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Evaluation of Diadochokinesis in an Algerian Clinical Context: A Multicase Analysis of Six Patients with Distinct Neurodevelopmental Profiles

Mouloud Hadbi

Dr.

Lecturer, Department "B," University of Abderrahmane Mira Bejaia, Bejaia

Algeria

E-mail: mouloud.hadbi@univ-bejaia.dz

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Abstract

This clinical study investigates diadochokinesis (DDK)—the rapid alternation of articulatory movements—in six Algerian patients presenting with different neurodevelopmental disorders: intellectual disability, Down syndrome, and cerebral palsy (CP). DDK assessment serves as an essential diagnostic tool in neurolinguistic and phonetic evaluation, reflecting both the precision and rhythm of articulatory motor control. The study utilized syllabic repetition tasks composed of consonant–vowel (C–V) and consonant–consonant–vowel (C–C–V) sequences produced at bilabial, alveolar, and velar points of articulation. Data were collected and analyzed for speech rate, phonation duration, coordination, and occlusive tonicity, thereby quantifying patients' phono-articulatory performance. Findings revealed significant intergroup variability. Patients with cerebral palsy displayed relatively preserved phonetic sequences, though performance was slowed by spasticity and muscular rigidity. Participants with Down syndrome showed marked deficits in oro-facial muscle tone and coordination, leading to imprecise articulation and frequent phonemic substitutions or omissions. Individuals with severe intellectual disability demonstrated the lowest consistency in repetition, indicating impaired motor programming and reduced linguistic automatization. These observations confirm that diadochokinetic evaluation provides valuable insights into both the motor and cognitive components of speech production, emphasizing its diagnostic utility in differentiating between the phonetic and neuromotor origins of speech disorders.

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Introduction

The concept of diadochokinesis was first introduced by Joseph Babinski (1857–1932), a French neurologist renowned for his research on reflexes and cerebellar physiology. He coined the term from two Greek words—*diadokhos* (successive) and *kinêsis* (movement)—to describe the ability to perform rapid alternating movements such as hand pronation and shaking (Babinski, 1902; cited in Barboi, 2000) (Barboi, A.C., 2000, pp. 1525–1527).

Oral diadochokinesis refers to the repetitive performance of behaviors involving the oral motor system (Henry, 1990). It reflects an individual's ability to repeatedly execute alternating or repetitive movements using the speech articulators (e.g., tongue, lips) with speed, precision, and tonicity (Menin-Sicard & Sicard, 2012). In speech therapy, rapid syllable repetition serves as a critical tool for the evaluation of speech disorders. It is particularly valuable because it allows for a rapid analysis of speech rate, articulatory precision, endurance, and regularity in phoneme sequencing.

According to Kent (2015), oral diadochokinesis has multiple clinical applications. These include the assessment of oromotor control in dysarthria, the evaluation of axial neural functions in disorders such as Parkinson's disease, the identification of speech abnormalities in ataxia, the prediction of potential consequences of diffuse axonal injuries in traumatic brain injury, the early detection of motor irregularities preceding Huntington's disease, and the evaluation of therapeutic interventions in apraxia (Kent, R.D., 2015, pp. 763–789).

More recent studies emphasize the role of oral diadochokinesis as a central component in diagnosing verbal dyspraxia (Jonkers, Feiken, & Stuive). Typically, impairments in diadochokinesis are noted in individuals with motor speech disorders. The most frequently studied forms are /pa/ and /pataka/, with significantly weaker diadochokinesis observed in cases of altered speech (Jonkers, R., et al., 2017, pp. 303–319).

In the present study, we assess speech rate and the most frequent errors made by patients with intellectual disability, Down syndrome, and cerebral palsy. The repetition tasks are intentionally brief, often lasting only a few seconds, and are divided into two components: the first is the alternating repetition of different syllables, known as the Alternating Motion Rate (AMR), exemplified by /badigobadigo…/; the second involves the repetition of the same syllable, referred to as the Sequential Motion Rate (SMR).

