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Enhancing Language Development in Children with Autism: A Comprehensive Guide to Phonological Assessment and Intervention

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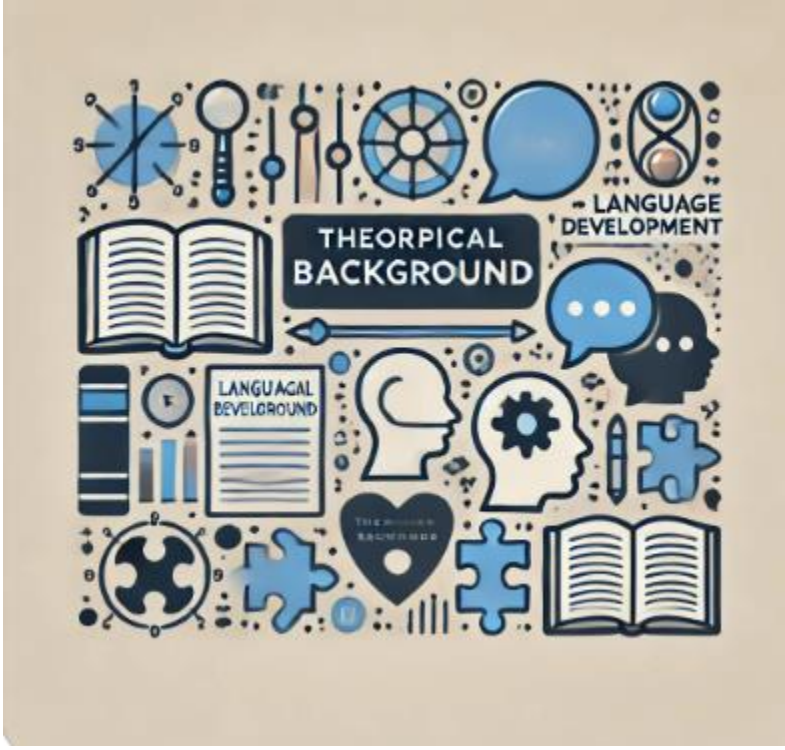
Theoretical Background



1.1 Introduction

Autism Spectrum Disorder (ASD) is a neurodevelopmental condition characterized by significant challenges in communication, behavior, and social interaction. These challenges manifest early in a child's development and persist throughout their lifetime, making ASD a condition that requires ongoing support and intervention. The study of ASD, particularly in the realm of language development, has garnered significant attention across various disciplines, including linguistics, psychology, and neuroscience. Despite the breadth of research in this field, there remains a notable gap in the study of language development in children with ASD who speak Arabic.

This chapter seeks to address this gap by focusing on the phonological mean length of utterance (pMLU) in Arabic-speaking children with ASD. pMLU is a metric used to assess the phonological complexity of a child's speech and provides valuable insights into their language development. This study aims to evaluate the level of phonological development in children with ASD by analyzing their word productions at a granular level, examining each consonant and vowel in their utterances. Additionally, this research will explore the influence of age on the production and development of pMLU in these children, providing a comprehensive understanding of their phonological abilities compared to typically developing (TD) children.

While pMLU has been studied extensively in children with ASD who speak other languages, such as English and Spanish, there is a scarcity of research on its application in the Arabic language. This study will fill this gap by examining the phonological language development of Arabic-speaking children with ASD. The significance of this research lies in its potential to contribute to the development of a standardized test for speech pathologists, linguists, teachers, and parents.

Such a test could enhance the early detection of ASD and inform timely interventions, ultimately improving the quality of life for children with ASD and their families.

1.1.1 Autism Spectrum Disorder

Autism Spectrum Disorder has a rich and complex history that has evolved over the past century. The term "autism" was first introduced by the Swiss psychiatrist Eugen Bleuler in 1911 to describe a symptom observed in individuals with severe schizophrenia. At that time, autism was associated with extreme self-absorption and social withdrawal, and it was thought to be a coping mechanism for dealing with a distressing reality. Bleuler's initial conceptualization of autism was far removed from our current understanding of the disorder, which is now recognized as a distinct neurodevelopmental condition (American Psychiatric Association, 2013).

The modern understanding of autism began to take shape in the 1940s, thanks to the pioneering work of Leo Kanner, an Austrian-American psychiatrist. In 1943, Kanner published a seminal paper that provided the first detailed description of autism as a distinct clinical entity. He observed that children with autism exhibited unique language behaviors, such as echolalia (repeating words or phrases spoken by others), pronoun reversal, and a preference for repetitive routines. Kanner's work laid the foundation for the diagnosis of "infantile autism," which was initially distinguished from other developmental disorders, such as intellectual disability (Kanner, 1943).

Around the same time, Hans Asperger, an Austrian pediatrician, conducted research on a group of children who exhibited similar social and communication difficulties but did not have significant language delays. Asperger's work, which was published in 1944, emphasized the social value of individuals with autism and advocated for their appropriate education. Asperger's findings were

not widely recognized until much later, but they eventually led to the inclusion of Asperger syndrome in the broader autism spectrum (Asperger, 1944).

In the mid-20th century, theories about the origins of autism began to diverge. One of the most controversial theories was the "refrigerator mother" hypothesis, popularized by Kanner and others. This theory suggested that emotionally distant and unresponsive mothers were to blame for their children's autism. The "refrigerator mother" theory gained traction in the United States and contributed to the stigmatization of parents, particularly mothers, of children with autism. However, this theory was eventually discredited as research began to uncover the biological and genetic underpinnings of autism (Kanner, 1949).

In contrast to the psychogenic theories of autism, Bernard Rimland, a psychologist and father of a child with autism, proposed the Neural Theory of Behavior in the 1960s. Rimland argued that autism was a neurodevelopmental disorder with a biological basis, rather than a result of poor parenting. His work, along with advances in genetics, helped shift the focus of autism research towards understanding the neurological and genetic factors that contribute to the disorder (Rimland, 1946; cited in Cohmer, 2014).

The Genetic Theory of autism gained significant support in the 1970s, following the publication of twin studies by Michael Rutter and Susan Folstein. Their research demonstrated that autism had a strong genetic component, with a much higher concordance rate among monozygotic (identical) twins compared to dizygotic (non-identical) twins. This finding underscored the importance of genetic factors in the development of autism and laid the groundwork for subsequent research into the genetic basis of the disorder (Folstein & Rutter, 1977).

The understanding of autism has continued to evolve, particularly with the development of the Diagnostic and Statistical Manual of Mental Disorders (DSM) by the American Psychiatric Association. The DSM has undergone several revisions, with significant changes in the classification and diagnosis of autism. The most recent edition, DSM-5, published in 2013, consolidated previously separate diagnoses, such as Autistic Disorder, Asperger's Syndrome, and Pervasive Developmental Disorder-Not Otherwise Specified (PDD-NOS), under the single umbrella of Autism Spectrum Disorder. This change reflects the recognition of autism as a spectrum of related conditions with varying degrees of severity (American Psychiatric Association, 2013).

Today, ASD is understood as a lifelong condition characterized by difficulties in communication, social interaction, and behavior. While there is no cure for autism, early intervention and therapeutic approaches can lead to significant improvements in the quality of life for individuals with ASD. Research continues to explore the genetic, neurological, and environmental factors that contribute to the development of ASD, with the goal of improving diagnosis, treatment, and support for affected individuals and their families (Chaste & Leboyer, 2012; Rossignol & Frye, 2012).

1.1.2 Whole-word Measures

Language development in children, especially those with ASD, can be assessed using a variety of metrics that provide insights into their phonological abilities. These metrics are crucial for understanding the nuances of language acquisition and identifying potential delays or impairments in children with ASD. This section introduces and explains the primary metrics used in this study to evaluate phonological development: Percentage of Consonants Correct (PCC), Phonological

Mean Length of Utterance (pMLU), Proportion of Whole-Word Proximity (PWP), and Proportion of Whole-Word Correctness (PWC).

Percentage of Consonants Correct (PCC):

PCC is a well-established metric used to assess the accuracy of consonant production in a child's speech. It was originally developed by Shriberg and Kwiatkowski (1982) as a segment-oriented measure, focusing on the individual consonant sounds produced by a child during a speech sample. To calculate PCC, the number of correctly articulated consonants is divided by the total number of consonants attempted, and the result is multiplied by 100 to obtain a percentage. A higher PCC percentage indicates greater accuracy in consonant production, which is often associated with more advanced phonological development.

However, PCC has limitations as it only considers consonants and does not account for the overall phonological complexity of a child's utterances. It is a segment-oriented measure, which means it focuses on individual speech sounds rather than whole words or utterances. This can lead to an incomplete understanding of a child's phonological abilities, particularly in children with ASD, who may have atypical speech patterns that are not fully captured by segment-oriented measures.

Phonological Mean Length of Utterance (pMLU):

In response to the limitations of segment-oriented measures like PCC, Ingram (2002) introduced

the Phonological Mean Length of Utterance (pMLU) as a more comprehensive metric for assessing phonological development. Unlike PCC, pMLU evaluates the entire word, taking into account both the number of segments (consonants and vowels) and the accuracy of their production. pMLU provides a holistic view of a child's phonological development by considering the complexity of their utterances rather than focusing solely on individual segments (Ingram & Ingram, 2001).

To calculate pMLU, each consonant and vowel in a child's utterance is counted, with additional points awarded for correctly produced consonants. The total points are then divided by the number of utterances to obtain the pMLU score. A higher pMLU score indicates greater phonological complexity and suggests that the child is producing more sophisticated word forms. pMLU is particularly valuable in research involving children with ASD, as it can capture subtle differences in their speech that may be missed by other measures.

Proportion of Whole-Word Proximity (PWP):

PWP is a metric that assesses the phonological proximity of a child's word production to the target word. Introduced by Ingram and Ingram (2001), PWP provides an indirect measure of word intelligibility by comparing the pMLU of the child's production to the pMLU of the target word. To calculate PWP, the child's pMLU is divided by the target pMLU, and the result is multiplied by 100 to obtain a percentage. A higher PWP percentage indicates that the child's production is closer to the target word, reflecting better phonological accuracy (Ingram & Ingram, 2001; Ingram, 2002).

