.6	2	1.9	1.5	2	2.1
	max	6.8	11	11	7.2	11.1	11.1	8.6	11.8	11.8
	min	5.6	6.4	5.6	5.6	5.8	5.6	4.6	6.7	4.6
72 – 83	m	9.8	5.4	7.6	8.8	6.1	7.5	8.2	6	7.1
	SD	2.7	0.7	2.9	2.4	0.7	2.2	2.4	0.6	2
	max	14.1	6.4	14.4	11.8	7.4	11.8	12.3	7.1	12.3
	min	7.5	4.4	4.4	5.3	5.5	5.3	6.1	5.4	5.4
84 – 95	m	6.4	6.7	6.5	6.1	6	6	5.8	5.9	5.9
	SD	2.2	2	2	2.4	1.5	1.9	2.1	1.4	1.7
	max	9.3	9	9.3	9.3	8	9.3	8.6	7	8.6
	min	4.3	4.4	4.3	3.6	4.3	3.6	3.7	4	3.7
96 – 107	m	5.7	6.1	5.9	5	5.6	5.3	5.7	6	5.8
	SD	1.6	0.6	1.1	1.1	0.4	0.8	1.2	0.9	1
	max	7.5	6.7	7.5	6.5	6	6.5	7.8	7	7.8
	min	3.3	5.2	3.3	3.3	5.2	3.3	4.6	4.4	4.4
108 – 119	m	7	7.8	7.4	6.7	7.8	7.3	6.8	7.7	7.3
	SD	0.9	1.2	1.1	1.2	1.8	1.5	2	1.5	1.7
	max	7.8	9	9	8.4	9.7	9.7	9.3	9	9.3
	min	5.9	6	5.9	5.2	5.1	5.1	4.4	5.2	4.4
120 – 131	m	5.9	5.8	5.8	5.6	5.3	5.4	5.1	5	5.1
	SD	0.4	0.9	0.6	0.4	0.9	0.7	0.4	0.8	0.6
	max	6.8	6.8	6.8	6	6.4	6.4	5.8	6.2	6.2
	min	5.5	4.4	4.4	4.9	4.3	4.3	4.6	4.1	4.1
132 – 143	m	4.9	5.6	5.2	4.8	5.6	5.2	5.1	5.4	5.2
	SD	0.4	0.3	0.5	0.4	0.7	0.7	0.5	0.7	0.6
	max	5.6	6.1	6.1	5.4	6.4	6.4	5.6	6.2	6.2
	min	4.3	5.1	4.3	4.2	4.4	4.2	4.2	4.2	4.2
144 – 155	m	5.9	6.3	6.1	5.9	6.2	5.8	5.8	5.8	5.8
	SD	0.6	1.7	1.2	1.1	2.2	0.9	0.9	2	1.4
	max	6.6	8.6	8.6	7.2	9.2	6.7	6.7	8.3	8.3
	Min	5	4.5	4.5	4.4	3.8	4.4	4.4	3.3	3.3
156 – 167	m	4.6	4.7	4.6	4.5	4.6	4.6	4.7	4.7	4.7
	SD	0.9	0.8	0.8	1.1	0.7	0.9	0.8	0.8	0.7
	max	6.2	5.9	6.2	6.2	5.8	6.2	5.6	5.7	5.7
	min	3.6	3.8	3.8	3.1	4	3.1	3.6	4.1	3.6
168 – 179	m	5.6	6.5	6.1	5.3	6.4	5.9	5.4	6.8	6.1
	SD	1.2	0.7	1	0.7	0.9	0.9	1.6	1.1	1.5

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Age (mo)		pʌ			tʌ			kʌ		
		M	F	#	M	F	#	M	F	#
	max	6.7	7.7	7.7	6.2	7.8	7.9	7.4	8.8	8.8
	min	3.7	5.8	3.7	4.5	5.8	4.5	3.2	6	3.2

Note: m = mean, SD = Standard Deviation, max = maximum time, min = minimum time, M = Male, F = Female, # = total mean

Table 2 explains statistic descriptive DDK at single syllable level. Syllable /pʌ/ indicates labial performance in doing DDK. Syllable /tʌ/ is an activity to indicate tongue performance, while repetition /kʌ/ is made to see velum integrity. There are varying descriptive data for each of age and sex groups. The older the age, the shorter is the time taken to do DDK.