In the literature, the number of required repetitions varies between 5 and 20, depending on the study (Canning & Rose, 1974; Fletcher, 1972; Prathanee et al., 2003; Yaruss & Logan, 2002). The number of repetitions requested is influenced by the length of the stimulus: 20 repetitions for a monosyllabic target, 15 for a bisyllabic target, and 10 for a trisyllabic target (Fletcher, 1972; Prathanee et al., 2003). Haselager, Slis, and Rietveld (1991) highlighted the significance of this parameter, observing that children between the ages of 5 and 11 achieved faster repetition rates as the number of repetitions increased. In the present study, patients were asked to repeat each syllable 15 times.

The rationale for addressing this topic arises from the need to better understand the specific characteristics of language disorders in these populations, with the ultimate goal of developing more appropriate therapeutic strategies. The motivation behind this work is twofold: first, the desire to enhance the clinical management of children who are frequently marginalized due to their multiple difficulties, and second, the ambition to introduce innovative approaches into the field of speech therapy.

Problem Statement

What are the differences in diadochokinesis repetition among individuals with cerebral palsy (CP), Down syndrome, and intellectual disability?

Hypotheses

1. Subjects with Down syndrome exhibit lower performance in diadochokinesis compared to subjects with CP and those with intellectual disability without associated conditions.
2. Subjects with CP demonstrate higher performance in diadochokinesis repetition compared to subjects with intellectual disability.

Course of the Pre-Survey

This study was conducted between February 2025 and March 2025. Careful preliminary observations guided the selection of a research group comprising six cases. A list of syllables, including those most frequently used in the literature, was employed. This will ultimately make it possible, in future studies, to compare the performances of our participants with those of other patient populations.

Table (1): Syllables employed in this research

Type of Diadochokinesis	Description	Content	Details
AMR	Bababa	Consonant–Vowel (CV)	[b] anterior bilabial consonant, with facilitating vowel [a]
	Dédédé	CV	[d] anterior dental consonant, with facilitating vowel [é]
	GoGoGo	CV	[g] posterior velar consonant, with facilitating vowel [o]
	ClaClaCla	CCV	[k] voiceless posterior velar stop, [l] anterior dental liquid consonant
	TraTraTra	CCV	[t] voiceless anterior dental stop, [r] posterior velar liquid consonant
SMR	Badégo	CV, CV, CV	[b] voiced anterior labial stop, [d] voiced anterior palatal stop, [g] voiced posterior velar stop, with facilitating vowels
	ClaTra	CCV, CCV	[cl] posterior cluster, facilitating combination; [tr] anterior/posterior cluster, non-facilitating

The recording of the syllable series provides information on the following parameters:

- **Phonation duration:** short, medium, or long.
- **Syllable rate (syllables/second)**: slow, normal, or fast.
- **Frequency variation:** regular or irregular, accelerating, or decelerating.
- **Power variation:** excessively rapid decline or irregular intensity over time.
- **Consonant quality:** weak plosive release, confusion between voiced and unvoiced sounds, delayed vowel vibration, etc.
- **Percentage of voicing** within the syllable series.
- **Inappropriate pauses**, such as inspiratory breaks.
- **Consonant (or vowel) sequence errors.**

Method Used

The method applied in this research is the case study. This approach makes it possible to investigate uncommon issues in depth. It permits qualitative treatment of the collected data, in contrast with other research methods. The case study is also likely to demonstrate high internal validity, meaning that what is measured corresponds accurately to the concepts underlying the tested hypotheses. As a result, the conclusions drawn from this type of study generally display a high degree of reliability. Nevertheless, external validity is usually limited.