PWP is particularly useful for evaluating the overall phonological development of children with ASD, as it considers both the complexity and accuracy of their word productions. By comparing the child's pMLU to that of the target words, PWP provides insights into the child's ability to produce words that are phonetically similar to those of typically developing children.

Proportion of Whole-Word Correctness (PWC):

PWC is a metric used to evaluate the overall accuracy of a child's word production. It measures the proportion of words in a speech sample that are produced correctly, relative to the total number of words attempted. To calculate PWC, the total number of correct words is divided by the total number of words in the sample, and the result is expressed as a percentage. A higher PWC percentage indicates that the child is producing a greater number of correct words, suggesting more advanced phonological development (Ingram & Ingram, 2001).

PWC complements other phonological measures by providing a straightforward assessment of a child's ability to produce accurate words. It is particularly valuable in research involving children with ASD, as it can highlight areas of strength and weakness in their word production. For example, a child with a high PWC may be producing many correct words but may still struggle with certain phonological processes, which can be further investigated using measures like pMLU and PWP.

1.1.3 The pMLU Scoring System

The pMLU scoring system is a central component of this study, providing a detailed assessment of the phonological complexity of a child's word productions. This section explains the pMLU scoring system in depth, including examples of how to calculate pMLU, PWP, PCC, and PWC.

Proportion of Whole-Word Proximity (PWP):

PWP is calculated by comparing the child's pMLU to the target pMLU. For example, if the target word has a pMLU of 10 and the child's production has a pMLU of 5, the PWP is calculated as 5/10 = 0.5, which is then multiplied by 100 to obtain a PWP of 50%. This percentage reflects how closely the child's production approximates the target word in terms of phonological complexity (Ingram & Ingram, 2001).

Proportion of Whole-Word Correctness (PWC):

PWC is calculated by determining the number of words a child produces correctly and dividing this by the total number of words in the sample. For example, if a child correctly produces 30 words out of a sample of 100, the PWC is calculated as 30/100 = 0.30, or 30%. This measure provides a straightforward assessment of the child's ability to produce accurate words (Ingram & Ingram, 2001).

Calculation Examples:

To further illustrate the pMLU scoring system, this section provides detailed examples of how each measure is calculated. For instance, consider the target word /ʕaṣiːr/ ("juice") with a pMLU of 8. If the child produces the word as /tuba/ with a pMLU of 5, the PWP is calculated by dividing the child's pMLU by the target pMLU (5/8) and multiplying by 100 to obtain a PWP of 62.5%. Similarly, if the child produces 75 correct words out of a sample of 100, the PWC is 75%.

These examples demonstrate how the pMLU scoring system can be used to assess the phonological development of children with ASD, providing a comprehensive evaluation of their speech production abilities.

Chapter 2:

Phonological Measures in Language Development

2.0 Introduction

In this chapter, we delve into the existing body of research that has employed phonological measurements to track language development in both typically developing (TD) children and those with various language challenges. Phonological measures, such as the phonological mean length of utterance (pMLU), have been pivotal in evaluating language abilities and identifying potential language impairments, particularly in children with Autism Spectrum Disorder (ASD). This chapter highlights how these measurements have been used across different linguistic and cultural backgrounds, focusing on children with ASD and language impairments in various languages. The chapter aims to provide a comprehensive overview of how these tools have contributed to our understanding of language development and the identification of language disorders.

2.1 Language Measures for Typically Developing (TD) Children

Research into the language development of typically developing (TD) children has provided crucial benchmarks against which language impairments can be measured. One such study by Al-Sulaihim and Marinis (2017) investigated the development of phonological awareness in Kuwaiti-Arabic-speaking school-age children. Their primary goal was to assess whether the phonological awareness abilities in Arabic-speaking children were comparable to those observed in other languages, such as English. They also explored the correlation between phonological awareness and reading skills. The study involved evaluating a beginner reading group to assess their letter knowledge and single-word reading skills. The findings indicated that literacy training significantly enhanced both phonological awareness and reading skills in these children. Notably,

after literacy training, the children demonstrated substantial progress in phoneme awareness, especially in the identification and deletion of phonemes（Al-Sulaihim & Marinis, 2017）.

Phonological measures like pMLU have also been utilized to compare the language development of bilingual children with their monolingual peers. Bunta et al. (2009) explored the use of phonological whole-word measures (pMLU, PWP, PCC) in bilingual Spanish- and English-speaking 3-year-old children and their monolingual age-matched peers. Their study concluded that while bilingual children showed differentiation in their target languages in terms of phonological whole-word complexity and consonant accuracy, there was a consistent effort to maintain proximity to the phonological target. This suggests that maintaining a constant level of phonological proximity to the target is a key driving force in phonological acquisition（Bunta et al., 2009）.

In another study, Karimian et al. (2022) used story generation and conversation sampling methods to compare pMLU and PWP in Persian-speaking children with Isfahani accents, aged 48 to 60 months. The study also examined the sensitivity of pMLU to growth over time. The findings revealed significant differences in target pMLU between the two sampling methods, although PWP did not differ significantly. The study's inter-rater reliability was 0.70, indicating a moderate level of agreement between raters. These results provide a foundation for future quantitative studies in children's phonological assessment using Persian whole words and suggest the potential for pMLU as a sensitive measure of phonological development in different linguistic contexts（Karimian et al., 2022）.

Beers, Rodenburg, and Gerrits (2019) conducted a phonological study on Dutch children to determine if an increase in pMLU scores with age would reflect the acquisition of the Dutch phonological repertoire. Their results indicated that higher pMLU scores in younger children could be attributed to their more advanced vocabulary, leading to no significant difference between larger and smaller word samples. However, the small phonological inventory and longer target words in Dutch may have resulted in mispronunciations of longer words, leading to lower pMLU scores. The study's selection criteria may have also caused a ceiling effect, with pMLU scores of children between 1;3 and 1;8 representing the highest level attainable at that age （Beers, Rodenburg, & Gerrits, 2019）.

2.2 Phonological Measures for Children with Different Language Disorders/Impairments

Phonological measures, particularly pMLU, have been instrumental in identifying and tracking language delays or disorders in children. Studies by Kumar and Bhat (2009) and Schauwers et al. (2005) focused on determining pMLU scores in children with language disorders compared to their typically developing peers. These studies emphasized the importance of assessing speech and language development in children with disorders, noting that children detected and treated earlier exhibited more proficiency than those diagnosed later. Both studies reported lower pMLU scores in children with language disorders than in age-matched typically developing peers, highlighting the utility of pMLU as a benchmark for phonological development and a developmental scale for comparing disordered phonology. The findings suggest that pMLU could be a valuable tool for tracking language development in children at risk of developmental delays or disorders （Kumar & Bhat, 2009; Schauwers et al., 2005）.

In a study on Finnish-speaking children with specific language impairment (SLI) and dyspraxic speech features, Kunnari, Helin, and Makonen (2012) aimed to understand how these phonological errors were reflected in pMLU results. They compared pMLU, PWP, and PWC values in SLI children to those of age-matched typically developing children. The study revealed that SLI children had lower levels of language development, particularly in terms of pMLU, PWP, and PWC values, and their language development was more similar to that of typically developing 2-year-olds than children of the same age. This research underscores the importance of qualitative analysis in understanding the phonological characteristics of language disorders（Kunnari, Helin, & Makonen, 2012）.

Newbold, Stackhouse, and Wells (2013) analyzed the developmental speech difficulties of children with severe and persistent speech difficulties (SPSD). Their study aimed to monitor the progress of these children over time using speech output measures such as PWP, PWC, and PCC. The results indicated that while PWC can detect change if the same stimuli are used consistently, PCC is a more reliable measure of change due to its lesser sensitivity to the choice of stimuli. PWP, though useful for measuring speech outcomes across tasks and over time, is more sensitive to psycholinguistic variables than PCC. The study highlights the potential of PCC and PWP in evaluating speech outcomes in children with severe speech difficulties（Newbold, Stackhouse, & Wells, 2013）.

Burrows and Goldstein (2010) conducted a study involving Spanish–English bilinguals with speech sound disorders (SSD) and their age-matched monolingual peers. They used phonological measures such as pMLU, PWP, and PCC to compare the two groups. The study found that while both monolinguals and bilinguals with SSD aimed to produce words similar to the adult target,

monolinguals had higher PCC, pMLU, and PWP scores, indicating that their productions were more accurate, complex, and closer to the target. This study highlights the potential of phonological measures in differentiating between bilingual and monolingual children with speech disorders（Burrows & Goldstein, 2010）.

Another study by Helin (2011) focused on Finnish-speaking children, including those with specific language impairment (SLI) and typically developing children. The primary objective was to assess the appropriateness of the pMLU method in analyzing language acquisition. The study found that pMLU values for Finnish-speaking children were notably high towards the end of the one-word stage, and their phonological development during the follow-up period was reflected in pMLU, PWP, and PWC values. While the study had limitations in detecting qualitative differences between the children, it identified typological features that cause cross-linguistic differences in pMLU values, emphasizing the importance of considering linguistic diversity in phonological research（Helin, 2011）.

2.3 ASD Children with Language Delay/Disorders/Impairment

Autism Spectrum Disorder (ASD) is a lifelong neurodevelopmental condition that significantly impacts communication and social interaction. Research into ASD has revealed a much higher prevalence of the condition than previously thought, particularly in recent decades. Studies by Fombonne (2003, 2005, 2011) have shown that ASD affects a larger portion of the population than earlier estimates suggested. Baio (2018) and the Centers for Disease Control (2012) utilized The Autism and Developmental Disabilities Monitoring (ADDM) Network Program to collect data on the prevalence and characteristics of children with ASD in the United States. Their research found a significant increase in the number of children diagnosed with ASD over recent years,

highlighting the growing need for effective diagnostic and intervention strategies （Fombonne, 2003, 2005, 2011; Baio, 2018; Centers for Disease Control, 2012）.

