International Journal of Innovative Research and Scientific Studies, 8(9) 2025, pages: 1-12

IJIRSS
International Journal of Innovative Research & Scientific Studies

ISSN: 2617-6548

URL: www.ijirss.com

Multimodal analysis of verbal behavior and phonological adaptation in children with cerebral palsy: A linguistic case study from Indonesia

Elitaria Bestri Agustina Siregar[1], Mulyadi[1*], Gustianingsih[1], Khairina Nasution[1]

[1]*Department of Linguistics, Faculty of Cultural Science, Universitas Sumatera Utara, Medan 20155, Indonesia*.

Corresponding author: Mulyadi (*Email: mulyadi@usu.ac.id*)

Abstract

This study investigates verbal behavior and phonological adaptation in children with Cerebral Palsy (CP) through an intensive case study using a mixed-method approach. Drawing from Skinner's verbal behavior theory, Chomsky's generative linguistics, and Blumstein's model of phonological change, the research analyzes two verbal CP subjects: AK (10 years) and MM (15 years), each observed over 12 sessions. Data collection involved linguistic operant testing (mand, tact, echoic, intraverbal), acoustic analysis via Praat software, and semi-structured interviews with caregivers. Results indicate a significant gap between linguistic competence and verbal performance, largely due to articulatory-motor limitations. Mand operants predominated, reflecting need-driven rather than spontaneous communication. Acoustic analysis revealed systematic phoneme substitution (/p/ → /ʔ/, /s/ → /ʃ/), omission, and vowel elongation, suggesting patterned adaptations. MM exhibited more advanced articulatory control and cognitive abstraction than AK, who remained reliant on external prompts. Methodologically, this research adopts a multimodal framework encompassing verbal, non-verbal, and paralinguistic dimensions to better understand communicative strategies in constrained conditions. Findings underscore the need for adaptive linguistic assessment and responsive communicative environments to support language development in children with CP.

Keywords: Acoustic analysis, Cerebral palsy, Linguistics, Multimodal communication, Phonological adaptation, Verbal behavior.

DOI: 10.53894/ijirss.v8i9.10598
Funding: This study received no specific financial support.
History: Received: 4 August 2025 / **Revised:** 21 September 2025 / **Accepted:** 24 September 2025 / **Published:** 10 October 2025

Competing Interests: The authors declare that they have no competing interests.
Authors' Contributions: All authors contributed equally to the conception and design of the study. All authors have read and agreed to the published version of the manuscript.
Transparency: The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.
Publisher: Innovative Research Publishing

1. Introduction

Cerebral Palsy (CP) is a non-progressive neurological disorder that significantly impairs motor function, including speech [1, 2]. One of the primary challenges in children with CP is articulatory impairment, which disrupts verbal communication despite preserved language comprehension. Consequently, it is essential to explore how children with CP adapt their language use in real-world social interactions [3, 4].

According to Chomsky's generative linguistic theory, all individuals possess an innate linguistic competence, yet their linguistic performance is often modulated by external constraints such as physical or social limitations [5]. In CP, motor-related articulatory challenges often create a disparity between comprehension (competence) and verbal expression (performance) [6]. Data from AK and MM reveal an understanding of semantic content but difficulty producing speech, reinforcing Chomsky's distinction between competence and performance.

From Skinner's behaviorist lens, language is viewed functionally in terms of verbal operants such as mand, tact, echoic, and intraverbal [7, 8]. This study observed a dominance of mand behavior in children with CP, implying that their verbal expressions are driven primarily by immediate needs rather than spontaneous or reflective engagement. This aligns with Skinner's view of language as behavior shaped by social reinforcement [9].

The study follows a qualitative descriptive case study design [10] enabling an in-depth exploration of linguistic phenomena in children with CP. Through direct observation, interviews, and audio recordings, the study captures both verbal and non-verbal communicative behavior, offering a holistic linguistic perspective [11, 12].

Phonological adaptations in children with cerebral palsy (CP) are also examined through Blumstein's framework, which interprets sound production errors not as random mistakes but as systematic strategies to navigate motor limitations. This perspective aligns with evidence from studies on compensatory articulation in cleft palate patients [13] phonological abstraction in loanword adaptation [14] and the phonological basis of perception-production links in shadowing tasks [15] all of which emphasize the role of cognitive-linguistic processes in shaping atypical speech patterns. Patterns such as substitution, omission, and simplification were identified in AK and MM, demonstrating consistent adaptation mechanisms.

When verbal expression is impaired, non-verbal signals become crucial to conveying meaning. Multimodal observation offers a comprehensive lens for assessing communicative competence. This approach is further supported by Tekin [16] who illustrates how individuals strategically design bodily movements to interface with machines, and by Dumitrescu and Trpkovic [17] who highlight how non-verbal displays are employed to frame disinformation narratives. Similarly, research by Coutinho, et al. [18] on behavioral inhibition in ADHD suggests that non-verbal behavior often reflects underlying neuropsychological processes. Adolphs and Knight [19] reinforce the value of corpus linguistics and multimodal interaction in understanding communication dynamics, while Alameda-Pineda, et al. [20] emphasize the challenges and advances in capturing multimodal behaviors in naturalistic settings.

Methodological triangulation was applied to ensure validity, incorporating observations, verbal tests, and caregiver interviews. This approach aligns with recent research emphasizing the integration of learner-centered perspectives [21] and community-based contextualization in planning and assessment [22] as well as participatory, performance-based evaluation models in adaptive local governance that foreground stakeholder input, contextual sensitivity, and iterative feedback loops [23]. Together, these perspectives highlight the importance of multilayered data sources to capture complex human experiences and behaviors, enhancing data credibility and enabling cross-verification of linguistic performance across modalities. Including participants from distinct geographic and socio-cultural backgrounds (Jambi and Depok) further enriches the data with developmental and environmental variation.

Acoustic measurements via Praat software allowed quantitative assessment of pitch, duration, and intensity of utterances, offering insights into articulatory timing and vocal quality. These parameters help differentiate speech characteristics tied to neuromotor maturity.