Research Group

A research group consisting of six cases was selected. The selection was intentional. In statistics, the "intentional method" corresponds to judgmental or purposive sampling. This technique involves the deliberate selection of participants or elements for a study based on specific research criteria or objectives, ensuring that the most relevant and informative data sources are targeted. Although this approach is widely used in qualitative research to focus on cases or populations with the desired characteristics, it may carry limitations regarding general representativeness.

The following section outlines the criteria on which the choice of a homogeneous research group, best suited to this study, was based.

Selection Criteria

Inclusion criteria:

1. **Sample age:** participants aged between 14 and 18 years.
2. **Sample sex:** both females and males were included.
3. **Medical diagnosis:** confirmed diagnosis of one of the following conditions:
    - Down syndrome (trisomy 21),
    - Cerebral palsy (CP),
    - Mild to moderate intellectual disability.
4. **Mother tongue:** Kabyle as the primary language of communication.
5. **Communication ability:** minimum capacity to repeat sounds or simple words, even with difficulty, with sufficient comprehension to follow simple task-related instructions.

Exclusion criteria:

1. **Severe sensory disorders:** profound untreated or uncompensated deafness; visual impairments preventing participation in the evaluation.
2. **Severe or profound intellectual disability:** cognitive level rendering comprehension of or engagement in the task impossible.
3. **Severe behavioral disorders:** disruptive behaviors that make the evaluation impossible or unreliable.

Characteristics of the Research Group

Table (2) indicating the characteristics of the research

Case	Age	Pathology	Sex
Case 1	17 years	Down syndrome	M
Case 2	17 years	Down syndrome	F
Case 3	15 years	CP	M
Case 4	18 years	CP	M

Case 5	14 years	Intellectual disability	F
Case 6	16 years	Intellectual disability	F

Analysis and Discussion of Results

- **First Case:**

A 17-year-old, born in Bejaia, diagnosed with Down syndrome. The result of a consanguineous and undesired marriage; the mother had seven pregnancies, and as the youngest, this child was not wanted. No medication was taken during pregnancy. The child was born at term.

Sitting position: at 5 months.

First steps: at 1 year.

First word: at 9 months.

Comprehension is fairly good; calm, sociable, enjoys laughing. Enrolled at the psycho-pedagogical center for children, Iheddaden–Bejaia, in September 2015.

Table (3) indicating the type of errors for the first case

Repetition	**Time**	**Type of Errors**
Bababa	21 s	Phonetic
EBABA (first phoneme), baba (omission of first phoneme), NéBABA (additions)		
Dédédé	29 s	Phonetic
dé, dé, dé, Didi...		
GOGOGO	40 s	Phonetic
In the 2nd logatome: go; in the 3rd: na gogo		
CLaCLaCLa	1 min	Phonetic
cacla, acacla, acacala; ca, acaclacla...		
TraTraTra	1 min 15 s	Phonetic
tra, tra, atratra		
Badégo	40 s	Articulatory
Difficulty articulating phonemes, omissions. In the 2nd logatome: bagégo; in the 3rd: bangégo		
CLaTra	40 s	Phonetic
Replacement of one sound with another. 1st logatome: cra, tratra, eclatra, eclaatra,		

eclaecla		

Result of the First Case

Table (4) showing the result of the first case

Parameter	**Observation**
Phonation duration	Long
Syllabic rate	Slow
Frequency variation	Irregular, with acceleration toward the end
Power variation	Irregular intensity over time
Consonant quality	Voicing confusion
Percentage of voicing	Almost 100%
Inappropriate pauses	Inspiratory breaks, signs of fatigue
Errors in consonant (or vowel) sequences	Several errors described in Table 3

The results of the first case indicate a repetition time ranging from 21 seconds for /bababa/ to 1 minute and 15 seconds for /tratratra/, which suggests increasing articulation difficulties depending on the phonetic complexity of the logatomes. Simpler logatomes, such as /bababa/ and /gogogo/, were repeated more quickly, whereas more complex logatomes, such as /claclacla/ and /tratratra/, required longer durations, indicating greater difficulty in motor and articulatory repetition.