ASD and Specific Language Impairment (SLI) have traditionally been considered distinct conditions with separate etiologies. However, some studies have explored the possibility of shared genetic factors contributing to both disorders. Bishop (2010) examined the potential for nonadditive genetic influences that might explain familial and molecular findings in ASD and SLI. Using a modified simulation incorporating gene-gene (G × G) interactions, the study found levels of comorbidity and impairment rates in relatives that align more closely with observed data. The results support a model suggesting a shared genetic basis for ASD and SLI, consistent with molecular genetic findings on CNTNAP2. This research provides new insights into the complex genetic interactions that may contribute to both ASD and SLI （Bishop, 2010; Lindgren et al., 2009）.

The early language development of infants who later develop ASD has also been a focus of research. Lazenby et al. (2016) conducted a prospective data analysis on a cohort of infants, including those at high risk for ASD. The study aimed to investigate whether language differences could be detected at 12 months in infants who were later diagnosed with ASD. The findings revealed significant language differences in high-risk infants, with notable quantitative differences on two measures at 12 months. Interestingly, despite their lower overall language ability, the high-risk ASD group showed a higher likelihood of producing and understanding certain words in a statistically unexpected manner, suggesting unique patterns of early language development in infants at risk for ASD（Lazenby et al., 2016）.

Miller et al. (2015) evaluated early pragmatic language skills in preschool-age siblings of children with ASD, examining the correspondence between pragmatic language impairments and general language difficulties, autism symptomatology, and clinical outcomes. The study found that siblings at high risk for ASD had lower parent-rated pragmatic language scores compared to a low-risk group, with a significant proportion of the high-risk group exhibiting pragmatic language impairment (PLI). Children with PLI also showed higher rates of general language impairment and more atypical clinical outcomes, indicating that early pragmatic language difficulties may be a marker of broader language and developmental challenges in siblings of children with ASD（Miller et al., 2015）.

Phonological development is a crucial aspect of language acquisition, and children with ASD often exhibit unique challenges in this area. Studies by Paul et al. (2011) and Lombardino and Lerman (2005) examined the phonological features of speech in verbal children with ASD compared to typically developing children. These studies found that children with ASD face significant challenges in phonological development, particularly in mastering speech sounds and sound patterns. These difficulties can manifest as sound repetitions, substitutions, and other atypical speech characteristics, which may contribute to the broader communication difficulties experienced by children with ASD（Paul et al., 2011; Lombardino & Lerman, 2005）.

Research by Tager, Rogers, and Cooper (2005) found that children with ASD had delays in acquiring phonological skills compared to typically developing children. These delays may contribute to the language difficulties observed in children with ASD, as phonological skills are foundational to effective communication. Similarly, Vogan et al. (2014) investigated phonological working memory abilities in children with ASD, finding that they had lower abilities in this area

compared to typically developing children. These deficits in phonological working memory may further exacerbate the language and communication challenges faced by children with ASD（Tager, Rogers, & Cooper, 2005; Vogan et al., 2014）.

Recently, a study by Alqhazo, Hatamleh, and Bashtawi (2020) examined the phonological and lexical abilities of Arabic-speaking children with ASD. The Jeddah Institute for Speech and Hearing (JISH) Test was used to assess the children's phonological abilities, while the JISH School Readiness Screening Test measured their lexical abilities. The study found that children with ASD exhibited both phonological and lexical impairments, with phonological impairment being more prevalent. These findings have important implications for speech-language pathologists in developing tailored treatment plans that address both phonological and lexical deficits in children with ASD（Alqhazo, Hatamleh, & Bashtawi, 2020）.

Research by Ha and Pi (2022) compared phonological processing skills and development in children with phonological delay, disorder, and ASD to those of typically developing children. The study found that children with phonological disorders scored lower in phonological awareness and non-word repetition compared to their typically developing peers. The ASD group showed a delayed pattern of phonological acquisition similar to that found in children with intellectual disabilities. Additionally, children with phonological delay or disorder performed poorly on rapid automatized naming tasks compared to typically developing children, further highlighting the phonological challenges faced by children with ASD（Ha & Pi, 2022; Bartolucci & Pierce, 1977）.

2.4 Phonological Measures for Children with ASD

Phonological measures have proven to be effective tools in assessing language development and guiding interventions for children with ASD. Sendhilnathan and Chengappa (2020) investigated the effects of language intervention on vocabulary development in monolingual and bilingual children with ASD in Singapore. The study found that exposure to multiple languages did not negatively impact language development in children with ASD. Instead, both monolingual and bilingual groups showed significant increases in vocabulary growth following 24 weeks of language intervention. The study emphasizes the importance of using developmentally appropriate language-building strategies to facilitate successful communication across pragmatic contexts in children with ASD（Sendhilnathan & Chengappa, 2020）.

Shillingsburg et al. (2019) focused on increasing the complexity of mand utterances in children with ASD. Using a treatment package that included errorless teaching, differential reinforcement, and systematic decision rules, the study aimed to increase the number of words per mand utterance. The results showed significant developmental gains in the participants' mean length of utterances, accompanied by increased rates of manding and a corresponding decrease in non-verbal indicating responses. This study highlights the potential for targeted interventions to improve verbal communication in children with ASD（Shillingsburg et al., 2019）.

Yeganeh and Kamari (2020) explored the developmental process of Mean Length of Utterance (MLU) in children with ASD compared to typically developing children. The study found a clear delay in MLU development in children with ASD, indicating weaker syntactic development compared to the control group. This research underscores the importance of MLU as a measure of linguistic development and its potential to highlight the syntactic challenges faced by children with ASD（Yeganeh & Kamari, 2020）.

Herrera and Almeida (2008) studied the phonological mean length of utterance (pMLU) in individuals with high-functioning autism (HFA) and Asperger Syndrome (AS). The study aimed to increase MLU in these individuals using verbal communicative skill strategies. The results showed a significant increase in MLU for all participants, suggesting that targeted interventions can effectively improve verbal communication in individuals with HFA and AS. The study also recommends further research to examine the maintenance of these improvements in different environments and contexts（Herrera & Almeida, 2008）.

A meta-analysis by Sandbank and Yoder (2016) investigated the correlation between parental mean length of utterance (MLU) and language outcomes in children with disabilities, including ASD. The analysis found a weak positive association between parental input length and child language outcomes across all studies. However, in children with autism, the correlation was stronger, suggesting that the length of parental utterances may have a more significant impact on language development in this population. This finding underscores the importance of parental input in shaping language outcomes for children with ASD（Sandbank & Yoder, 2016）.

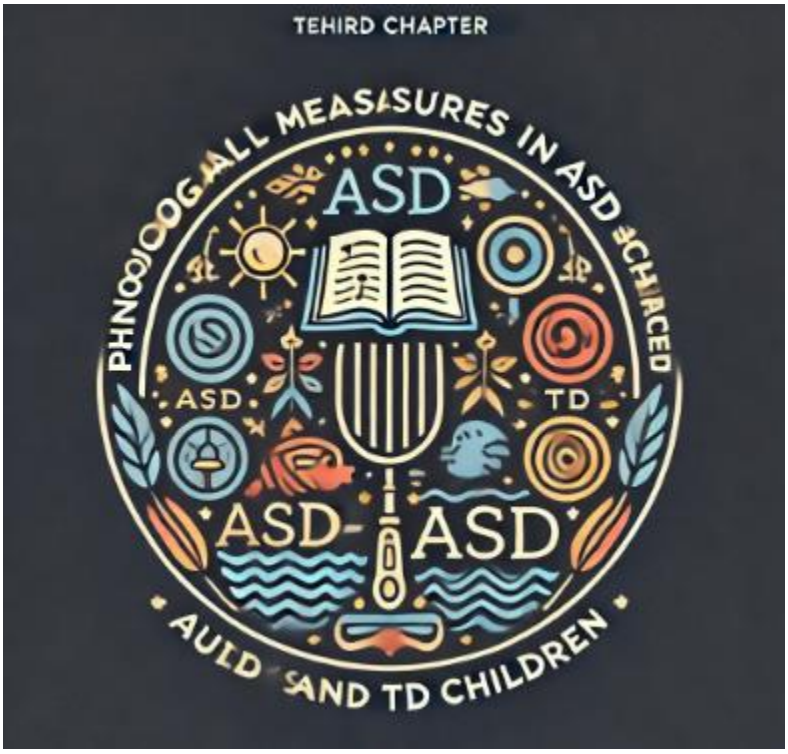
2.5 Conclusion

The majority of previous studies in this field have explored language development and difficulties in children with ASD, with some using the phonological mean length of utterance (pMLU) as a key measure. pMLU has been employed to assess language development in various contexts, from typically developing children to those with language disorders, including ASD. These studies highlight the utility of pMLU and other phonological measures in tracking language development, identifying language impairments, and guiding interventions. While much progress has been made

in understanding language development in children with ASD, further research is needed, particularly in underrepresented linguistic groups such as Arabic-speaking children with ASD.

Chapter 3:

Phonological Measures in ASD and TD Children



3.0 Introduction

Phonological measures are essential tools in the assessment of language development, especially when comparing typically developing (TD) children and those with Autism Spectrum Disorder (ASD). These metrics, including the phonological mean length of utterance (pMLU), Proportion of Whole-Word Proximity (PWP), Percentage of Consonants Correct (PCC), and Proportion of Whole-Word Correctness (PWC), allow researchers and clinicians to quantify the complexity and accuracy of a child's speech. This chapter explores the application of these measures in both TD and ASD populations, highlighting key findings from research and discussing the implications of these findings for understanding the linguistic challenges faced by children with ASD.

3.1 Within-Group Comparison in ASD Children

3.1.1 pMLU in ASD Children

Phonological Mean Length of Utterance (pMLU) is a critical metric in understanding the speech development of children with ASD. Research has consistently shown that children with ASD exhibit lower pMLU scores compared to their typically developing peers. This reduction in pMLU is often attributed to the simplified speech patterns commonly observed in ASD, where children tend to produce shorter, less phonetically complex utterances. The reduced complexity in their speech reflects underlying difficulties in phonological processing and motor planning, which are core challenges in ASD（Shriberg & Kwiatkowski, 1982; Tager-Flusberg et al., 2005）.