The theoretical novelty of this study lies in integrating linguistic theory, behavioral analysis, and phonological adaptation to understand verbal functioning in Indonesian children with CP—a gap not thoroughly addressed in prior research. Most existing studies focus either on motor rehabilitation or surface-level speech therapy. This study aims to bridge that gap by applying integrated linguistic theory to empirically investigate CP-related speech phenomena, contributing both theoretically and practically to applied linguistics and communication therapy.

2. Methodology

2.1. Research Design

This study employed a mixed-methods case study approach with a qualitative emphasis to explore verbal behavior in children with CP. The qualitative strand provided contextual depth, while the quantitative elements offered measurable linguistic insights, especially regarding verbal operants and acoustic-phonological features.

2.2. Subjects

Two male children with verbal CP participated:

- AK (10 years old) from Jambi
- MM (15 years old) from Depok

Selection criteria focused on children with moderate CP who retained sufficient verbal capacity for linguistic and acoustic testing.

2.3. Research Timeline and Setting

Data collection spanned three months (May–July 2023), with each subject undergoing 12 observation sessions of 60 minutes each.

Table 1.
Frequency Distribution of Verbal Operants Across Sessions for Subjects AK and MM.

Subject	No. of Sessions	Duration/Session (minutes)	Mand	Tact	Echoic	Intraverbal	Total Verbal
AK	12	60	134	25	10	10	179
MM	12	60	145	25	10	10	190

2.4. Data Collection Methods
2.4.1. Observations and Linguistic Testing
Children were tested on their ability to produce:
- Basic syntactic structures
- Vocabulary comprehension
- Contextual sentence use
- Verbal operants (mand, tact, echoic, intraverbal)

Table 2.
Cumulative Frequency of Verbal Operants by Type Across Subjects AK and MM.

Verbal Operant	AK (10 y/o)	MM (15 y/o)	Total
Mand	134	145	279
Tact	25	25	50
Echoic	10	10	20
Intraverbal	10	10	20

2.4.2. Semi-Structured Interviews
Interviews with caregivers explored communication patterns, adaptive strategies, and environmental support, enhancing data triangulation.

2.5. Data Analysis Techniques
2.5.1. Acoustic-Phonetic Analysis
Speech data were analyzed using *Praat* software to extract four core parameters: pitch (fundamental frequency), duration (at phoneme and word levels), vocal intensity, and formant structure (F1, F2). These measures assessed articulatory control, phonatory stability, and vocal energy.

2.5.2. Verbal Operant Classification
Verbal outputs were categorized based on Skinner's verbal operants: mand, tact, echoic, and intraverbal. Coding was validated using synchronized audio-video recordings to ensure contextual accuracy and functional intent.

2.5.3. Comparative Benchmarking
Each subject's performance was compared to age-appropriate linguistic norms, enabling identification of deviations in phonological, prosodic, and cognitive-verbal development.

2.6. Data Validity
To enhance validity, the study employed:
- Triangulation (method, source)
- Member-checking with caregivers
- Re-review of recordings for transcription accuracy and behavioral interpretation [24]

2.7. Ethics approval and consent to participate
This study was reviewed and approved by the Institutional Review Board of the Faculty of Cultural Science, Universitas Sumatera Utara. Prior to data collection, verbal informed consent was obtained and audio-recorded from the parents/guardians of both participants. Where developmentally feasible, child assent was also obtained verbally. Participants were informed about the study aims, procedures, risks, benefits, confidentiality, voluntary participation, and the right to withdraw at any time without penalty.

3. Results and Interpretation
3.1. Dominance of Mand-Type Verbal Behavior
Observational data across 12 sessions revealed that both subjects—AK and MM—exhibited a pronounced dominance of verbal operants categorized as *mand* (requests or commands). Of the total 369 utterances collected, 279 or 75.6% were mand-type responses, with AK producing 134 and MM 145 (see Table 3). This pattern indicates that communication in both children is primarily motivated by immediate needs and desires rather than reflective or interactive language use.

This aligns with B.F. Skinner's assertion that mand is the most basic verbal operant, shaped directly by motivational variables and reinforced by specific outcomes [9]. The reliance on mand suggests that language in these children with CP is functionally driven—used to fulfill concrete needs such as food, play, or assistance.

Interestingly, MM demonstrated greater spontaneity, often initiating mand utterances without additional cues. In contrast, AK relied significantly on external prompts (e.g., visual or gestural cues from the researcher) to produce similar responses. This highlights a differential level of independence in language performance and responsiveness to communicative environments.

Table 3.
Distribution of Verbal Operants in Subjects AK and MM.

Operant Type	AK	MM	Total
Mand	134	145	279
Tact	25	25	50
Echoic	10	10	20
Intraverbal	10	10	20
Total Utterances	179	190	369

This disparity underscores the role of reinforcement learning, caregiver engagement, and prior exposure in facilitating more advanced verbal responses in MM. AK's reliance on structured cueing suggests a need for more scaffolded language environments to encourage autonomy.
"Children with CP may have latent language competence, but their performance is heavily moderated by motor and contextual barriers. Mand dominance reflects a lower-tier verbal strategy where speech acts are instrumental rather than symbolic" [25].

3.2. Duration and Pitch Across Stimulus Words

This section examines speech motor control in children with Cerebral Palsy by analyzing two primary acoustic parameters: duration and pitch, along with intensity as a supplementary measure. Using Praat software, ten common Indonesian words were recorded and analyzed for both subjects (AK and MM). These acoustic parameters offer insight into the integrity of motor execution, respiratory-phonatory coordination, and pitch modulation ability—critical for intelligible and fluent speech.

Table 4.
Comparative Acoustic Parameters Between Subject AK and Subject MM.