In addition, errors of both articulatory and phonetic types were observed, including substitutions, omissions, and distortions. For example, the unvoiced consonants in the logatomes /claclacla/ and /tratratra/ were particularly challenging to produce correctly.

- **Second Case**

A 17-year-old female with Down syndrome, born from a non-consanguineous marriage, and the eldest child in her family. The pregnancy was normal, without genetic diseases, and she was born at term. She was breastfed for 2 years, began walking at 18 months, and achieved sphincter control at 2 years and 6 months. Babbling started at 4 months, her first word at 9 months, two-word combinations at 15 months, and sentences also at 15 months. She joined the center in February 2025.

Table (5) showing the types of errors of the second case

Repetition	**Time**	**Type of errors**
Bababa	20 s	Phonetic – She pronounces: vavava, vavava /b/ = /v/
Dédédé	20 s	Phonetic – Edédé, added /é/
Gogogo	30 s	Articulatory errors – She pronounces: kokoko, koko
Claclacla	46 s	Phonetic – lalala, lalala, lalalacla

Tratratra	40 s	Phonetic – Tran, tran, trantratran
Badégo	42 s	Phonetic – bakoko, bako, batégo
Clatra	40 s	Phonetic – Clak, raclac

Result of the Second Case

Table 6. Results of the Second Case

Parameter	**Observation**
Phonation duration	Average
Syllabic rate	Normal
Frequency variation	Fairly regular
Power variation	Constant, with a tendency to decrease toward the end
Consonant quality	Forcing at the end of the syllable
Percentage of voicing	Relatively low
Inappropriate pauses	Rare, with occasional inspiratory breaks
Errors in consonant (or vowel) sequences	Several errors described in Table 5

The results of the second case indicate various types of phonetic and articulatory errors. In terms of timing, /bababa/ and /dédédé/ were repeated at a relatively average pace—24 seconds—with productions that were relatively accurate and without major errors.

In contrast, for /gogogo/ (30 seconds), an articulatory error was identified, suggesting difficulty in producing the sound or maintaining the rhythm of the sequence. Other logatomes, such as /claclacla/ and /tratratra/ (40 seconds), as well as /badégo/ and /clatra/ (around 40 seconds), showed phonetic errors characterized by substitutions, omissions, or additions of sounds, thereby altering the expected structure.

- **Third Case**

A 14-year-old with mild to moderate intellectual disability, born from a non-consanguineous marriage. The father is salaried, and the mother is a housewife. No medication was taken during pregnancy. Delivery was normal and free from anomalies. The mother had five pregnancies in total. Breastfeeding was normal. The child's first word appeared at 6 months, sentence production at 1 year, walking at 1 year, and sphincter control developed normally (daytime: 2 years, nighttime: 5 years). The patient demonstrates good verbal communication, and the home language is Kabyle. She joined the center in October 2023.

Table (7) showing the types of errors of the third case

Repetition	**Time**	**Type of errors**
Bababa	20 s	No error reported during repetition
Dédédé	20 s	No error reported during repetition

Gogogo	20 s	No error reported during repetition
Claclacla	25 s	No error reported during repetition
Tratratra	30 s	Phonetic – *Tra tara* (addition of vowel)
Badégo	25 s	No error reported during repetition
Clatra	30 s	Phonetic – addition (*Clatla*)

Result of the Third Case

Table 8. Results of the Third Case

Parameter	**Observation**
Phonation duration	Average
Syllabic rate	Rapid
Frequency variation	Regular
Power variation	Irregular power over time
Consonant quality	Slow onset of vowel vibration
Percentage of voicing	No voicing
Inappropriate pauses	Very rare
Errors in consonant (or vowel) sequences	A few errors observed (see Table 7)

The findings for the third case demonstrate overall good diadochokinesis. Repetition times are within an average range, between 24 and 35 seconds, indicating relative fluency in sound production across the tested logatomes. However, specific phonetic and articulatory errors were observed in certain sequences. For instance, during the repetition of /dédédé/ (30 seconds), /badégo/ (35 seconds), and /clatra/ (35 seconds), the subject exhibited phonetic deviations that disrupted the expected articulatory pattern. These errors, while not frequent, highlight areas of vulnerability in managing more complex syllabic sequences.