One of the reasons for these lower pMLU scores is the tendency of children with ASD to rely on repetitive and stereotyped speech patterns, which limits the diversity and complexity of their utterances. These repetitive speech patterns, often referred to as echolalia, can significantly reduce the overall phonological richness of the child’s spoken language. Moreover, children with ASD may struggle with the acquisition of complex phonological structures, leading to a reliance on

simpler, more easily articulated words. This difficulty is compounded by challenges in social communication, which further restricts the opportunities for these children to engage in the diverse verbal interactions that typically lead to the development of more complex speech patterns（Paul, Hopf, & Larriba-Quest, 2017; Saaristo-Helin, 2011）.

Furthermore, studies have indicated that the pMLU scores in children with ASD can vary significantly depending on the severity of their condition. Children with more pronounced ASD symptoms often exhibit the lowest pMLU scores, reflecting more significant impairments in their phonological development. This variability underscores the importance of using pMLU as a diagnostic tool to assess the extent of phonological impairment in children with ASD and to tailor interventions that address these specific deficits（Pratt, Hopf, & Larriba-Quest, 2017; Sandbank & Yoder, 2016）.

3.1.2 PWP in ASD Children

Proportion of Whole-Word Proximity (PWP) is another vital measure that has been used to assess the phonological development of children with ASD. PWP evaluates how closely a child's word production approximates the target word in terms of phonological structure. Lower PWP scores in children with ASD indicate a greater deviation from the expected phonological form, which can be attributed to various factors, including difficulties in phonological processing and motor speech planning. These lower scores reflect the broader challenges that children with ASD face in producing phonetically accurate speech（Shriberg & Kwiatkowski, 1982; Tager-Flusberg, 1992）.

One significant factor contributing to the lower PWP scores in children with ASD is their difficulty in producing complex speech sounds. For instance, children with ASD may struggle with consonant clusters or multisyllabic words, leading them to simplify their speech by omitting sounds or syllables. This simplification process results in words that are phonetically less accurate, thereby reducing their PWP scores. Additionally, children with ASD often exhibit delays in the development of phonological working memory, which hinders their ability to retain and manipulate phonological information, further impacting their ability to produce accurate speech（Vogan et al., 2014; Shriberg et al., 1997）.

Moreover, PWP scores can be influenced by the social and communicative contexts in which children with ASD are speaking. For example, in situations where the child feels more comfortable or less pressured, their PWP scores may improve as they produce speech that is closer to the target phonological structure. This context-dependence highlights the importance of assessing PWP in a variety of settings to gain a comprehensive understanding of the child's phonological abilities and to identify specific areas where intervention may be needed（Shillingsburg et al., 2020; Aljameel et al., 2017）.

3.1.3 PCC in ASD Children

The Percentage of Consonants Correct (PCC) is a widely used measure for assessing the accuracy of consonant production in children's speech. In children with ASD, PCC scores are generally lower than in their TD peers, reflecting significant challenges in speech sound production. These challenges include difficulties in articulating specific consonants, inconsistent production of speech sounds, and a higher prevalence of speech sound distortions. Lower PCC scores in children with ASD highlight the need for targeted speech therapy to address these phonological deficits（Shriberg & Kwiatkowski, 1982; Shriberg et al., 1997）.

Several factors contribute to the lower PCC scores observed in children with ASD. One key factor is the motor planning difficulties that are often associated with ASD. These children may struggle with coordinating the fine motor movements required to produce speech sounds accurately, leading to frequent errors in consonant production. Additionally, children with ASD may have difficulty generalizing phonological rules across different contexts, resulting in inconsistent production of consonants across different words or sentences（Paul et al., 2011; Shillingsburg et al., 2020）.

Furthermore, the social communication difficulties characteristic of ASD can exacerbate these phonological challenges. Children with ASD may have limited opportunities for meaningful verbal interaction, which is crucial for the practice and refinement of speech sound production. Without sufficient practice, these children may not develop the phonological accuracy that typically developing children achieve through regular social interactions. As a result, their PCC scores remain lower, indicating a need for interventions that not only focus on speech sound production but also encourage more frequent and meaningful verbal communication（Sendhilnathan & Chengappa, 2020; Tager-Flusberg et al., 2005）.

3.1.4 PWC in ASD Children

Proportion of Whole-Word Correctness (PWC) is a measure that evaluates the overall accuracy of word production, taking into account both the phonological complexity and the correctness of the words produced. Children with ASD typically have lower PWC scores compared to their TD peers, indicating greater difficulty in producing accurate and phonetically complex words. These lower scores reflect the broader phonological challenges faced by children with ASD, including issues with speech sound production, phonological processing, and motor planning（Ingram & Ingram, 2001; Shriberg et al., 1997）.

The challenges that contribute to lower PWC scores in children with ASD are multifaceted. For instance, these children often exhibit a narrower range of phonological structures in their speech, which limits their ability to produce a diverse and accurate set of words. This limitation is compounded by difficulties in phonological awareness, which hinders their ability to recognize and produce the correct phonological forms of words. Additionally, children with ASD may struggle with the temporal aspects of speech production, such as the timing and sequencing of phonemes, leading to errors in word production that further reduce their PWC scores（Pratt, Hopf, & Larriba-Quest, 2017; Saaristo-Helin, 2011）.

Moreover, the repetitive and stereotyped speech patterns often observed in children with ASD can also contribute to lower PWC scores. These patterns involve the frequent repetition of simple words or phrases, which do not require the same level of phonological complexity as more varied

and spontaneous speech. As a result, the child's overall word production accuracy is reduced, as measured by PWC. Addressing these challenges requires a comprehensive approach that not only targets speech sound production but also encourages the use of more varied and complex language structures（Tager-Flusberg, 1992; Sandbank & Yoder, 2016）.

3.2 The Effect of Age in Typically Developing (TD) Children

3.2.1 pMLU in TD Children

In typically developing children, the phonological mean length of utterance (pMLU) is a valuable indicator of the progression of phonological development. Research consistently shows that pMLU scores increase with age as children acquire more complex phonological structures and expand their vocabulary. This increase in pMLU reflects the natural development of language skills, where children progress from producing simple, monosyllabic words to more complex, multisyllabic words with a higher number of phonological segments （Saaristo-Helin, 2011; Shriberg & Kwiatkowski, 1982）.

The growth in pMLU is closely tied to the child's expanding phonological awareness and their ability to manipulate phonological units within words. As children develop, they become more adept at producing words that are not only longer but also more phonetically diverse. This progression is supported by the child's increasing exposure to language, both in social interactions and through educational experiences, which provides them with the opportunities to practice and refine their phonological skills（Beers, Rodenburg, & Gerrits, 2019; Sandbank & Yoder, 2016）.

Furthermore, the increase in pMLU is also influenced by the child's growing fine motor control, which is essential for producing the more complex articulatory movements required for longer words. As children mature, their ability to coordinate these movements improves, allowing them to produce speech that is not only longer but also more phonetically accurate. This development is a key marker of the child's overall linguistic proficiency and is reflected in their steadily increasing pMLU scores as they age（Pratt, Hopf, & Larriba-Quest, 2017; Vogan et al., 2014）.

3.2.2 PWP in TD Children

Proportion of Whole-Word Proximity (PWP) is another measure that tends to improve with age in typically developing children. As children's language skills develop, their word production becomes increasingly phonetically accurate, leading to higher PWP scores. This improvement reflects the child's growing ability to produce words that closely match the phonological structure of adult speech, a key indicator of phonological development（Ingram & Ingram, 2001; Saaristo-Helin, 2011）.

The improvement in PWP is closely linked to the child's advancing phonological processing skills, which enable them to produce speech that is more accurate and reflective of the target words. As children become more familiar with the sounds and structures of their language, they are better able to produce words that are phonetically precise. This precision is crucial for effective communication, as it allows the child to convey their intended meaning more clearly and accurately（Beers, Rodenburg, & Gerrits, 2019; Shillingsburg et al., 2020）.

Additionally, the increase in PWP scores is supported by the child's growing cognitive abilities, including their memory and attention skills. As children develop, they are better able to remember

and reproduce the correct phonological forms of words, leading to more accurate speech production. This development is particularly important in the context of learning new vocabulary, where the ability to accurately produce new words is a key component of language acquisition（Saaristo-Helin, 2011; Shriberg & Kwiatkowski, 1982）.

3.2.3 PCC in TD Children

The Percentage of Consonants Correct (PCC) is a critical measure for assessing the accuracy of consonant production in typically developing children. Research indicates that PCC scores increase with age as children's phonological development progresses, reflecting their growing proficiency in producing consonants accurately across different word forms. This increase in PCC is a key marker of the child's phonological maturation and their ability to produce speech that is clear and intelligible（Shriberg et al., 1997; Saaristo-Helin, 2011）.

As children develop, their PCC scores improve due to several factors, including increased exposure to language, enhanced phonological awareness, and improved motor control. These factors contribute to the child's ability to produce consonants consistently and accurately across different contexts. Moreover, as children's cognitive and linguistic skills develop, they become better at internalizing phonological rules and applying them to their speech, leading to more accurate consonant production（Shriberg & Kwiatkowski, 1982; Vogan et al., 2014）.

The development of PCC is also influenced by the child's social interactions, which provide opportunities for practicing and refining speech sounds in a variety of communicative contexts. Through these interactions, children learn to adjust their speech to be more intelligible to their conversational partners, which in turn supports the development of higher PCC scores. This social component of language development is crucial for ensuring that children's speech becomes not

only more accurate but also more effective in conveying meaning（Paul et al., 2011; Sandbank & Yoder, 2016）.