Word	Duration AK (s)	Pitch AK (Hz)	Duration MM (s)	Pitch MM (Hz)	Intensity AK (dB)	Intensity MM (dB)
Papa	4.7	200.6	3.4	234.1	45.9	63.3
Mama	6.1	200.0	1.7	331.3	38.9	81.0
Bola	4.3	210.7	2.7	270.0	54.2	78.6
Makan	4.3	210.0	1.4	344.7	37.6	62.8
Minum	3.5	250.2	1.9	364.6	60.8	75.9
Cuci	2.8	200.0	2.7	367.4	17.8	75.9
Jalan	4.8	99.9	2.0	308.5	55.7	66.8
Kaki	4.2	228.9	2.6	305.1	41.4	79.5
Gajah	3.5	158.0	2.2	367.7	33.2	80.6
Halo	3.5	248.3	1.4	367.7	33.2	84.2

Interpretation:

- Duration: Subject AK exhibited consistently longer utterance durations across all stimulus words, ranging from 2.8 to 6.1 seconds. This prolonged phonation suggests delayed motor planning, reduced oral agility, and articulatory hesitation. In contrast, MM produced all stimuli with shorter durations, indicative of more efficient motor execution and faster speech timing.
- Pitch: The pitch data reveal clear differences in laryngeal control. AK's pitch fluctuated widely (99.9–250.2 Hz), reflecting instability in subglottal pressure and limited control over vocal fold tension. MM, however, demonstrated consistently higher and more stable pitch values (234.1–367.7 Hz), which are hallmarks of more mature phonatory regulation.
- Intensity: While not the primary focus, intensity values support the interpretation of breath control differences. AK's utterances were generally softer (17.8–60.8 dB), indicating reduced aerodynamic energy and weak vocal fold closure. In contrast, MM showed stronger and more consistent intensities (62.8–84.2 dB), reflecting better respiratory-phonatory coordination

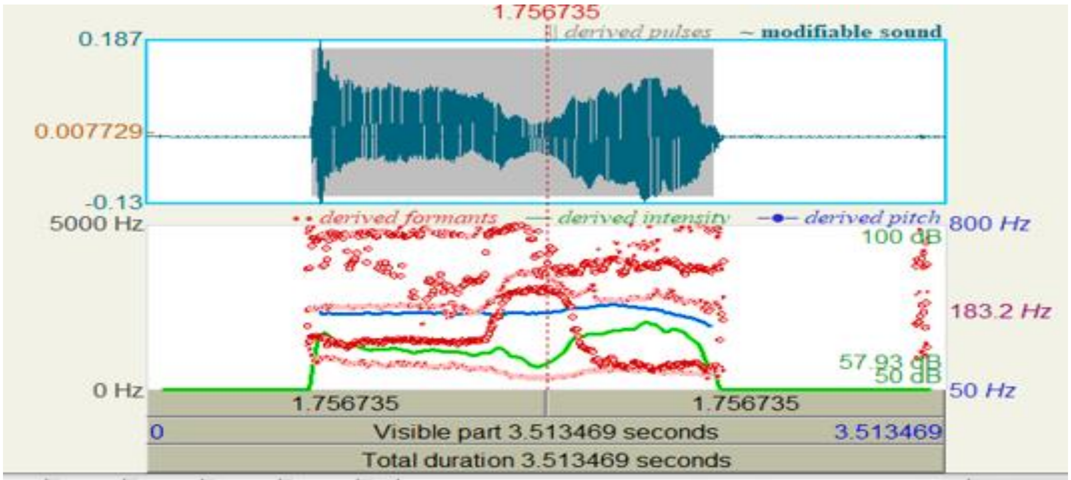

Figure 1.
Word "halo" by AK responded.

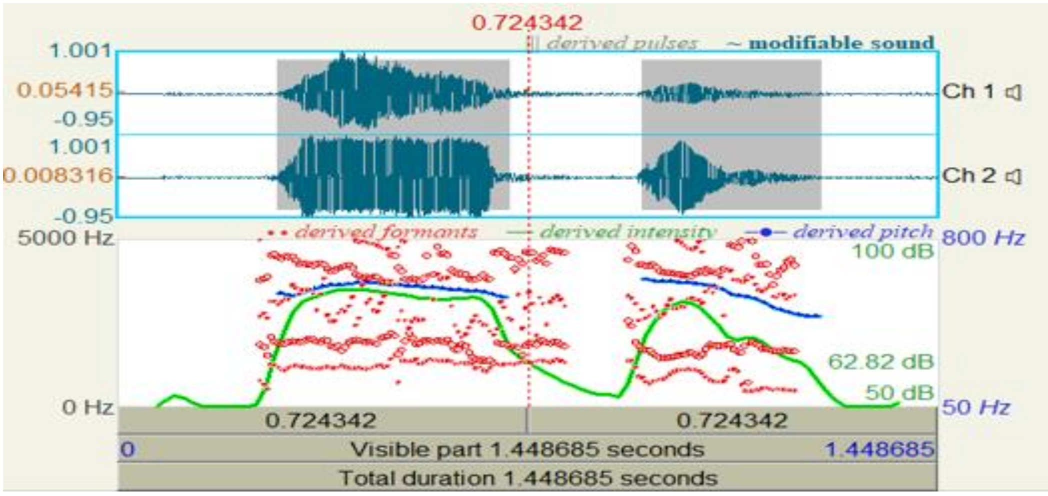

Figure 2.
Word "halo" by MM responded.

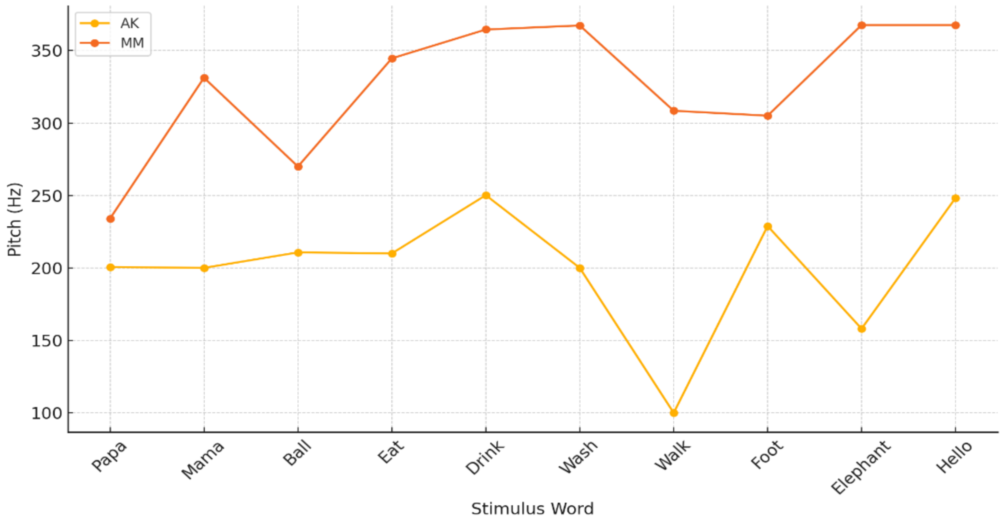

Figure 3.
Pitch Patterns Across Stimulus Words in AK and MM.