DDK Quantification at the double syllable with voiceless consonant level

Furthermore, analysis should be conducted to see DDK ability at syllable level. There are four groups of syllable with voiceless consonant. Table 3 showing data of DDK at double-syllable level. Double voiceless syllable includes bisyllable and trisyllable.

Table 3. DDK at double-syllable level

Age (mo)		pʌtʌ			pʌkʌ			tʌkʌ			pʌtʌkʌ		
		M	F	#	M	F	#	M	F	#	M	F	#
60 – 71	m	5.5	7	6.2	6	7.1	6.6	5.9	6.3	6.1	8.1	9.8	9
	SD	1.4	2.5	2	0.8	0.6	0.9	1.6	1	1.3	2	1.2	1.7
	max	7.7	10.5	10.5	6.9	7.9	7.9	8.6	7.8	8.6	10.6	10.8	10.8
	min	4	3.5	3.5	5	6.1	5	4.3	4.7	4.3	6.2	7.8	6.2
72 – 83	m	5.1	5.4	5.3	6	6.3	6.2	5.6	5.5	5.5	7.8	7.9	7.9
	SD	1.3	0.8	1	1.7	1	1.3	1.3	0.6	1	1.5	0.3	1
	max	6.6	6.6	6.6	8.7	7.7	8.7	7	6.6	7	9.8	8.5	9.8
	min	3.7	4.5	3.7	4.1	5	4.1	3.5	5	3.5	6.2	7.5	6.2
84 – 95	m	4.4	4.6	4.5	4.3	5.2	4.8	4.5	4.4	4.5	6	6.1	6.1
	SD	2.2	1.8	1.9	1.5	1.7	1.6	1.4	1.8	1.5	2	1.4	1.6
	max	7	7	7	6	8	8	6	7	7	8.4	7.8	8.4
	min	1.9	1.9	1.9	2.3	3.2	3.2	2.8	2	2	4	4.4	4
96 – 107	m	4.2	5.2	4.7	4	4.9	4.4	4.2	4.9	4.6	5.3	6.5	5.9
	SD	1.5	1.7	1.6	1.3	1.2	1.3	0.8	1.2	11	1.4	1	1.3
	max	5.7	8	8	5.9	6.2	6.2	5.3	6.2	6.2	7.3	8	8
	min	2.1	3.1	2.1	2.3	3.1	2.3	3.2	3.1	3.1	3.9	5.2	3.9
108 – 119	m	5.8	5.7	5.7	5.3	6	5.6	5	6.1	5.6	6.6	6.2	6.4
	SD	1.6	1.1	1.3	1.5	2	1.7	1.1	1.3	1.3	2.2	0.7	1.5
	max	7.9	7	7.9	7.1	8.9	8.9	6.2	8	8	10.2	7.1	10.2
	min	3.4	4.2	3.4	2.8	3.8	2.8	3.2	4.2	3.2	4.2	5.2	4.2
120 – 131	m	3.8	4.3	4	3.8	4.3	4	3.9	4	4	4.6	5.1	4.8
	SD	1.1	0.9	1	0.8	0.4	0.6	0.5	0.5	0.5	1	0.6	0.8
	max	5.1	5.8	5.8	4.5	4.9	4.9	4.7	4.8	4.8	6.1	6.1	6.1
	min	2.4	3.1	2.4	2.5	3.8	2.5	3.2	3.4	3.2	3.2	4.5	3.2
132 – 143	m	3.4	4.2	3.8	3.1	4	3.6	3.2	4.3	3.7	4.4	4.8	4.6
	SD	0.6	0.6	0.7	0.4	0.7	0.7	0.7	1	1	0.9	0.4	0.7
	max	4.3	4.9	4.9	3.8	5.1	5.1	4.1	5.9	5.9	5.6	5.2	5.6