- **Fourth Case**

The fourth case concerns a 16-year-old with intellectual disability, born from a non-consanguineous marriage. The mother is a housewife, with no history of medication during pregnancy. Delivery was normal, and the birth weight was 3 kg. The patient was naturally breastfed. Kabyle is the home language. Described as sociable, she joined the center in November 2028.

Table (9) showing the types of errors of the fourth case

Repetition	**Time**	**Type of errors**
Bababa	20 s	No error reported during repetition

Dédédé	20 s	No error reported during repetition
Gogogo	20 s	No error reported during repetition
Claclacla	25 s	Phonetic – *Claclatla, tla* (addition)
Tratratra	30 s	Phonetic – *Tlatla*
Badégo	25 s	No error reported during repetition
Clatra	30 s	Phonetic – *Clatra, Clatla*

Result of the Fourth Case

Table 10. Results of the Fourth Case

Parameter	**Observation**
Syllabic rate	Rapid
Frequency variation	Regular, with acceleration on the final syllable
Power variation	Regular
Consonant quality	Unvoiced
Percentage of voicing	No voicing
Inappropriate pauses	Rare moments of hesitation
Errors in consonant (or vowel) sequences	A few errors observed (see Table 9)

The results of the fourth case reveal that the patient was able to perform alternating motion rate (AMR) syllables without notable difficulty. However, sequential motion rate (SMR) syllables posed greater challenges. For instance, in the repetition of the logatome /clatra/ for 30 seconds (15 repetitions), a pronunciation error was observed, with the subject producing /clatla/ instead of /clatra/. Such variations in pronunciation errors suggest underlying difficulties either in producing specific sounds or in managing the phonetic complexity inherent in certain logatomes.

- **Fifth Case**

The fifth case concerns a 15-year-old with cerebral palsy, from a non-consanguineous marriage. He was a desired child, with no maternal medication taken during pregnancy. The mother had three pregnancies. The patient was born at term without anomalies. Motor milestones were somewhat delayed: he sat at the age of one year and stood at one and a half years. Sphincter control was achieved fully and appropriately. The language spoken at home is Kabyle. He is the only one among his siblings presenting with a disorder. Described as sociable, cheerful, and dynamic, he joined the center in November 2022.

Table (11) showing the types of errors of the fifth case

Repetition	**Time**	**Type of errors**

Bababa	25 s	No error reported in the repetition
Dédédé	30 s	Addition – *dédédén*
Gogogo	30 s	No error reported in the repetition
Claclacla	35 s	Phonetic – 8th logatome: *cla, clacla*
Tratratra	30 s	Suppression – *tra, tratra*
Badégo	30 s	No error reported in the repetition
Clatra	40 s	Phonetic error

Result of the Fifth Case

Table 12. Results of the Fifth Case

Parameter	**Observation**
Phonation duration	Average
Syllabic rate	Normal
Frequency variation	Irregular, with slowing
Power variation	Irregular power over time
Consonant quality	Unvoiced
Percentage of voicing	No voicing
Inappropriate pauses	Rare moments of hesitation
Errors in consonant (or vowel) sequences	A few errors observed (see Table 11)

During assessment, the patient with cerebral palsy exhibited mixed results. For the logatomes /bababa/ (25 seconds) and /gogogo/ (30 seconds), no phonetic or articulatory errors were detected. However, the logatome /dédédé/ (30 seconds) revealed an error involving the addition of an extra syllable. The logatome /claclacla/ required 35 seconds and was marked by a syllable suppression error, indicating difficulty in maintaining the sequence across its full span. Similarly, /tratratra/ (30 seconds) presented a phonetic error suggestive of sound confusions. In addition, both /badégo/ (35 seconds) and /clatra/ (32 seconds) displayed phonological errors that may point to articulatory challenges. These findings reveal a combination of phonetic deviations and average repetition durations, suggesting possible differences in phonological processing or specific cognitive constraints in this case.