The pitch trajectory of subject AK reveals erratic phonation. Notably, the utterance for Walk *"jalan"* (walk) dropped sharply to 99.9 Hz, significantly lower than average conversational pitch, signaling vocal fold under-engagement and insufficient subglottal support. Conversely, MM's pitch profile maintained a high range (270–367 Hz), with minimal abrupt shifts, denoting better control over laryngeal muscles and vocal pitch regulation. This regularity is particularly evident in words like *"cuci," "gajah,"* and *"halo,"* where MM maintained a consistent tonal quality.

In terms of intensity, MM's output was substantially louder across almost all words, especially *"halo"* (84.2 dB) and *"gajah"* (80.6 dB). These elevated intensity levels suggest stronger vocal fold adduction and greater control over airflow and pressure during phonation. AK, on the other hand, produced significantly lower intensities, especially for the word *"cuci"* (17.8 dB), indicating likely interruptions in vocal fold vibration and poor aerodynamic support, common in children with speech motor disorders.

Taken together, these acoustic patterns align with known motor speech impairments in Cerebral Palsy: AK exhibits slower, softer, and more erratic speech—all signs of compromised oral-motor function and weak laryngeal control. MM, despite some temporal delays, shows more controlled and efficient phonatory behavior, which may reflect better compensatory strategies or milder motor involvement.

3.3. Cross-Subject Acoustic Summary

Table 5.
Contrastive Analysis of Prosodic and Articulatory Features Between Subject AK and Subject MM.

Feature	Subject AK	Subject MM
Duration	Longer and variable; indicates delayed motor coordination	Shorter and consistent; suggests improved temporal control
Pitch	Moderate but erratic; some drops in vocal tone	Higher and stable; indicative of phonatory maturity
Intensity	Fluctuating, often low; implies weak respiratory-vocal integration	High and sustained; reflects greater vocal effort
Pulsemapping	Missing in several words; inconsistent voicing patterns	Richer pulses; smoother transitions and syllable execution

The acoustic discrepancies between AK and MM provide a valuable diagnostic and therapeutic foundation:
Subject AK:

- Requires structured phoneme imitation training, particularly targeting bilabial plosives (/p/, /b/) and nasals (/m/), using multi-sensory reinforcement.
- Needs respiratory and phonatory integration exercises to improve breath support and pitch stabilization (e.g., humming games, airflow-based tasks).
- Would benefit from motor oral relaxation routines and auditory-visual mapping to enhance coordination between hearing, vision, and articulation.
- Employ repetitive structured imitation with gradual increases in syllabic complexity.

Subject MM:

- Can progress to more complex articulation targets, including fricatives (/s/, /ʃ/) and affricates (/t͡ʃ/, /d͡ʒ/).
- Should receive intonation and phrasing modulation training to develop pragmatic and prosodic expressiveness.
- Beneficial to apply syllable diadochokinesis tasks to increase articulatory speed and smoothness.
- Utilize prosody-based exercises to refine pitch modulation and expressive speech patterns.

These individualized recommendations can support speech-language pathologists (SLPs) and educators in designing data-driven, child-specific therapy modules, particularly for children with CP exhibiting mixed motor-articulatory deficits.

"These findings support psycholinguistic models associating vocal control with neuromuscular maturity" [26].

3.4. Segmental Phoneme Accuracy and Error Classification

Table 6.
Phoneme Accuracy in Word Repetition Tasks.

Stimulus	Target Phonemes	AK Output	Error AK	MM Output	Error MM
Papa	/p/, /a/	"a-a"	Omission /p/	"baba"	Substitution /p/→/b/
Mama	/m/, /a/	"a-a"	Omission /m/	"mama"	Accurate
Bola	/b/, /o/, /l/, /a/	"owa"	Omit /b/, /l/	"bola"	Accurate
Makan	/m/, /a/, /k/, /a/	"a-a"	Omit /m/, /k/	"makan"	Accurate
Minum	/m/, /i/, /n/, /u/	"mum"	Sub /i/→/u/	"minum"	Accurate
Cuci	/ʧ/, /u/, /ʧ/, /i/	"sisi"	Sub /ʧ/→/s/	"cuci"	Accurate
Jalan	/ʤ/, /a/, /l/, /a/, /n/	"anan"	Omit /ʤ/, /l/	"jalan"	Distortion /ʤ/→/z/
Kaki	/k/, /a/, /k/, /i/	"a-i"	Omit /k/	"kaki"	Accurate
Gajah	/g/, /a/, /ʤ/, /a/, /h/	"a-a"	Omit /g/, /ʤ/	"gajah"	Accurate
Halo	/h/, /a/, /l/, /o/	"a-o"	Omit /h/, /l/	"halo"	Slight distortion /h/

AK showed high rates of omission (initial and medial consonants) and substitution in high-load phonemes, while MM was largely accurate, with minor distortions in complex articulations.

3.5. Phoneme Class-Level Comparison

A categorical analysis of phoneme-level production accuracy to examine how distinct phonological classes are articulated by both subjects. By grouping errors based on phoneme classes—namely plosives, nasals, affricates, fricatives, and vowels—we aim to elucidate the segmental-level articulatory constraints that shape each subject's speech intelligibility. The classification allows us to move beyond surface-level word accuracy and instead capture the underlying motor planning and execution challenges associated with each phonological class.

Table 7.
Phoneme Class Accuracy Comparison Between Subjects AK and MM.