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Age (mo)		pʌtʌ			pʌkʌ			tʌkʌ			pʌtʌkʌ		
		M	F	#	M	F	#	M	F	#	M	F	#
	min	2.7	3.4	2.7	2.5	3.2	2.5	2.1	3.1	2.1	3.5	4.1	3.5
144 – 155	m	4.5	4.5	4.5	4.5	4.3	4.4	4.6	4.5	4.6	5.4	4.9	5.1
	SD	0.7	1	0.8	0.9	1	0.9	1	1.5	1.2	1.1	1.6	1.3
	max	4.9	6	6	6.1	6.2	6.2	6	7.3	7.3	6.7	7.6	7.6
	min	3.2	3.1	3.1	3.5	3.3	3.3	3.3	3.3	3.3	4.3	3.4	3.4
156 – 167	m	3.5	4	3.7	3.2	3.7	3.5	3.4	3.4	3.4	4.2	4.9	4.2
	SD	0.9	2	1.5	0.5	1	0.8	0.8	0.9	0.8	1.2	1.6	1
	max	4.6	7.6	7.6	4	5	5	4.8	4.6	4.8	6	5.4	6
	min	2.1	2.1	2.1	2.6	2.2	2.2	2.5	1.9	1.9	2.5	2.7	2.5
168 – 179	m	3.7	3.7	3.7	3.4	3.8	3.6	3.4	3.6	3.5	4.2	4.4	4.3
	SD	0.5	0.7	0.6	0.5	0.7	0.6	0.3	0.5	0.4	0.4	0.4	0.4
	max	4.5	4.6	4.6	3.9	4.8	4.8	3.7	4.1	4.1	4.6	5.1	5.1
	min	3.2	2.9	2.9	2.6	3	2.6	2.8	3	2.8	3.5	4	3.5

Note: m = mean, SD = Standard Deviation, max = maximum time, min = minimum time, M = Male, F = Female, # = total mean

The more complex the syllable repetition, the longer is the time taken to do DDK, compared with the syllables with simpler complexity. There is a difference of quantification value between age groups in each type of syllables. Syllables with three syllables have longer repetition time than the simpler syllables.

DDK Quantification at the single syllable with voiced consonant level

The list of syllable with *voiced* used as DDK material includes /bʌ/, /dʌ/, and /gʌ/, The table below shows the detail of mean and standard deviation values. The data also presents detailed data indicating DDK abilities of male and female respondents. Table 4 shows DDK data at one-syllable level. Table 5 shows DDK data at double-syllable level.

Table 4. DDK data at one-syllable level

Age (mo)		bʌ			dʌ			gʌ		
		M	F	#	M	F	#	M	F	#
60 – 71	m	6.7	7.9	7.3	5.6	9	7.3	6.1	9.4	7.7
	SD	1	1.2	1.2	0.3	0.7	1.8	0.9	0.5	1.9
	max	8.2	9.3	9.3	6.1	10	10	7.7	10.2	10.2
	min	5.5	6.4	5.5	5.3	8.3	5.3	5.2	8.9	5.2
72 – 83	m	7.6	6.1	6.9	9	6.1	7.5	8.4	6.1	7.3
	SD	2.5	1.2	2	3.7	1	3	2.1	1	2
	max	11.8	8	11.8	14.4	7.9	14.4	10.9	7.9	10.9
	min	5.2	4.7	4.7	4.8	5.3	4.8	5.5	5.3	5.3
84 – 95	m	6.3	7	6.6	5.9	6.3	6.1	5.8	6.2	6
	SD	1.6	2.4	1.9	1.9	2	1.9	1.8	2.2	1.9
	max	8.7	10	10	8.8	9.1	9.1	8.2	9.8	9.8
	min	4.4	4.1	4.1	3.7	4.2	3.7	3.6	4.4	3.6
96 – 107	m	5.9	5.9	5.9	5.8	6.1	5.9	6.1	6	6
	SD	0.7	0.8	0.7	1.7	1	1.3	1.6	1	1.2
	max	7	6.5	7	8.8	7.6	8.8	9	7	9
	min	5.3	4.5	4.5	4.1	4.6	4.1	5	4.5	4.5