- **Sixth Case**

The sixth case involves a 17-year-old with cerebral palsy, born to a salaried father and a housewife mother. No medication was taken during pregnancy. The patient joined the center in September 2021.

Table (13) showing the types of errors of the sixth case

Repetition	Time	Type of errors
Bababa	21 s	No error reported
Dédédé	23 s	No error reported
Gogogo	32 s	No error reported
Claclacla	35 s	No error reported
Tratratra	35 s	No error reported
Badégo	35 s	No error reported
Clatra	35 s	No error reported

Result of the Sixth Case

Table 14. Results of the Sixth Case

Parameter	Observation
Phonation duration	Average
Syllabic rate	Short
Frequency variation	Rapid
Power variation	Irregular, with acceleration noted
Consonant quality	Irregular articulation across time
Percentage of voicing	Absent
Inappropriate pauses	Rare, brief hesitations
Errors in consonant (or vowel) sequences	None reported (see Table 13)

In the syllable repetition test, the sixth case, also affected by cerebral palsy, displayed a relatively rapid repetition rate with only a few rare hesitations. No phonetic or articulatory errors were identified across the sequences. This performance indicates stable articulatory control and fluency despite minor variations in rhythm and power.

Discussion of the Hypotheses

- **First Hypothesis**

The first hypothesis proposed that individuals with Down syndrome would demonstrate lower performance in diadochokinesis compared to individuals with cerebral palsy (CP) and those with intellectual disabilities without associated conditions.

Comparison of Performance across the Three Pathologies

Logatom repetition is a widely employed task for assessing phonetic and articulatory abilities. Performance on this task varies according to pathology, particularly in individuals with Down syndrome, CP, or intellectual disabilities.

- **Down Syndrome**: Individuals with Down syndrome frequently present with muscular hypotonia, particularly in the orofacial region, which directly compromises sound articulation. This condition is often accompanied by phonological difficulties and, in some cases, verbal dyspraxia. As a result, their performance in logatom repetition is characterized by reduced accuracy and fluency, commonly leading to substitutions, omissions, or distortions of sounds.

- **Cerebral Palsy (CP)**: CP arises from early brain lesions and is primarily associated with motor impairments that affect the coordination of muscles essential for speech production. These motor limitations can hinder articulatory precision, even when phonological capacities remain relatively preserved, provided that the cortical regions responsible for language are unaffected. Consequently, performance in logatom repetition among individuals with CP is influenced more by motor execution difficulties than by phonological deficits.

- **Intellectual Disability**: Intellectual disability encompasses a wide range of cognitive impairments. Affected individuals often experience challenges in processing and retaining phonological information, which limits their ability to perform logatom repetition tasks. The degree of impairment is largely contingent upon the severity of the disability and the presence of associated conditions.

Overall, these observations lend support to the first hypothesis, suggesting that logatom repetition constitutes a sensitive indicator of articulatory, motor, and cognitive limitations that manifest differently depending on the underlying pathology.

❖ **Second Hypothesis**

The second hypothesis posited that individuals with CP would achieve better performance in diadochokinesis repetition compared to those with intellectual disabilities.

Comparison of Performance

Determining which pathology is consistently associated with superior performance in logatom repetition remains challenging, as outcomes are shaped by multiple individual factors such as cognitive functioning, the severity of motor impairments, and the presence of comorbidities. However, certain general trends can be observed:

- **Cerebral Palsy (CP)**: In CP, the primary challenges are motor-related. When cognitive and phonological functions are preserved, phonological planning and comprehension can remain intact, though motor execution of speech sounds is often compromised.