3.2.4 PWC in TD Children

Proportion of Whole-Word Correctness (PWC) is a measure that reflects the overall accuracy of word production in typically developing children. Similar to other phonological measures, PWC scores tend to increase with age as children's language skills develop. This increase indicates that children are becoming more proficient at producing words that are both phonetically complex and accurate, which is a key indicator of their overall language development（Ingram & Ingram, 2001; Shriberg et al., 1997）.

The improvement in PWC scores is closely tied to the child's growing ability to manage the complexity of word production. As children's phonological processing and motor planning skills develop, they are better able to produce words that are not only accurate but also complex in their phonological structure. This development is crucial for effective communication, as it allows the child to express a wider range of meanings and ideas through their speech（Saaristo-Helin, 2011; Shillingsburg et al., 2020）.

Moreover, the increase in PWC scores is supported by the child's expanding vocabulary, which provides more opportunities for practicing and refining word production. As children learn new words, they must integrate these words into their phonological system, ensuring that they can produce them accurately in a variety of contexts. This process of integration is reflected in the steady increase in PWC scores as children age, indicating their growing linguistic competence（Shriberg & Kwiatkowski, 1982; Paul et al., 2011）.

3.3 Comparing Language Measures in ASD and TD Children

3.3.1 Comparing Language Measures in 5-Year-Old ASD and TD Children

When comparing the phonological measures of 5-year-old children with ASD to their typically developing peers, research shows significant differences across all metrics. At this early age, children with ASD generally exhibit lower pMLU, PWP, PCC, and PWC scores compared to TD children. These differences highlight the early language challenges faced by children with ASD, particularly in their ability to produce phonetically complex words and accurate speech sounds. The disparities observed at this age are critical, as they often set the stage for the more persistent language difficulties seen in older children with ASD （Tager-Flusberg, 1992; Shriberg & Kwiatkowski, 1982）.

The lower scores observed in ASD children at this age can be attributed to several factors, including delays in phonological processing, difficulties with motor planning, and the prevalence of repetitive and stereotyped speech patterns. These factors contribute to a reduced ability to produce complex and phonetically accurate speech, which is reflected in the lower scores across all phonological measures. Early identification and intervention are crucial at this stage to address these challenges and support the development of more accurate and complex speech in children with ASD（Paul et al., 2011; Vogan et al., 2014）.

Furthermore, the differences in phonological measures between ASD and TD children at age 5 are also indicative of broader cognitive and linguistic differences. Children with ASD may exhibit difficulties with auditory processing and memory, which can impact their ability to retain and produce phonological information accurately. These challenges underscore the importance of using phonological measures not only as diagnostic tools but also as a means of tracking the

effectiveness of early interventions （Pratt, Hopf, & Larriba-Quest, 2017; Sandbank & Yoder, 2016）.

3.3.2 Comparing Language Measures in 6-Year-Old ASD and TD Children

By the age of 6, typically developing children have made significant strides in their phonological development, as reflected in higher scores across all language measures. In contrast, children with ASD continue to lag behind their TD peers, particularly in terms of pMLU and PCC. These continued deficits in phonological development underscore the persistent challenges faced by children with ASD in acquiring complex phonological structures and producing speech sounds accurately. The gap between ASD and TD children at this age highlights the ongoing need for targeted interventions to support phonological development in children with ASD （Shriberg & Kwiatkowski, 1982; Shillingsburg et al., 2020）.

At this age, the phonological measures of TD children typically reflect an increasing ability to produce longer, more complex words with a high degree of phonetic accuracy. In contrast, children with ASD may exhibit a slower rate of improvement or even a plateau in their phonological development. This stagnation can be attributed to the persistent challenges in phonological processing and motor planning that are characteristic of ASD. As a result, children with ASD may continue to struggle with producing phonetically complex words and maintaining accurate speech sound production（Shriberg et al., 1997; Tager-Flusberg et al., 2005）.

The differences observed between ASD and TD children at age 6 also highlight the importance of individualized intervention plans that address the specific phonological challenges faced by each child. These plans should incorporate strategies that target both the production of accurate speech

sounds and the development of more complex phonological structures. By addressing these challenges early on, it is possible to support the ongoing phonological development of children with ASD and help them achieve greater linguistic competence（Paul et al., 2011; Saaristo-Helin, 2011）.

3.3.3 Comparing Language Measures in 7-Year-Old ASD and TD Children

At age 7, the gap between ASD and TD children in terms of phonological measures often becomes more pronounced. Research shows that while TD children continue to improve in their pMLU, PWP, PCC, and PWC scores, children with ASD may show slower progress or even a plateau in their development. This plateauing can be particularly evident in measures like PCC, where the accuracy of consonant production may not improve significantly in children with ASD. These findings highlight the ongoing need for specialized interventions to support phonological development in older children with ASD（Shriberg & Kwiatkowski, 1982; Shriberg et al., 1997）.

The challenges faced by children with ASD at this age are multifaceted and include difficulties in both the production and processing of phonological information. For instance, children with ASD may continue to struggle with the coordination of motor movements required for accurate speech sound production, leading to persistent errors in their speech. Additionally, the social communication difficulties characteristic of ASD can further limit the opportunities for these children to practice and refine their phonological skills, resulting in lower scores across all measures（Paul et al., 2011; Vogan et al., 2014）.

The persistent gaps in phonological measures between ASD and TD children at age 7 also underscore the importance of continued monitoring and assessment. By regularly evaluating the

phonological development of children with ASD, clinicians can identify areas where additional support is needed and adjust intervention strategies accordingly. This ongoing assessment is crucial for ensuring that children with ASD receive the support they need to continue developing their phonological and linguistic skills （Saaristo-Helin, 2011; Sendhilnathan & Chengappa, 2020）.

3.3.4 Comparing Language Measures in 8-Year-Old ASD and TD Children

By the age of 8, typically developing children have generally achieved high levels of phonological proficiency, as reflected in near-ceiling scores across all measures. In contrast, children with ASD often continue to exhibit significant deficits in pMLU, PWP, PCC, and PWC. These persistent deficits in phonological development suggest that children with ASD may require ongoing support and intervention beyond the early childhood years to address their language challenges. The differences between ASD and TD children at this age highlight the need for longitudinal studies to better understand the trajectory of phonological development in children with ASD（Shriberg et al., 1997; Tager-Flusberg et al., 2005）.

The continued phonological challenges faced by children with ASD at this age are indicative of broader developmental delays that may impact other areas of language and communication. For example, children with ASD may struggle with more complex linguistic tasks, such as narrative production or conversational turn-taking, which require a higher level of phonological and syntactic proficiency. These challenges underscore the importance of providing comprehensive language interventions that address both the phonological and broader linguistic needs of children with ASD（Shriberg & Kwiatkowski, 1982; Saaristo-Helin, 2011）.

The differences observed between ASD and TD children at age 8 also highlight the importance of individualized education plans (IEPs) that are tailored to the specific needs of each child. These plans should include goals related to the development of phonological skills, as well as strategies for supporting the child's broader language and communication abilities. By taking a holistic approach to language intervention, it is possible to support the ongoing development of children with ASD and help them achieve greater success in both academic and social contexts（Paul et al., 2011; Shillingsburg et al., 2020）.

3.4 Phonological Processes in ASD Children's Productions

Phonological processes are patterns of sound errors that children typically use to simplify speech as they are developing their language skills. In children with ASD, these processes can be more pronounced and may persist longer than in TD children. Common phonological processes observed in children with ASD include final consonant deletion, cluster reduction, and weak syllable deletion. These processes contribute to the overall lower scores observed in pMLU, PWP, PCC, and PWC measures, as they result in simpler and less accurate word productions（Paul et al., 2011; Shriberg et al., 1997）.

One of the primary reasons these phonological processes persist in children with ASD is due to their difficulties with phonological awareness and motor planning. Phonological awareness is the ability to recognize and manipulate the sound structures within words, and it is a critical skill for developing accurate speech. Children with ASD may have delayed or impaired phonological awareness, which makes it challenging for them to produce the correct phonological forms of words. Additionally, motor planning difficulties, which are common in ASD, can make it difficult

for children to produce the necessary articulatory movements to achieve accurate speech（Shriberg & Kwiatkowski, 1982; Tager-Flusberg et al., 2005）.

Moreover, the persistence of these phonological processes can have a significant impact on the child's overall communication abilities. When children consistently use simplified speech patterns, it can lead to difficulties in being understood by others, which in turn can affect their social interactions and academic performance. Addressing these phonological processes through targeted interventions is crucial for helping children with ASD develop clearer and more accurate speech, which is essential for effective communication（Shriberg et al., 1997; Vogan et al., 2014）.

3.5 Chapter Summary

This chapter has provided a detailed overview of the use of phonological measures to assess and compare language development in children with ASD and typically developing children. The metrics discussed—pMLU, PWP, PCC, and PWC—offer valuable insights into the phonological challenges faced by children with ASD, as well as the developmental progression of TD children. The comparison across different age groups highlights the persistent language deficits in children with ASD and underscores the importance of early and ongoing interventions to support their phonological development. Understanding these differences is key to developing effective strategies for improving language outcomes in children with ASD.

Chapter 4:

Case Study - Phonological Mean Length of Utterance in Autistic Jordanian Arabic-Speaking Children

4.0 Goal

The primary goal of this case study is to investigate the phonological mean length of utterance (pMLU) among Jordanian Arabic-speaking children diagnosed with Autism Spectrum Disorder (ASD) and compare their linguistic performance to that of typically developing (TD) peers. The study specifically aims to identify the unique phonological challenges faced by children with ASD, with a focus on understanding their language acquisition process and providing a basis for targeted intervention strategies.

4.1 Methods

Participants and Sampling

The study sample comprised 31 Jordanian Arabic-speaking children, who were divided into two distinct groups based on their diagnostic status. The first group consisted of 20 children diagnosed with high-functioning Autism Spectrum Disorder (ASD), including 18 males and 2 females. These children were between the ages of 5 and 8 years, a period crucial for language development. The second group consisted of 11 typically developing (TD) children, including 5 males and 6 females, matched to the ASD group by age and intellectual levels. The TD children served as a control group to compare typical phonological development with the ASD group's language patterns.