Phoneme Class	AK Accuracy (%)	MM Accuracy (%)
Plosives	20	90
Nasals	50	95
Affricates	0	80
Fricatives	10	85
Vowels	90	100

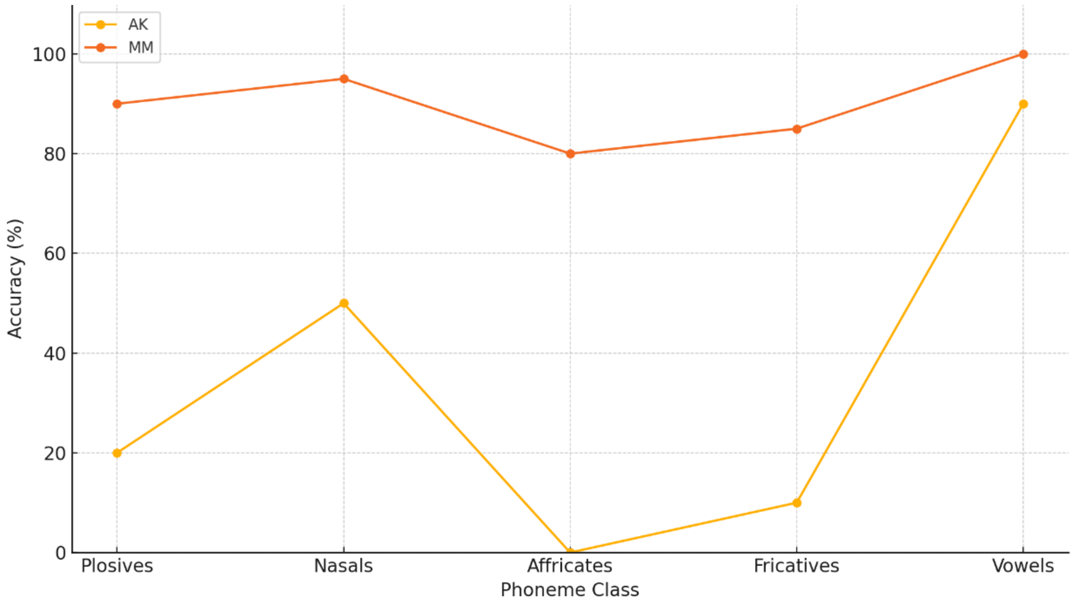

Figure 4.
Accuracy Comparison Across Phoneme Classes.

The results reveal a stark contrast in phonological precision between AK and MM. Subject AK demonstrated significant deficits across most consonantal classes. The most profound challenges appeared in affricates (0%) and fricatives (10%), where articulatory targets were either omitted, severely distorted, or substituted with less complex phonemes. These patterns are consistent with motor speech disorders involving imprecise articulator coordination and reduced intraoral pressure regulation—critical for the successful production of complex phonemes such as /ʧ/, /ʤ/, /s/, and /f/.

AK's performance on plosives (e.g., /p/, /b/, /t/, /d/) was similarly impaired, with only 20% accuracy. Plosive consonants require a coordinated sequence of complete oral closure followed by rapid air release—a motorically demanding task often compromised in children with dysarthria or apraxia of speech. Substitutions with glottal stops or nasal intrusions were frequently observed in AK's productions, indicating difficulties in managing articulatory timing and pressure control.

Nasal phonemes (e.g., /m/, /n/, /ŋ/) showed moderate accuracy at 50%, suggesting relatively better control over velopharyngeal function compared to oral closure. However, errors still included instances of devoicing, nasal omission, or prolongation, pointing to general instability even in simpler articulatory gestures. In contrast, vowel accuracy in AK was high (90%), indicating preserved vocalic production likely due to the reduced demand for fine articulatory gestures and the longer duration of vowel segments, which may allow for compensatory adjustments.

Subject MM, on the other hand, demonstrated consistently high accuracy across all phoneme classes, achieving near-perfect performance in vowels (100%) and nasals (95%), and exceeding 80% accuracy even for complex classes like affricates and fricatives. This phoneme-level precision reflects a more intact articulatory system and higher stability in motor planning. The difference in performance between the two subjects likely reflects not only motor control proficiency but also differences in neuromuscular tone, phonological awareness, and perhaps access to therapeutic intervention.

This comparison underscores the importance of phoneme class-based analysis in speech assessment for children with Cerebral Palsy. Whereas general articulation scores may mask specific deficits, a phoneme class framework highlights the disproportionate impairment in high-demand consonants (e.g., affricates, fricatives) and the preservation of low-load segments (e.g., vowels). For clinicians, such profiles can inform tailored phonological intervention programs, emphasizing intensive training in manner-specific articulatory gestures and motor sequencing for complex segments.

3.6. Intraverbal Ability Analysis: Cognitive-Linguistic Complexity

Intraverbal behavior represents one of the most cognitively demanding verbal operants within the verbal behavior framework [9]. It requires not only linguistic competence but also memory recall, temporal reasoning, and abstraction, since no direct physical stimuli are present. In this study, both subjects—AK and MM—were evaluated on five standardized prompts designed to probe varying levels of abstraction, from concrete object naming to temporal reasoning tasks. The stimuli included functional questions (e.g., “What do you use to eat?”), categorical identification, and temporal inference (e.g., “If today is Monday, what is tomorrow?”).

Table 8 reveals that subject AK demonstrated partial proficiency in responding to concrete prompts, answering 3 out of 5 correctly. The correct responses (e.g., “Spoon” and “Bird”) reflected intact lexical-semantic access for tangible referents. However, AK failed to respond to more abstract questions, such as those involving time and color inference. The average response latency was 5.5 seconds, and prompt dependency emerged for at least one item, suggesting difficulties with autonomous verbal recall and conceptual abstraction. Speech clarity also varied, averaging only 2.25 on a 5-point scale, indicating moderate-to-low articulation intelligibility.

Table 8.
Intraverbal Response Data – Subject AK.

Prompt	Response	Accuracy	Time (s)	Prompt	Clarity (1–5)
What do you use to eat?	Spoon	Correct	4	No	3
Name a flying animal	Bird	Correct	7	No	3
If today is Monday, what is tomorrow?	—	Incorrect	—	Yes	—
What color is the sky?	Red	Incorrect	6	No	1
Name one fruit	Apple	Correct	5	No	2

Subject MM (Table 9), in contrast, exhibited stronger intraverbal capabilities. Despite a slower mean latency (6.4 seconds), MM provided four correct answers out of five, including accurate responses to both concrete and abstract stimuli. Notably, MM did not require prompting and maintained better clarity (mean 2.8), suggesting more robust internal language processing and expressive control. The only incorrect answer was for the temporal item, where MM responded “Thursday” instead of “Tuesday,” implying a conceptual confusion rather than a total breakdown in comprehension.