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Age (mo)		bʌ			dʌ			gʌ		
		M	F	#	M	F	#	M	F	#
108 – 119	m	6.6	8	7.3	6.4	8.4	7.4	6.7	9	7.8
	SD	2.2	1.9	2.1	2.7	1	2.2	2.1	1.4	2
	max	9.4	11.1	11.1	10.3	10	10.3	10.1	11.1	11.1
	min	3.9	6.1	3.9	3.1	7.2	3.1	4.8	7.7	4.8
120 – 131	m	5.7	5.5	5.6	5.7	5.4	5.5	5.6	5.4	5.5
	SD	0.8	0.8	0.8	0.8	0.8	0.7	0.9	1	0.9
	max	7.1	6.7	7.1	6.9	6.6	6.9	7	6.8	7
	min	5	4.6	4.6	4.8	4.4	4.4	4.5	4.4	4.4
132 – 143	m	5.6	6.8	6.2	5.3	6	5.7	5.2	6	5.6
	SD	1.1	1.2	1.2	1.4	1.1	1.2	1.3	0.8	1.1
	max	7.6	8.1	8.1	7.5	7.7	7.7	7.6	7.2	7.6
	min	4.8	5.6	4.8	3.7	4.9	3.7	4.1	5.1	4.1
144 – 155	m	6.2	6.7	6.5	6.2	6.3	6.2	6	6.3	6.1
	SD	0.6	2.1	1.5	0.9	2	1.5	0.9	2.2	1.6
	max	7.1	9.1	9.1	7.1	8.5	8.5	6.8	8.8	8.8
	Min	5.4	3.9	3.9	5	3.8	3.8	4.9	3.4	3.4
156 – 167	m	4.9	5.3	5.1	4.8	4.9	4.9	4.8	5.1	4.9
	SD	0.6	1.2	0.9	0.6	0.9	0.7	0.5	1.1	0.8
	max	5.6	7	7	5.5	6.2	6.2	5.5	6.8	6.8
	min	3.9	3.9	3.9	4.3	3.8	3.8	4.3	3.7	3.7
168 – 179	m	6.5	6	6.2	5.5	5.9	5.7	5.5	5.9	5.7
	SD	1	0.8	0.9	0.6	0.5	0.5	0.8	0.4	0.8
	max	8.1	7.3	8.1	6.1	6.6	6.1	6.6	6.8	6.8
	min	5.5	5	5	4.8	5	4.8	4.8	5.5	4.8

Note: m = mean, SD = Standard Deviation, max = maximum time, min = minimum time, M = Male, F = Female, # = total mean

Syllable /bʌ/ indicates labial performance in doing DDK. Syllable /dʌ/ is an activity to indicate tongue performance, while repetition /gʌ/ is made to see velum integrity. There are varying descriptive data for each of age and sex groups. The older the age, the shorter is the time taken to do DDK.

DDK Quantification at the double syllable with voiced consonant level

The list of multi syllable with *voiced* consonant used as DDK material includes /bʌdʌ/, /bʌgʌ/, /dʌgʌ/, and /bʌdʌgʌ/.

Table 5. DDK at double-syllable level

Age (mo)		bʌdʌ			bʌgʌ			dʌgʌ			bʌdʌgʌ		
		M	F	#	M	F	#	M	F	#	M	F	#
60 – 71	m	5.3	7.3	6.3	5.9	6.9	6.4	5.9	7.1	6.5	8.5	10.8	9.7
	SD	0.5	2	1.7	0.7	1.7	1.3	0.5	1.4	11	1.7	2.2	2.2
	max	5.9	9.8	9.8	7.3	8.6	8.6	6.4	8.3	8.3	11.5	14	14
	min	4.7	4.2	4.2	5.3	4.3	4.3	5.1	4.8	4.8	7.1	8.2	7.1
72 – 83	m	5.8	6	5.6	6	5.8	5.9	6.1	5.8	5.9	8.4	9.1	8.7
	SD	1.9	1.2	1.4	1.2	1	1	1.5	1.1	1.3	1.2	2	1.6