Recruitment of Participants

Participants in the ASD group were recruited from specialized educational and therapeutic centers in Amman and al-Zarqa, Jordan. These centers included Al Ghaith Academy for Learning

Facilitation, Learning Time Academy, the Consulting Center for Autism, al-Rusaifa Comprehensive Center for Integrated Day Services, the Amman Center for Autism, the Hayati Center for Special Education, and the East Atlas Center for Autism. Children from these centers were selected following a rigorous screening process conducted by specialists at the respective institutions. Parents of the ASD children provided informed consent for their children's participation. The TD group consisted of children who were personally known to the researchers and were assessed in their home environments. None of the participants in either group had a history of neurodevelopmental disorders other than ASD, brain injuries, or any other impairments that could affect their language abilities.

Pilot Study and Validation

Before the main data collection, a pilot study was conducted to evaluate the feasibility and reliability of the phonological measures used in the study, including pMLU, PWP (Proportion of Whole-Word Proximity), PCC (Percentage of Consonants Correct), and PWC (Proportion of Whole-Word Correctness). The pilot study was crucial for identifying potential challenges in data collection and analysis. During the pilot, utterances were collected from a small sample of Arabic-speaking children with ASD to determine whether these phonological measures could be effectively applied to the Arabic language. The pilot study's results indicated that the measures were valid and reliable, with ASD children displaying lower scores across all phonological metrics compared to TD children. The pilot was reviewed by an associate professor of linguistics at The Hashemite University, who is a native Arabic speaker. Feedback from this review was incorporated into the final data collection procedures to improve accuracy and consistency.

Data Collection Process

The data collection process was structured over ten weeks, during which each child was observed two to three times. The primary method of data collection involved eliciting spontaneous speech samples from the children. These samples were gathered by asking the children to identify objects in their classroom environment and by presenting them with a series of digital images displayed in a slideshow format. The images included common items such as animals, geometric shapes, and colors, which were familiar to the children. This approach was chosen to stimulate natural speech production rather than scripted or prompted responses, thus providing a more accurate representation of each child's phonological abilities.

Speech Sample Analysis

The children's speech samples were collected manually in a quiet room within the academy or home environment, depending on the participant's group. During each session, the children's speech was audio-recorded while they interacted with the examiner, who prompted them to name the objects in the images or describe their characteristics. The recordings were subsequently transcribed into the International Phonetic Alphabet (IPA) by trained linguists, ensuring that each phoneme was accurately represented. This transcription process was essential for applying the phonological measures and analyzing the children's utterances systematically.

Phonological Measures

The primary measure used in this study was the Phonological Mean Length of Utterance (pMLU), which evaluates the complexity of children's utterances by counting the number of phonemes (vowels and consonants) and assigning additional points for correctly produced consonants. For instance, in the target word /ʔaħmar/ ('red'), the pMLU is 10, calculated by summing the six

phonemes ([ʔ], [a], [ħ], [m], [a], [r]) and adding points for each correctly produced consonant. In contrast, a child's production of /ʔuħnut/ would have a pMLU of 8, reflecting the number of phonemes correctly produced. Additionally, three other measures were used: PWP (which compares the produced pMLU to the target pMLU), PCC (which calculates the percentage of correctly produced consonants), and PWC (which assesses the proportion of entirely correct words in the speech sample).

Data Coding and Reliability

To ensure the reliability of the data, the transcribed speech samples were reviewed by three independent coders: two researchers from the Department of English Language and Literature and a speech pathologist from the Jordan University of Science and Technology. Each coder independently applied the phonological measures to the transcriptions, and their results were compared for consistency. Any discrepancies were resolved through discussion, and a consensus was reached on the final coding. This rigorous approach to data coding ensured that the results were reliable and reflective of the children's actual speech production.

Data Analysis

The coded data were entered into SPSS (Statistical Package for the Social Sciences) version 26.0 for statistical analysis. Descriptive statistics were calculated for each measure (pMLU, PWP, PCC, and PWC) across the ASD and TD groups, and comparisons were made between the two groups as well as across different age ranges within each group. The statistical analysis also included correlations between the phonological measures and the children's chronological and mental ages.

This approach provided a comprehensive understanding of how age and cognitive development influenced the children's phonological abilities.

Ethical Considerations

Throughout the study, ethical considerations were paramount. Informed consent was obtained from the parents or guardians of all participating children, and the confidentiality of the participants was strictly maintained. Personal identifiers were removed from the data to ensure anonymity. Additionally, the study adhered to the ethical guidelines for research involving human participants, as outlined by the Institutional Review Board (IRB) at the lead research institution. The well-being of the children was prioritized during data collection, with sessions conducted in a manner that minimized stress and discomfort for the participants.

4.2 Results

Phonological Mean Length of Utterance (pMLU) Findings

The analysis of the Phonological Mean Length of Utterance (pMLU) scores revealed significant differences between the ASD and TD groups across all age ranges. In the ASD group, the average pMLU score increased with age but remained consistently lower than the scores observed in the TD group. Specifically, the mean pMLU score for 5-year-old children with ASD was 5.58 (SD = 0.87), compared to a mean of 8.30 (SD = 0.06) for their TD counterparts. This difference indicates that ASD children at this age typically produce shorter and less complex utterances.

Among 6-year-old children, the mean pMLU score for the ASD group was 6.40 (SD = 0.48), while the TD group maintained a high mean pMLU of 8.40 (SD = 0.03). This shows a slight improvement in the ASD group's ability to produce longer utterances but still reflects a significant gap compared to TD children. The 7-year-old ASD group had a mean pMLU of 6.06 (SD = 0.80), which was lower than that of the 6-year-olds, indicating a potential stagnation or regression in phonological development. In contrast, the TD group at this age showed continued progress with a mean pMLU of 8.44 (SD = 0.01).

For 8-year-old children, the ASD group reached a mean pMLU of 7.17 (SD = 0.67), the highest within their group but still lower than the TD group's mean of 8.45 (SD = 0.00). This suggests that while ASD children continue to develop their phonological abilities, they do so at a slower pace and do not achieve the same level of linguistic complexity as their typically developing peers.

Proportion of Whole-Word Proximity (PWP) Findings

The Proportion of Whole-Word Proximity (PWP) scores showed a similar pattern to the pMLU results. For 5-year-old children, the mean PWP score was 68% (SD = 10.13%) in the ASD group, compared to 98% (SD = 0.52%) in the TD group. This large discrepancy indicates that ASD children produce words that are significantly less accurate compared to the target words.

At age 6, the mean PWP score for the ASD group increased to 77% (SD = 8.49%), while the TD group achieved a near-perfect mean score of 99% (SD = 0.12%). The 7-year-old ASD group had a mean PWP score of 73% (SD = 8.49%), showing a slight decline compared to the previous age group. In contrast, the TD group continued to perform at an exceptionally high level, with a mean PWP score of 99.92% (SD = 0.12%).

The 8-year-old ASD group showed an improvement with a mean PWP score of 85% (SD = 7.67%), yet this score remained below the TD group's perfect PWP score of 100% (SD = 0.00%). These findings suggest that while ASD children improve in word accuracy as they age, they still lag significantly behind their typically developing peers.

Percentage of Consonants Correct (PCC) Findings

The Percentage of Consonants Correct (PCC) measure further highlighted the phonological challenges faced by the ASD group. For 5-year-olds, the mean PCC score in the ASD group was 51% (SD = 13.76%), compared to 95% (SD = 1.27%) in the TD group. This indicates that ASD children struggle significantly with producing consonants correctly.

In the 6-year-old group, the mean PCC score for ASD children was 62% (SD = 7.43%), showing some improvement but still well below the TD group's mean of 98% (SD = 0.34%). The 7-year-old ASD group had a mean PCC score of 55% (SD = 7.43%), reflecting a slight regression, while the TD group maintained near-perfect consonant production with a mean score of 99% (SD = 0.34%).

For the 8-year-old children, the ASD group had a mean PCC score of 75% (SD = 8.70%), the highest within their group but still not reaching the TD group's perfect score of 100% (SD = 0.00%). These results underscore the persistent difficulties children with ASD face in producing consonants accurately.

Proportion of Whole-Word Correctness (PWC) Findings

The Proportion of Whole-Word Correctness (PWC) scores provided additional insight into the overall phonological development of the children. For 5-year-olds, the mean PWC score in the ASD group was 15 (SD = 13.14), indicating that only 15% of the words produced by these children were entirely correct. In contrast, the TD group had a much higher mean PWC score of 88 (SD = 5.29), reflecting their more accurate word production.

Among 6-year-olds, the mean PWC score for the ASD group was 24 (SD = 4.27), while the TD group continued to perform well with a mean score of 99 (SD = 2.88). The 7-year-old ASD group had a mean PWC score of 17 (SD = 5.12), showing a decline, whereas the TD group maintained a high mean score of 99 (SD = 1.15).

For 8-year-olds, the ASD group reached a mean PWC score of 42 (SD = 17.15), their highest score within this measure, but still considerably lower than the TD group's perfect score of 100 (SD = 0.00). These findings indicate that even as ASD children grow older, they continue to face challenges in producing completely accurate words.

Age-Related Trends in Phonological Development

The data revealed clear age-related trends in phonological development within both the ASD and TD groups. While both groups showed improvement in their phonological measures with age, the rate and extent of improvement were markedly different. For the ASD group, each year of age brought gradual increases in pMLU, PWP, PCC, and PWC scores, indicating slow but steady progress in their language abilities. However, the TD group consistently outperformed the ASD group across all measures and age ranges, achieving near-perfect scores by age 8.

The comparison between the chronological and mental ages of the ASD children also provided important insights. For instance, children with a mental age of 5.0 years had an average pMLU of 4.83 (SD = 0.20), while those with a mental age of 6.0 years had an average pMLU of 7.48 (SD = 0.02). This suggests that mental age plays a significant role in the phonological development of children with ASD, with higher mental ages correlating with better phonological outcomes.