Table 9.
Intraverbal Response Data – Subject MM.

Prompt	Response	Accuracy	Time (s)	Prompt	Clarity (1–5)
What do you use to eat?	Spoon	Correct	4	No	3
Name a flying animal	Bird	Correct	7	No	3
If today is Monday, what is tomorrow?	Thursday	Incorrect	10	No	2
What color is the sky?	Blue	Correct	6	No	3
Name one fruit	Apple	Correct	5	No	3

These findings are visually summarized in Figure 5, a radar chart comparing four critical dimensions of intraverbal behavior: accuracy, response latency, prompt dependency, and speech clarity. The chart clearly illustrates that MM outperforms AK in overall accuracy, clarity, and autonomy, while AK shows slightly faster—though less accurate—response times. The divergence in performance suggests that while AK’s language retrieval for concrete referents remains somewhat functional, MM exhibits a more generalized and flexible capacity for verbal problem-solving and abstraction.

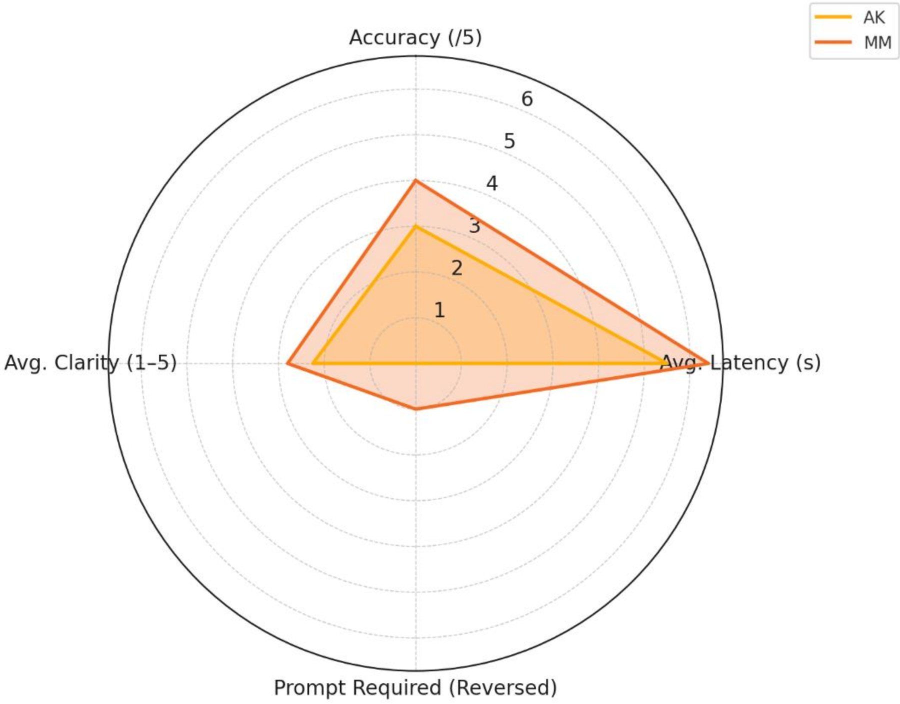

Figure 5.
Intraverbal Ability Radar (AK vs MM).

From a neurocognitive perspective, the disparity may reflect differences in working memory load, verbal sequencing, and motor-linguistic integration, all of which are essential in intraverbal exchanges [4, 25]. These insights underscore the importance of customizing therapeutic goals. For AK, interventions should emphasize improving conceptual inference and verbal independence, while MM may benefit more from refining response speed and reinforcing temporal concepts through scaffolded cognitive training.

3.7. Cross-Subject Comparative Analysis

To synthesize all dimensions of performance, the following table compares AK and MM in terms of verbal operant use, acoustic articulation, phonological accuracy, and intraverbal cognition.

Table 10.
Summary Comparison of Verbal Parameters.

Domain	AK	MM
Total Verbal Output	179 utterances	190 utterances
Mand Dominance	Yes, needs prompting	Yes, spontaneous
Tact/Echoic/Intraverbal	Low autonomy	Consistent, responsive
Pitch/Intensity	Lower, erratic	Higher, stable
Duration	Long, variable	Shorter, controlled
Phoneme Accuracy	53.3%	76.7%
Substitution Errors	30%	10%
Affricate/Fricative Errors	Frequent	Minimal
Intraverbal Accuracy	Partial (3/5)	Near complete (4/5)
Conceptual Flexibility	Low	Moderate to high

These comparisons reaffirm that MM's verbal system—though not without challenges—shows more integration between language competence, articulatory execution, and cognitive abstraction.

4. Discussion

4.1. Functional Language Use and Operant Profiles

The data clearly demonstrate that mand is the most frequently utilized verbal operant in both AK and MM, which aligns with Skinner's assertion that mand is the most basic and primary form of verbal behavior, driven directly by motivational states [9]. This indicates that the children's communicative behaviors are strongly functional, aimed at fulfilling immediate needs, rather than exploratory or symbolic. While both subjects used mand extensively, MM exhibited more spontaneous mands, whereas AK often required verbal or visual prompts. This disparity reflects differing levels of communicative independence and suggests that MM's language learning history has been reinforced in more responsive environments [27].

The relatively lower occurrence of tact, echoic, and intraverbal responses in both participants signals limited development in these higher-order operants, which require more abstract, symbolic, or socially responsive communication. In particular, tact and intraverbal operants are essential for narrative language, conversation, and academic communication [25]. These findings underscore the importance of expanding language training beyond request-based communication to include descriptive, interactive, and conceptual verbal skills.

4.2. Acoustic Control and Articulatory Precision

Praat-based acoustic analysis revealed that AK consistently produced longer and more variable durations, lower and fluctuating pitch, and reduced vocal intensity across stimuli. This profile is indicative of poor respiratory-vocal coordination and delayed neuromotor planning, commonly associated with spastic CP and dysarthria [26, 28]. In contrast, MM exhibited shorter, more consistent durations and stable pitch, suggesting better laryngeal control and speech-motor integration.