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Age (mo)		bʌdʌ			bʌgʌ			dʌgʌ			bʌdʌgʌ		
		M	F	#	M	F	#	M	F	#	M	F	#
	max	8.3	7.6	8.3	7.6	7.2	7.6	7.7	7.5	7.7	10.2	12.2	12.2
	min	3.8	4.5	3.8	4.5	4.8	4.5	4.4	4.5	4.4	6.6	7.1	6.6
84 – 95	m	4.7	5.1	4.9	5	5.1	5.1	4.8	5	4.9	6.4	6.7	6.5
	SD	2.2	2.1	2	1.5	1.6	1.4	1.6	1.3	1.3	1.7	1.7	1.6
	max	8	8.5	8.5	7	7.5	7.5	7	6.6	7	8.4	9.4	9.4
	min	2.9	3.1	2.9	3.6	3.2	3.2	3.5	3.5	3.5	4.3	5	4.3
96 – 107	m	4.7	4.9	4.8	4.7	5.6	5.1	4.6	5.7	5.1	5.5	6	5.8
	SD	1.3	1	1.1	1.4	1	1.2	1.4	1.4	1.4	1.5	0.8	1.1
	max	6.7	6.5	6.7	6.6	7	7	6.9	8	8	7.3	7.1	7.3
	min	3.3	3.7	3.3	2.9	4.5	2.9	3	4.5	3	3.6	5.2	3.6
108 – 119	m	4.6	5	4.8	5	5.9	5.5	4.9	5.9	5.4	6.4	6.7	6.6
	SD	1	0.2	0.7	0.7	2.1	1.5	0.6	1.4	1.1	1.2	1.2	1.1
	max	5.8	5.4	5.8	5.9	9.6	9.6	5.7	8.2	8.2	7.5	7.9	7.9
	min	3.2	4.7	3.2	4.2	4.6	4.2	4	4.7	4	4.4	4.8	4.4
120 – 131	m	3.8	4.5	4.1	4.1	4.2	4.2	4.2	4.5	4.3	5.6	5.4	5.5
	SD	0.7	0.8	0.8	0.7	0.4	0.5	0.6	0.4	0.5	1.5	0.3	1
	max	4.8	6	6	5	5	5	5.2	5.1	5.2	7.8	5.6	7.8
	min	2.8	3.9	2.8	3.5	3.9	3.5	3.6	4	3.6	3.4	4.8	3.4
132 – 143	m	3.4	4.1	3.7	3.3	4.1	3.7	3.5	4.2	3.8	4.4	5.3	4.9
	SD	0.5	1	0.9	0.5	1	0.8	0.6	0.9	0.8	1.3	1.2	1.2
	max	4.1	5.7	5.7	4.1	5.5	5.5	4.6	5.5	5.5	6.1	6.7	6.7
	min	2.8	3.1	2.8	2.7	3.2	2.7	3	3.2	3	2.9	4.1	2.9
144 – 155	m	4.6	4.6	4.6	4.9	4.1	4.5	4.7	4.1	4.4	5.7	5.4	5.5
	SD	0.8	1.3	1	1	0.6	0.9	0.6	0.8	0.7	1.1	1.3	1.1
	max	5.6	6.7	6.7	6.1	5	6.1	5.5	5.6	5.6	6.9	7.8	7.8
	min	3.3	2.9	2.9	3.5	3.3	3.3	3.8	3.2	3.2	4.9	4.4	4.4
156 – 167	m	4	3.6	3.8	3.8	3.6	3.7	3.5	3.6	3.6	4.7	4.5	4.6
	SD	1.3	0.8	1	1.2	0.9	1	0.5	0.8	0.6	1	0.9	0.9
	max	5.7	4.8	5.7	5.6	4.5	5.6	4.1	4.4	4.4	6.1	5.3	6.1
	min	2.3	2.5	2.3	2.5	2.2	2.2	2.8	2.1	2.1	3.3	3	3
168 – 179	m	4	3.8	3.9	4	3.7	3.7	3.9	3.5	3.7	4.6	4.4	4.5
	SD	0.9	0.7	0.7	0.7	0.5	0.5	0.6	0.5	0.5	0.8	0.9	0.8
	max	5.5	4.9	5.5	5	4.5	5	4.7	4.5	4.7	5.8	5.3	5.8
	min	3.2	3	3	3	3	3	3.2	3	3	3.6	3	3

Note: m = mean, SD = Standard Deviation, max = maximum time, min = minimum time, M = Male, F = Female, # = total mean

Just like in voiceless consonant, the repetition at multisyllable level takes longer time. The finding shows that the longer syllables take longer time.

DDK Quantification at word level

Activity of repeating one syllable consists of ten words: *tas* (bag), *pin* (pin), *lem* (glue), *pos* (post), *kap* (car roof), *tos* (toss), *jas* (coat), *dus* (box), *bak* (tub), and *cas* (charge). The word used for the repetition of three-syllable word consists of ten words: *baju* (clothing), *pita* (ribbon), *kopi* (coffee), *kali* (time or river), *bika*, *kita* (we), *roti* (bread), *sapu* (broom), *pacu* (spur), and *busi* (spark plug). The last activity was

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conducted by telling the children to repeat words consisting of three syllables: *kepala* (head), *sepeda* (bicycle), *kelapa* (coconut), *sepatu* (shoes), *papaya* (papaya), *terapi* (therapy), *lemari* (cupboard), *garasi* (garage), *batako* (concrete brick), and *kereta* (cart).