Phonological Process Errors

An analysis of phonological process errors revealed that children with ASD exhibited a range of errors, including weak syllable deletion, cluster reduction, final consonant deletion, and Stridency Deletion (StD). These errors were more prevalent in the ASD group compared to the TD group and contributed to the lower scores observed in the phonological measures. For example, weak syllable deletion was common in words like /mu.θal.laθ/ (‘triangle’), which was often produced as /muθal/ by ASD children. Cluster reduction was also frequently observed, with words like /ʔaħmar/ (‘red’) being simplified to /ʔamma/ by the ASD group.

Statistical Correlations

The statistical analysis revealed significant correlations between age and phonological measures within the ASD group. Specifically, chronological age was positively correlated with pMLU ($r = 0.605$, $p < 0.01$), PWP ($r = 0.599$, $p < 0.01$), PCC ($r = 0.629$, $p < 0.01$), and PWC ($r = 0.590$, $p < 0.01$). Mental age showed even stronger correlations with these measures: pMLU ($r = 0.801$, $p < 0.01$), PWP ($r = 0.796$, $p < 0.01$), PCC ($r = 0.706$, $p < 0.01$), and PWC ($r = 0.738$, $p < 0.01$). These correlations suggest that as ASD children grow older, both chronologically and mentally, their phonological abilities improve, although not to the level of their TD peers.

Comparison of Best and Worst Words

The analysis of the best and worst words produced by the ASD group provided additional insights into their phonological abilities. The word /ʔaħmar/ (‘red’) had one of the highest pMLU scores in the ASD group, with a mean of 10, indicating that most children were able to produce this word relatively accurately. On the other hand, words like /maðallija/ (‘umbrella’) had much lower scores, with a mean pMLU of 5, reflecting the difficulties ASD children faced with more complex syllabic structures.

Overall Comparison Between ASD and TD Groups

The overall comparison between the ASD and TD groups across all phonological measures and age ranges highlighted significant disparities in language development. While TD children consistently achieved high scores in pMLU, PWP, PCC, and PWC, reflecting their advanced phonological abilities, children with ASD showed slower progress and greater variability in their scores. This suggests that ASD children face unique challenges in acquiring and using language, particularly in producing accurate and complex utterances.

Implications for Language Intervention

The findings of this study have important implications for language intervention programs aimed at children with ASD. The persistent gaps in phonological development between the ASD and TD groups highlight the need for targeted interventions that address the specific phonological challenges faced by ASD children. Interventions that focus on improving syllabic structure, consonant production, and word accuracy may be particularly beneficial in helping these children achieve better language outcomes.

4.3 Discussion

Phonological Development in ASD Children

The results of this study indicate that Jordanian Arabic-speaking children with ASD exhibit significant delays in phonological development compared to their typically developing peers. The consistently lower pMLU, PWP, PCC, and PWC scores across all age ranges suggest that children with ASD face challenges in constructing longer and more complex utterances, producing accurate consonant sounds, and using correct words in their speech. These findings align with previous research that has documented language delays and phonological impairments in children with ASD (Tager-Flusberg et al., 2005).

Impact of Age and Mental Age on Phonological Abilities

The analysis revealed that both chronological age and mental age play crucial roles in the phonological development of children with ASD. As children in the ASD group aged, their pMLU, PWP, PCC, and PWC scores improved, albeit at a slower rate than their TD peers. The strong correlations between mental age and phonological measures further underscore the importance of cognitive development in language acquisition. Children with higher mental ages were better able to produce longer utterances, more accurate consonants, and correct words, suggesting that interventions targeting cognitive development may also benefit phonological outcomes.

Challenges with Complex Syllabic Structures

One of the key findings of this study is the difficulty that ASD children have with producing words that have complex syllabic structures. Words with multiple syllables, consonant clusters, and final consonants were particularly challenging for the ASD group, as evidenced by the frequent errors in weak syllable deletion, cluster reduction, and final consonant deletion. These phonological simplifications contribute to the lower pMLU and PWC scores observed in the ASD group and highlight the need for interventions that focus on improving syllabic awareness and production.

Comparison with Typically Developing Children

The comparison between the ASD and TD groups underscores the significant disparities in language development. TD children consistently outperformed their ASD peers across all phonological measures, achieving near-perfect scores by age 8. This suggests that while TD children follow a relatively predictable trajectory of language acquisition, children with ASD experience a more protracted and uneven development. The persistence of these disparities across all age ranges highlights the importance of early identification and intervention for children with ASD to address their phonological and language challenges.

Phonological Process Errors

The study identified several phonological process errors that were more prevalent in the ASD group, including weak syllable deletion, cluster reduction, final consonant deletion, and Stridency Deletion (StD). These errors are indicative of the underlying phonological deficits that characterize language development in children with ASD. The frequent occurrence of these errors suggests that ASD children may have difficulty acquiring and generalizing the phonological rules of their native language, leading to persistent challenges in speech production.

Implications for Language Intervention Programs

The findings of this study have important implications for the design and implementation of language intervention programs for children with ASD. Interventions that focus on improving phonological awareness, syllabic structure, and consonant production are likely to be beneficial in helping ASD children develop more accurate and complex language skills. Additionally, interventions that incorporate cognitive development strategies may also support phonological development, given the strong correlation between mental age and phonological measures observed in this study.

Limitations of the Study

While this study provides valuable insights into the phonological development of Jordanian Arabic-speaking children with ASD, it is important to acknowledge its limitations. The sample size was relatively small, particularly for the TD group, which may limit the generalizability of the findings. Additionally, the study focused exclusively on children with high-functioning ASD, and the findings may not be applicable to children with lower-functioning ASD or those with co-occurring neurodevelopmental disorders.

Future Research Directions

Future research should aim to replicate this study with larger and more diverse samples to validate the findings and explore the phonological development of children with different levels of ASD severity. Additionally, longitudinal studies that track the phonological development of children with ASD over time would provide valuable insights into the trajectory of language acquisition in

this population. Research that explores the effectiveness of specific intervention strategies in improving phonological outcomes for children with ASD would also be beneficial.

Cultural Considerations in Phonological Development

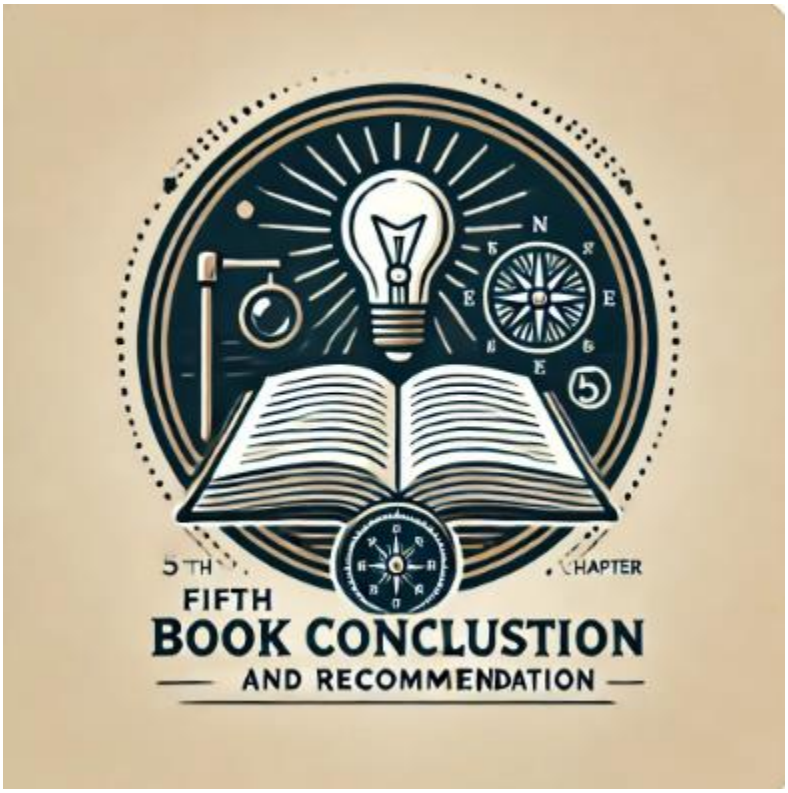
The study's focus on Jordanian Arabic-speaking children highlights the importance of considering cultural and linguistic factors in the study of phonological development. The unique phonological features of the Arabic language, such as its consonant clusters and emphatic sounds, may present additional challenges for children with ASD, which are not present in other languages. This underscores the need for culturally and linguistically appropriate assessment and intervention strategies for children with ASD.

Conclusion

In conclusion, this study provides a comprehensive analysis of the phonological development of Jordanian Arabic-speaking children with ASD, revealing significant delays and challenges compared to their typically developing peers. The findings underscore the importance of early identification and targeted intervention for children with ASD to support their language development. While children with ASD do show progress in their phonological abilities as they age, they do so at a slower rate and with greater variability than TD children. These results highlight the need for ongoing support and intervention to help children with ASD achieve their full linguistic potential.

Chapter 5:

Book Conclusion and Recommendation



5.1 Conclusion

This book has made a substantial contribution to the understanding of language development in children with Autism Spectrum Disorder (ASD), particularly through the lens of phonological metrics such as the Phonological Mean Length of Utterance (pMLU). The exploration of language acquisition patterns among children with ASD, compared to typically developing (TD) peers across various age groups, has shed light on the distinct linguistic challenges these children face. By focusing on pMLU and related measures—Proportion of Words Produced (PWP), Percentage of Consonants Correct (PCC), and Percentage of Words Correct (PWC)—the book emphasizes the critical role these metrics play in assessing and addressing language impairments.

A key conclusion of this book is the clear evidence of delayed phonological development in children with ASD. The consistently lower pMLU scores observed in these children, compared to their TD counterparts, underscore the slower pace of language acquisition, particularly in producing complex phonological structures. This delay is not merely a developmental lag but a significant barrier that can impede communication abilities, social integration, and cognitive growth over time.