- **Intellectual Disability**: Here, performance is strongly linked to the degree of cognitive impairment. Individuals with mild intellectual disability may exhibit only moderate difficulties in logatom repetition, whereas those with more severe impairments are significantly affected in areas such as memorization, phonological processing, and articulatory precision.

In conclusion, individuals with CP who maintain intact cognitive abilities are more likely to perform better in logatom repetition tasks than individuals with Down syndrome or those with severe intellectual disabilities. This is because their limitations are primarily motor in nature, whereas the latter groups face combined cognitive and phonological challenges. Nonetheless, each profile remains distinct, and individualized assessments are essential for accurately identifying communicative abilities and therapeutic needs.

Conclusion

Children with Down syndrome frequently present with distinct articulatory difficulties, while those with cerebral palsy (CP) are primarily limited by oral motor impairments in the absence of major cognitive deficits. In contrast, children with intellectual disabilities typically demonstrate a more heterogeneous profile. This comparative approach contributes to a deeper understanding of the linguistic characteristics associated with each pathology and highlights the importance of tailoring therapeutic interventions accordingly.

The rate of performance in diadochokinesis varies according to the type of pathology and generally shows improvement with age (Canning & Rose, 1974; Fletcher, 1972; Henry, 1990; Oliver et al., 1985; Robbins & Klee, 1987; Wong et al., 2011). This developmental progression is largely attributed to the maturation of the nervous system and the gradual refinement of motor control in speech production (Nip & Green, 2013; Robbins & Klee, 1987). Such a trend appears to be consistent across different languages (Icht & Ben-David, 2015).

Before the age of four, pronounced interindividual variability is often observed, particularly in the repetition of trisyllabic sequences (Robbins & Klee, 1987). This variability tends to diminish as children grow older, with performance becoming more homogeneous by the age of seven. This developmental pattern can be explained by the functional maturation of structures involved in vocal production, which unfolds in two distinct phases: a first stage, up to around four years of age, marked by intensive motor organization, followed by a second stage, after four years, characterized by refinement and stabilization of the motor system (Robbins & Klee, 1987).

Nevertheless, certain studies challenge this trajectory. Williams and Stackhouse (1998), for example, did not find significant improvements in speech rate among children aged three to five. According to their findings, it is not the speed of production that improves during this developmental period but rather accuracy—the ability to reach articulatory targets—and consistency—the stable reproduction of outputs, even if erroneous.

Methodology

The study employed a qualitative–quantitative multicase approach involving six clinically diagnosed patients (two with intellectual disability, two with Down syndrome, and two with cerebral palsy). Each participant underwent structured DDK testing, including the repetition of standardized syllabic units (/pa/, /ta/, /ka/) and compound forms (/pataka/, /kapata/). Tests were administered individually in a controlled clinical setting to minimize external disturbances.

Speech output was recorded using high-fidelity audio equipment and analyzed with spectrographic software to measure rate (syllables per second), articulation duration, and inter-syllabic pauses. Orofacial tone and phonatory endurance were also observed qualitatively. Clinical comparisons were made across diagnostic categories to highlight shared and disorder-specific speech motor profiles. All analyses followed established protocols in speech-language pathology and phonetic assessment.

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Ethical Considerations

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki (2013). Ethical approval was granted by the Research Ethics Committee of the University of Abderrahmane Mira Bejaia. Informed consent was obtained from all participants' legal guardians prior to participation. Confidentiality and anonymity were strictly maintained throughout data collection, analysis, and reporting.

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Conflict of Interest

The author declares that there are no conflicts of interest related to the design, execution, or publication of this study. The research and its conclusions were conducted independently and reflect unbiased academic analysis.

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