Pitch instability and soft intensity in AK suggest compromised subglottal pressure control and weak articulatory force. MM's data showed higher and steadier values, reinforcing that motor speech function in CP exists on a spectrum and that maturation, therapy history, and environmental stimulation may significantly mediate expressive capacity [29].

4.3. Phonological Adaptation and Error Patterns

Phoneme-level analysis showed that AK's articulatory errors were most frequent in affricates (/ʧ/, /ʤ/) and fricatives (/s/, /ʃ/, /h/), with common error types including omissions and substitutions (e.g., /ʧ/ → /s/, /p/ → /ʔ/). These substitutions are not random but rather represent systematic adaptations to articulatory constraints, consistent with Blumstein's phonological change theory. Meanwhile, MM's phonological output was far more accurate, with only occasional distortions in complex consonants, affirming the role of motor control in facilitating phonemic accuracy.

Phoneme class accuracy further differentiated the subjects: AK performed well only in vowel production (90%) and nasals (50%), while MM surpassed 80% in all consonantal classes. This reinforces the need for articulatory therapy in children like AK that focuses on segmental accuracy, syllabic sequencing, and multisensory cueing (e.g., PROMPT, DTTC).

4.4. Intraverbal Complexity and Cognitive Load

The intraverbal test revealed significant differences in cognitive-linguistic flexibility. AK produced quick responses to concrete prompts but struggled with tasks involving temporal or categorical abstraction, even with cues. This suggests limited working memory capacity, slow retrieval speed, and insufficient symbolic reasoning. Conversely, MM performed well across four of five prompts independently, showing stronger verbal recall and abstraction, though with slightly longer response latency.

The incorrect temporal sequencing response ("Thursday" instead of "Tuesday") in MM indicates a conceptual proximity error rather than a breakdown in reasoning. These observations are consistent with prior research indicating that children with CP may have relatively preserved semantic knowledge but impaired executive functioning and working memory [4].

4.5. Clinical and Educational Implications

This study highlights critical differences in verbal functioning across multiple dimensions—verbal operants, phonological planning, acoustic execution, and cognitive verbal expression. For practitioners, the implications are profound:

- AK requires foundational intervention targeting articulatory precision, segmental awareness, and verbal autonomy. Tasks should include high-frequency phoneme production, visual phonics, and prompt-fading strategies.
- MM can benefit from more complex exercises aimed at fluency, prosody, and abstract intraverbal reasoning, such as timed semantic association tasks, conversational scaffolding, and prosodic variation drills.

Importantly, both children would benefit from naturalistic language therapy, such as Functional Communication Training (FCT), play-based storytelling, and multimodal interaction embedded in real-life settings [30].

5. Conclusion

This study provided an in-depth, multimodal comparison of verbal behaviors, articulatory control, phoneme production, and cognitive language use in two children with Cerebral Palsy in Indonesia. The findings demonstrate the complexity of verbal development in CP, where linguistic competence often exceeds actual performance due to motor, cognitive, and environmental constraints.

Both subjects exhibited functional use of language, with mand emerging as the dominant operant. However, only MM showed the ability to extend this usage to more complex intraverbal contexts and to maintain articulatory clarity across phoneme classes. In contrast, AK's performance remained grounded in concrete and reactive speech, with significant dependence on external cues and lower phonemic accuracy.

Acoustic data further revealed differential patterns: AK's longer durations and pitch instability reflected limited motor planning, while MM's more stable output correlated with better neuromuscular coordination. Phoneme-level analysis confirmed these differences, especially in the accuracy of affricates and fricatives.

The most pronounced divergence was found in intraverbal performance, where MM's accuracy and autonomy contrasted sharply with AK's difficulty in abstraction and symbolic thought. These findings suggest that speech-language interventions must be highly individualized, targeting not just phonemic articulation but also the underlying cognitive and social processes that support language growth.

6. Implications For Future Research and Practice

- Research: Future studies should include a broader range of subjects, longitudinal tracking, and neuroimaging to correlate linguistic performance with motor and cognitive brain networks.
- Practice: Clinicians should implement therapy models that combine phonological articulation, prosody training, and cognitive-language strategies, tailored to each child's verbal and cognitive profile.
- Policy: In Indonesia and similar contexts, increased access to early screening, inclusive education, and community-based rehabilitation programs could significantly enhance language outcomes for children with CP.

7. Limitations

While this study offers meaningful insights, several limitations must be noted:

- The small sample size (N=2) limits generalizability, although it allowed for rich case analysis.
- Variability in recording environments and vocal fatigue may have affected acoustic measurements.
- No neuroimaging was conducted to support cognitive-linguistic interpretations.
- Ecological validity may be limited, as the sessions were semi-structured and not fully naturalistic.

Despite these constraints, the study sets a precedent for integrated linguistic, behavioral, and phonological analysis in CP populations, particularly in underrepresented linguistic contexts such as Indonesia.

References

[1] M. N. Eek, A. Blomkvist, K. Olsson, K. Lindh, and K. Himmelmann, "Objective measurement of sitting–application in children with cerebral palsy," *Gait & Posture,* vol. 96, pp. 210-215, 2022. https://doi.org/10.1016/j.gaitpost.2022.05.039

[2] J. Niyonsenga *et al.*, "The effects of perceived therapist guidance and advice on adherence to home-based exercise programs in mothers of children with cerebral palsy in Rwanda," *Heliyon,* vol. 10, no. 17, p. e36903, 2024. https://doi.org/10.1016/j.heliyon.2024.e36903

[3] J. Bootsma *et al.*, "Implementing the language comprehension test C-BiLLT: A qualitative description study using the COM-B model of behaviour change," *BMC Health Services Research,* vol. 22, p. 1421, 2022. https://doi.org/10.1186/s12913-022-08803-8

[4] L. Pennington, "Cerebral palsy and communication," *Paediatrics and Child Health,* vol. 18, no. 9, pp. 405-409, 2008. https://doi.org/10.1016/j.paed.2008.05.013

[5] J. Collins, "Generative linguistics:'Galilean style'," *Language Sciences,* vol. 100, p. 101585, 2023. https://doi.org/10.1016/j.langsci.2023.101585

[6] G. Terzian, "Chomsky in the playground: Idealization in generative linguistics," *Studies in History and Philosophy of Science Part A,* vol. 87, pp. 1-12, 2021. https://doi.org/10.1016/j.shpsa.2021.02.006

[7] M. Dixon, J. C. Baker, and K. A. Sadowski, "Applying Skinner's analysis of verbal behavior to persons with dementia," *Behavior Therapy,* vol. 42, no. 1, pp. 120-126, 2011. https://doi.org/10.1016/j.beth.2010.05.002

[8] M. A. Shillingsburg, S. E. Frampton, S. A. Cleveland, and T. Cariveau, "A clinical application of procedures to promote the emergence of untrained intraverbal relations with children with autism," *Learning and Motivation,* vol. 62, pp. 51-66, 2018. https://doi.org/10.1016/j.lmot.2017.02.003

[9] B. F. Skinner, "Verbal behavior." New York: Appleton-Century-Crofts, 1957.