The variability in language development among children with ASD is another critical conclusion. The book highlights that while some children with ASD may show gradual improvements in their phonological skills, others may struggle significantly without targeted, individualized interventions. This variability underscores the inadequacy of a one-size-fits-all approach to language development and points to the need for personalized, flexible strategies that can be adapted to the specific needs of each child.

The book also emphasizes the importance of early detection and intervention in language delays. The findings suggest that identifying language impairments early, using metrics such as pMLU, PWP, PCC, and PWC, can significantly enhance the effectiveness of interventions. Early identification allows for the implementation of tailored educational and therapeutic strategies that can help mitigate the impact of language delays and improve long-term outcomes for children with ASD.

Another significant conclusion drawn from this book is the potential of phonological measures as standardized tools for assessing language development in children with ASD. These measures not only provide a quantitative assessment of language abilities but also offer insights into specific areas of difficulty, enabling more precise and targeted interventions. The book advocates for the broader adoption of these metrics in educational and clinical settings as a means to better understand and address the unique language challenges faced by children with ASD.

The book also highlights the crucial role of collaboration among parents, educators, clinicians, and speech pathologists in supporting the language development of children with ASD. It underscores the importance of a coordinated approach where all stakeholders work together to create a supportive environment that fosters language acquisition and communication skills. This collaborative effort is essential in ensuring that children with ASD receive the comprehensive support they need to overcome language barriers.

Additionally, the book discusses the broader implications of language impairments in children with ASD on their overall development. It suggests that language delays can have cascading effects on other areas of development, including social interaction, academic performance, and emotional well-being. By addressing language impairments early and effectively, it is possible to mitigate these broader impacts and support the holistic development of children with ASD.

In conclusion, this book provides a comprehensive examination of the language development challenges faced by children with ASD and offers valuable insights into the use of phonological measures as tools for assessment and intervention. The findings underscore the need for early detection, personalized interventions, and collaborative efforts among all stakeholders to support the language development and overall well-being of children with ASD. Through these efforts, it is possible to enhance the communication skills of children with ASD, enabling them to achieve their full potential.

5.2 Recommendations

1. **Early Detection and Assessment**: It is recommended that parents, educators, and clinicians prioritize early detection of language delays in children with ASD. Utilizing phonological measures such as pMLU, PWP, PCC, and PWC can help identify language impairments early and allow for timely interventions.
2. **Personalized Intervention Strategies**: Given the variability in language development among children with ASD, it is crucial to develop personalized intervention strategies tailored to the specific needs of each child. These strategies should be flexible and adaptable to accommodate the unique challenges faced by individual children.
3. **Comprehensive Language Programs**: Implement comprehensive language development programs that integrate phonological training with other aspects of language acquisition, such as vocabulary building, syntax, and pragmatics. These programs should be designed to address the multifaceted nature of language impairments in children with ASD.
4. **Parental Involvement**: Encourage active involvement of parents in their child's language development journey. Parents should be provided with tools and resources to monitor and

support their child's language progress, including guidance on using phonological measures to track development.

5. **Collaborative Approach**: Foster collaboration among educators, speech pathologists, clinicians, and parents to create a cohesive support system for children with ASD. Regular communication and coordinated efforts among these stakeholders are essential for the success of language interventions.
6. **Standardization of Phonological Measures**: Promote the standardization of phonological measures like pMLU, PWP, PCC, and PWC in educational and clinical settings. Standardized assessment tools can provide a consistent framework for evaluating language development and tailoring interventions.
7. **Integration of Technology**: Explore the use of technology, such as speech recognition software and language development apps, to enhance phonological training and provide interactive learning opportunities for children with ASD.
8. **Teacher Training**: Provide specialized training for teachers to equip them with the skills and knowledge needed to support the language development of children with ASD. This training should include strategies for using phonological measures in the classroom and creating inclusive learning environments.
9. **Longitudinal Studies**: Encourage further research through longitudinal studies that track the language development of children with ASD over time. These studies can provide valuable insights into the long-term effectiveness of different intervention strategies.
10. **Inclusion of Siblings and Peers**: Promote the involvement of siblings and peers in language development activities. Interactions with typically developing children can

provide naturalistic language learning opportunities and enhance social communication skills in children with ASD.

11. **Focus on Social Communication**: Emphasize the development of social communication skills alongside phonological training. Social communication is a critical component of language development that can significantly impact a child's ability to interact with others.
12. **Cultural Sensitivity in Interventions**: Recognize the importance of cultural sensitivity in language interventions. Tailoring strategies to align with the cultural and linguistic backgrounds of children with ASD can improve the effectiveness of interventions.
13. **Speech-Language Pathology Services**: Ensure access to speech-language pathology services for children with ASD. These services should be integrated into early childhood education programs to provide consistent and specialized support.
14. **Parental Education Programs**: Develop educational programs for parents to increase their understanding of language development in children with ASD. These programs can empower parents to actively participate in their child's language interventions.
15. **Research on Comorbidities**: Investigate the impact of comorbid conditions, such as ADHD or sensory processing disorders, on language development in children with ASD. Understanding these interactions can lead to more effective, holistic intervention approaches.
16. **Policy Advocacy**: Advocate for policies that support early screening and intervention for language delays in children with ASD. Policy initiatives should focus on ensuring that all children have access to the resources and services they need for optimal language development.

17. **Public Awareness Campaigns**: Launch public awareness campaigns to educate communities about the importance of early language assessment and intervention for children with ASD. Increased awareness can lead to earlier detection and better support for affected families.
18. **Cross-Disciplinary Research**: Encourage cross-disciplinary research that combines insights from linguistics, psychology, neuroscience, and education to develop a comprehensive understanding of language development in children with ASD.
19. **Development of New Assessment Tools**: Support the development of new, culturally and linguistically appropriate assessment tools for evaluating language development in children with ASD. These tools should be designed to address the specific needs of diverse populations.
20. **Regular Monitoring and Feedback**: Implement regular monitoring and feedback mechanisms to assess the progress of children with ASD in language development programs. Continuous evaluation can help adjust interventions to ensure they remain effective and responsive to the child's needs.

5.3 Implications

1. **Impact on Educational Practices**: The findings from this book suggest that educational practices must be adapted to better support the language development of children with ASD. This includes incorporating phonological measures into regular assessments and designing curricula that address the specific language needs of these children.
2. **Influence on Clinical Approaches**: Clinicians, particularly speech-language pathologists, can use the insights from this book to refine their approaches to diagnosing and treating

language impairments in children with ASD. The emphasis on phonological measures can lead to more precise assessments and targeted interventions.

3. **Policy Development**: The book's conclusions have significant implications for policy development, particularly in the areas of early childhood education and special education. Policymakers should consider mandating early screening for language delays using standardized phonological measures to ensure timely interventions.
4. **Advancement of Research**: The book highlights the need for continued research into the language development of children with ASD, particularly in understanding the factors that influence phonological development. Future research should build on the findings presented here to explore new avenues for intervention and support.
5. **Parental Engagement**: The book emphasizes the critical role of parents in supporting their child's language development. This has implications for how educators and clinicians engage with parents, encouraging more active involvement and providing them with the tools needed to support language development at home.
6. **Teacher Training and Professional Development**: The book's findings underscore the importance of providing teachers with specialized training in supporting language development in children with ASD. This has implications for teacher education programs and ongoing professional development initiatives.
7. **Collaboration Across Disciplines**: The need for a collaborative approach to language development, involving educators, clinicians, and parents, is a key implication of this book. Such collaboration can lead to more effective interventions and better outcomes for children with ASD.

8. **Technology Integration**: The book suggests that technology can play a valuable role in supporting language development in children with ASD. This has implications for the design and implementation of educational technologies, as well as for how these tools are integrated into therapy and classroom settings.
9. **Cultural Sensitivity in Language Interventions**: The book's emphasis on the need for culturally sensitive language interventions highlights the importance of developing strategies that are tailored to the linguistic and cultural backgrounds of children with ASD. This has implications for both practice and research.
10. **Social and Emotional Development**: The book's focus on language development also has implications for the broader social and emotional development of children with ASD. Effective language interventions can lead to improved social interactions and emotional well-being.
11. **Inclusion in Mainstream Education**: The findings suggest that with appropriate support, many children with ASD can succeed in mainstream educational settings. This has implications for how schools design inclusive education programs and support systems.
12. **Long-Term Outcomes**: The book suggests that early and effective language interventions can have significant long-term benefits for children with ASD, including improved academic performance and better social integration. This has implications for how interventions are prioritized and funded.
13. **Global Relevance**: While the book's findings are drawn from specific contexts, they have global relevance. The implications for language development and intervention strategies can be applied across different cultural and linguistic settings, making this research broadly applicable.

14. **Equity in Education**: The book highlights the need for equitable access to language development resources for all children with ASD, regardless of their background. This has implications for educational equity and the allocation of resources within school systems.
15. **Development of New Therapeutic Approaches**: The emphasis on phonological measures in this book could lead to the development of new therapeutic approaches that focus specifically on improving phonological skills in children with ASD. This has implications for clinical practice and therapy design.
16. **Impact on Family Dynamics**: The book's findings suggest that effective language interventions can positively impact family dynamics by improving communication between children with ASD and their family members. This has implications for family-centered approaches to therapy and support.
17. **Public Health Initiatives**: The book's emphasis on early detection and intervention has implications for public health initiatives aimed at supporting children with developmental disorders. Public health programs could incorporate language screening as part of routine child health assessments.
18. **Professional Standards and Guidelines**: The findings from this book could influence the development of professional standards and guidelines for speech-language pathologists and other professionals working with children with ASD. These standards could include the use of phonological measures as part of best practices.
19. **Ethical Considerations**: The book raises important ethical considerations related to the assessment and treatment of children with ASD. This includes ensuring that interventions are evidence-based, culturally appropriate, and tailored to the individual needs of each child.

20. **Future Research Directions**: Finally, the book's conclusions point to several directions for future research, including the need to explore the relationship between phonological development and other aspects of cognitive and social functioning in children with ASD. This has implications for the broader field of developmental psychology and education.

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