Table 6. DDK at word level

Age (mo)		Single word		syllable	Double word		syllable	Triple word		syllable
		M	F	#	M	F	#	M	F	#
60 – 71	m	4	4.7	4.3	4.8	5.3	5	6.3	7.3	6.8
	SD	0.4	0.2	0.4	0.3	0.6	0.5	0.4	0.8	0.8
	max	4.5	4.9	4.9	5.2	6	6	7	8.1	8.1
	min	3.5	4.3	3.5	4.4	4.5	4.4	6	6.3	6
72 – 83	m	4.6	5.1	4.2	5.1	5.3	5.2	7.1	6.3	6.7
	SD	0.9	1	0.8	1	0.6	0.8	1.3	0.6	1
	max	6.2	6.2	6.2	6.2	6	6.2	8.5	7.2	8.5
	min	3.4	3.7	3.4	3.7	4.4	3.7	5.1	5.6	5.1
84 – 95	m	3.5	3.6	3.5	4.1	4.5	4.3	5.9	5.7	5.8
	SD	0.8	0.6	0.7	1.1	1	1	1.9	0.8	1.4
	max	4.7	4.6	4.7	5.6	5.9	5.9	9.5	7.3	9.5
	min	2.7	2.9	2.7	3.2	3.3	3.2	4.8	5.2	4.8
96 – 107	m	3.8	4.1	3.9	4.1	4.3	4.2	5.2	5.3	5.3
	SD	0.8	0.8	0.8	1	0.7	0.8	1.3	0.7	1
	max	5.3	5.5	5.5	5.6	5.5	5.6	7	6.2	7
	min	3.1	3.3	3.1	3.2	3.6	3.2	4.1	4.7	4.1
108 – 119	m	3.2	4.5	3.9	3.9	5.1	4.5	4.6	5.3	5
	SD	0.4	0.4	0.7	0.4	0.6	0.7	0.3	0.4	0.5
	max	3.9	5	5	4.6	5.9	5.9	5.3	5.9	5.9
	min	2.7	4.1	2.7	3.4	4.3	3.4	4.2	4.8	4.2
120 – 131	M	2.9	3.1	3	3.5	3.7	3.6	4.5	4.7	4.6
	SD	0.3	0.1	0.2	0.6	0.1	0.4	0.8	0.3	0.6
	max	3.5	3.3	3.5	4.2	3.9	4.2	5.5	5.1	5.5
	min	2.6	2.9	2.6	2.8	4.6	2.8	3.5	4.1	3.5
132 – 143	M	2.7	3.1	2.9	3.1	3.3	3.2	4	4.3	4.2
	SD	0.5	0.5	0.5	0.4	0.5	0.4	0.6	0.5	0.5
	max	3.5	4	4	3.8	4.1	4.1	5	4.9	5
	min	2	2.6	2	2.7	2.8	2.7	3.6	3.6	3.6
144 – 155	M	3.2	3.2	3.2	3.8	3.5	3.6	4.5	3.9	4.2
	SD	0.2	0.7	0.5	0.6	0.4	0.5	0.3	0.5	0.5
	max	3.6	4	4	4.5	4	4.5	5.2	4.5	5.2
	min	2.9	2.4	2.4	3.3	3	3	4.2	3.1	3.1
156 – 167	M	2.8	2.8	2.8	3.2	3.3	3.2	3.7	3.9	3.8
	SD	0.2	0.4	0.3	0.2	0.5	0.4	0.3	0.7	0.5
	max	3.1	3.5	3.5	3.3	3.9	3.9	4	4.7	4.7
	min	2.3	2.3	2.3	2.8	2.5	2.5	3.3	3.1	3.1
168 – 179	M	2.8	3.1	3	3.2	3.3	3.3	3.9	4.1	4
	SD	0.2	0.3	0.3	0.1	0.2	0.1	0.4	0.5	0.4
	max	3.1	3.7	3.7	3.4	3.7	3.7	4.5	4.9	4.9
	min	2.8	2.8	2.8	3.1	3.1	3.1	3.4	3.4	3.4

Note: m = mean, SD = Standard Deviation, max = maximum time, min = minimum time, M = Male, F = Female, # = total mean

The ability of repeating words with single syllable can be performed more easily by respondents. It is indicated with duration of DDK. The longer the word structure, the relatively longer is the time taken to complete the repetition.