[10] J. W. Creswell and J. D. Creswell, *Research design: Qualitative, quantitative, and mixed methods approaches*, 5th ed. Thousand Oaks, CA: Sage Publications, 2017.

[11] M. J. Pickering, S. Garrod, and V. S. Ferreira, "Language production and comprehension as a joint action," *Psychological Review,* vol. 131, no. 2, pp. 243–266, 2024.

[12] L. Bøttcher, "Supporting unusual development through moral imagination," *Learning, Culture and Social Interaction,* vol. 30, p. 100384, 2021. https://doi.org/10.1016/j.lcsi.2020.100384

[13] M. C. Pamplona, A. Ysunza, M. González, E. Ramírez, and C. Patiño, "Linguistic development in cleft palate patients with and without compensatory articulation disorder," *International Journal of Pediatric Otorhinolaryngology,* vol. 54, no. 2-3, pp. 81-91, 2000. https://doi.org/10.1016/S0165-5876(00)00332-3

[14] M. Lü, "Understanding perception and production in loan adaptation: Cases of English loans in Mandarin," *Speech Communication,* vol. 171, p. 103207, 2025. https://doi.org/10.1016/j.specom.2025.103207

[15] H. Mitterer and M. Ernestus, "The link between speech perception and production is phonological and abstract: Evidence from the shadowing task," *Cognition,* vol. 109, no. 1, pp. 168-173, 2008. https://doi.org/10.1016/j.cognition.2008.08.002

[16] B. S. Tekin, "Disciplined body: How players design their game movements for the machine," *Discourse, Context & Media,* vol. 57, p. 100754, 2024. https://doi.org/10.1016/j.dcm.2023.100754

[17] D. Dumitrescu and M. Trpkovic, "The use of non-verbal displays in framing COVID-19 disinformation in Europe: an exploratory account," *Frontiers in Psychology,* vol. 13, p. 846250, 2022. https://doi.org/10.3389/fpsyg.2022.846250

[18] T. V. Coutinho, S. P. S. Reis, A. G. d. Silva, D. M. Miranda, and L. F. Malloy-Diniz, "Deficits in response inhibition in patients with attention-deficit/hyperactivity disorder: the impaired self-protection system hypothesis," *Frontiers in Psychiatry,* vol. 8, p. 299, 2018. https://doi.org/10.3389/fpsyt.2017.00299

[19] S. Adolphs and D. Knight, *Corpus linguistics and multimodal interaction. In Reference Module in Social and Behavioral Sciences*. Amsterdam, Netherlands: Elsevier, 2025.

[20] X. Alameda-Pineda, E. Ricci, and N. Sebe, *Multimodal behavior analysis in the wild: An introduction. In Multimodal Behavior Analysis in the Wild: Advances and Challenges*. Amsterdam, Netherlands: Academic Press, 2019.

[21] D. Hooper, S. Egitim, and J. Hofhuis, "Exploring the impact of near-peer role modeling on learners' basic psychological needs: Insights from English classes in Japanese higher education," *International Journal of Educational Research Open,* vol. 8, p. 100429, 2025. https://doi.org/10.1016/j.ijedro.2024.100429

[22] J. Davis, D. Pijawka, E. A. Wentz, and M. Hale, "Evaluation of community-based land use planning through Geodesign: Application to American Indian communities," *Landscape and Urban Planning,* vol. 203, p. 103880, 2020. https://doi.org/10.1016/j.landurbplan.2020.103880

[23] M. A. Nasution, W. O. Ginting, E. Revida, F. Trimurni, and A. A. R. D. Lubis, "A Participatory and Performance-Based Evaluation Model for Adaptive Local Governance," *International Journal of Sustainable Development & Planning,* vol. 20, no. 6, pp. 2589-2596, 2025. https://doi.org/10.18280/ijsdp.200626

[24] Sudaryanto, *Methods and various techniques of language analysis: An introduction to linguistic research on cultural vehicles*. Yogyakarta, Indonesia: Sanata Dharma University Press, 2015.

[25] M. L. Sundberg and J. Michael, "The benefits of Skinner's analysis of verbal behavior for children with autism," *Behavior Modification,* vol. 25, no. 5, pp. 698–724, 2001.

[26] R. D. Kent and H. K. Vorperian, "Speech impairment in Down syndrome: A review," *Journal of Speech, Language, and Hearing Research,* vol. 56, no. 1, pp. 178–210, 2013.

[27] R. L. Koegel, M. C. O'Dell, and L. K. Koegel, "A natural language teaching paradigm for nonverbal autistic children," *Journal of Autism and Developmental Disorders,* vol. 9, no. 2, pp. 147–157, 2001.

[28] B. Maassen, *Speech motor control: New developments in basic and applied research*. Oxford, UK: Oxford University Press, 2007.

[29] E. Tobias, M. I. Visser-Bochane, H. A. Reinders-Messelink, and N. F. de Jong, "Acoustic analyses of speech in children with cerebral palsy: Variability and stability across speech subsystems," *Folia Phoniatrica et Logopaedica,* vol. 67, no. 6, pp. 297–305, 2015.

[30] E. G. Carr and V. M. Durand, "Reducing behavior problems through functional communication training," *Journal of Applied Behavior Analysis,* vol. 18, no. 2, pp. 111–126, 1985. https://doi.org/10.1901/jaba.1985.18-111