DISCUSSION

Normative data on syllable repetition shows variation between age groups. The difference of syllable repetition speed is indicated with the different mean score viewed from age group and sex. Data collection involved sample size of 100 respondents divided into ten age groups. Each of age groups consists of ten respondents divided into five male and female respondents.

Diadochokinetic is an ability of repeating syllables quickly used to determine the precision of oral motor movement. *Diadochokinetic* approach is used effectively to measure the accuracy of articulator movement, particularly lips, tongue, and velum (Prathanee et al., 2003). They use some syllables to measure the accuracy of articulator movement functionally with syllables pə, tə, and kə. The result of current research is different from that of previous studies in some points. Generally, the mean score of word repetition in Indonesia is lower than English native speaker. The mean score of DDK rate in English can be seen in Fletcher, (1972). Different finding was also suggested by Seifpanahi et al., (2008) reporting the DDK finding in Persian language.

The result of statistics shows that there is a mean score between word groups. This finding is linear to the repetition at syllable level. The result of inter-group correlation test shows positive relationship between groups viewed from word structure. The word with simpler syllable structure has a mean score smaller that that of words with more complex phoneme structure. The difference of speaking speed in various contexts with syllable structure has been identified (Tiffany, 1980). The result of research shows the difference of speaking and reading context. Simple structure has smaller mean score of repetition. Another finding shows similar result with higher mean score in the utterance with higher syllable number (Robb & Gillon, 2007). The data indicates that syllable string affects the speaking speed significantly.

Another issue arising in the relationship between word structure complexity and speaking speed is motor-speech study. Study on motor-speech process is an important issue contributing to speech production. Syllable or word with more complex structure has a long motor-speech process hierarchy. The motor-speech mechanism consists of all motor systems constituting an inseparable unit. In producing one phoneme, all motor mechanisms work by adjusting muscular and nervous systems concomitantly. *Lower motor neuron* (LMN) mechanism is the one inseparable from speech producing process. LMN mechanism organizes how cranial nervous system works in integrative manner in producing a speech sound (Duffy, 2013).

The repeated speech producing mechanism activates motor-speech process. The need for appropriate processing is a compulsory component in word repeating process. Word repetition component is a compulsory component in examining patients with motor-speech disorder. Word repetition error and inaccuracy in *diadochokinetic* activity indicates the motor-speech mechanism error (Duffy, 2013). The component in performing the mechanism is affected by the control over oral motor, posture, and other muscular variable. Muscular variables used in motor-speech mechanism are, among others: *articulation placement, resting tongue posture, swallowing patterns*, and *resting*

mouth posture (Hale et al., 1992). Oral motor ability balance is the key to fluent speech production (Ben-David & Icht, 2018; Lowit et al., 2018; Pratomo & Siswanto, 2020; Redstone & KowalskI, 2011).

This finding has broad implication to clinicians. One of clinical implications is the presence of normative data in *diadochokinetic*. Normative data is required to measure the gap between individual's ability and cumulative mean score. Normative data can be used if the measurement is normative in nature. The data of research gives additional information particularly on the use of words as an instrument in *diadochokinetic* measurement. The word use in *diadochokinetic* measurement provides more variations compared with the measurement using one syllable only. Furthermore, clinicians can use additional age variable in *diadochokinetic* measurement. It becomes important because clinicians report the retarded DDK ability in children with verbal apraxia (Shakibayi et al., 2019).

CONCLUSION

This research finds a fact indicating the variation of *diadochokinetic* data, viewed from age, sex, and data complexity aspects. This study finds DDK data in word and non-word. Normative data found can be used as a valid examining instrument. This data quantification can be used as the comparator to find whether or not there is a speech problem. The appropriate interpretation, both quantitatively and qualitatively, will affect intervention process significantly. Indication of problem requiring DDK examination is motor-speech mechanism disorder. Examination is one of strong determinants in establishing dysarthria and verbal apraxia diagnoses (Duffy, 2013).

Despite some novelties, some questions still need to be answered in this study. This study has a limitation related to sample size in each of age groups. The data reflected is still inadequate, in relation to sample size and generalization area. The syllables used in the measurement are limited to CV, CVCV, and CVCVCV structures. It leads to a new question, "will similar result be found in other syllable structures?"

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