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SYSTEMIC LITERATURE REVIEW: NEUROLINGUISTICS IN LANGUAGE PROCESSING IN CHILDREN WITH AUTISM SPECTRUM DISORDER (ASD)

Lenny Solo[1], Ninuk Lustyantie[2], Uwes Anis Chaeruman[3]

[1,2,3]Universitas Negeri Jakarta
E-mail : lenny.solo@mhs.unj.ac.id[1], ninuk.lustyantie@unj.ac.id[2], uwes@unj.ac.id[3]

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Corresponding Author:
Lenny Solo
Email Corresponding :
lenny.solo@mhs.unj.ac.id

ABSTRACT
Neurolinguistic research on language processing in children with autism spectrum disorder (ASD) has progressed markedly in the last ten years. The variability in research methodologies and results frequently hinders the formation of a holistic comprehension of advancements in this domain. This study is to do a comprehensive literature review to summarize and evaluate publication trends, principal subjects, and commonly employed methodologies in neurolinguistic research focused on language processing in children with ASD. This analysis also indicates underexplored research areas and gaps that can inform future investigations. This research used a Systematic Literature Review (SLR) methodology in accordance with PRISMA criteria to examine academic papers from many databases, including Google Scholar and Scopus. The research identifies numerous significant trends, such as heightened focus on lexical and semantic perception impairments, the application of brain imaging technology, and linguistics-based therapies. These findings are anticipated to provide a reference for more targeted future study and facilitate the development of therapies designed to improve language skills in children with ASD.

Keywords: Neurolinguistics, Autism Spectrum Disorder, Language Processing, Systematic Literature Review, PRISMA

1. INTRODUCTION

Autism Spectrum Disorder (ASD) is a neurodevelopmental condition that impairs a child's capacity for communication, social interaction, and behavioral engagement (World Health Organization (WHO), 2019). Studies indicate that the incidence of ASD cases is on the rise, and children with ASD frequently encounter challenges in language and communication. Language proficiency is essential for social engagement and education; nevertheless, children with ASD encounter considerable obstacles in this domain. Numerous individuals encounter challenges in comprehending conversational context, exhibit inflexible or repetitious language, and struggle to interpret social cues (American Psychiatric Association (APA) in (Maenner et al., 2020).

Arifuddin (Sastra et al., 2019) defines neurolinguistics as the neurology of language, an interdisciplinary discipline of linguistics that examines the brain's role in language understanding and processing. This field also examines issues related to language comprehension and production. It analyzes the structural components of the human brain associated with typical language processing to assess linguistic symptoms in individuals via their speaking and communicating skills.

2. LITERATURE REVIEW

Neurolinguistic is a branch of science that examines the relationship between language and the brain, particularly how the human nervous system processes, produces, and comprehends language. This discipline focuses on analyzing the brain's structure and functions that support language abilities, as well as the impact of brain damage on linguistic skills (Ratu Eka BKJ, 2024). Meanwhile, according to (Ade Aripardiansyah, 2024) in his article titled *Neurolinguistics: Exploring the Relationship Between the Brain and*

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Language, the study investigates the relationship between the brain and language, as well as how brain structure and function influence human language abilities in both production and comprehension.

Both perspectives emphasize the importance of neurolinguistics as a discipline for understanding the brain mechanisms underlying linguistic abilities and their impact on human communication. This aligns with dengan (Greig I. de Zubicaray & Niels O. Schiller (ed), 2019) in their book *The Oxford Handbook of Neurolinguistics*, where neurolinguistics is defined as an interdisciplinary study that explores the relationship between the brain's structure and functions and language ability. This field includes understanding how the human brain processes, produces, and comprehends language, as well as the impact of neurological disorders on linguistic abilities.

(Tripathi et al., 2020) support this view by stating that neurolinguistics is an interdisciplinary field focusing on the brain mechanisms underlying language acquisition, comprehension, and production. Their research highlights the importance of understanding the role of neural networks in language processing to uncover how various parts of the brain interact to support language functions. Neurolinguistics also involves studying the impact of neurological disorders on an individual's language abilities, significantly contributing to the development of clinical applications and language therapies.

Overall, neurolinguistics aims to unravel the complex processes within the brain that enable humans not only to master but also to effectively use language. The study of neurolinguistics is not only essential for understanding the normal process of language acquisition but also contributes significantly to understanding and addressing language disorders in cases of neurological abnormalities. This understanding provides a scientific foundation for developing therapies or interventions to address language disorders caused by brain disorders.

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder that impacts various aspects of an individual's social communication and behavior. Being a broad spectrum, ASD manifests in varying symptoms, ranging from difficulties in understanding and engaging socially to repetitive and rigid behaviors. The understanding and definition of ASD continue to evolve through contributions from various experts.

Simon Baron-Cohen in (Polónyiová et al., 2024) describes ASD as a condition characterized by social communication challenges and repetitive behavior. He highlights the concept of theory of mind, the ability to understand others' perspectives and emotions, which is often limited in individuals with ASD. According to him, this limitation in theory of mind hinders effective social interaction in individuals with ASD. In neurolinguistics, Simon Baron-Cohen (Polónyiová et al., 2024) emphasizes that the theory of mind concept helps explain how difficulties in understanding others can affect language processing and social comprehension.

Another approach comes from (Happé & Uta Frith, 2020) through the weak central coherence theory, which states that individuals with ASD tend to focus on details rather than seeing the overall context. This tendency makes it difficult for them to understand social meanings and contextual environments (Happé & Uta Frith, 2020). This theory is relevant in neurolinguistics because it illustrates how children with ASD may face challenges in capturing conversational contexts, ultimately affecting their overall language development.

(Turner-Brown & Frisch, 2020) highlight ASD as a neurodevelopmental condition characterized by difficulties in social communication and restricted, repetitive behaviors. In their book *Clinical Guide to Early Interventions for Children with Autism*, they explain that restricted and repetitive behaviors (RRBs) are one of the core features of ASD. These behaviors can take various forms, including an obsession with routines, highly specific interests in particular objects, or repetitive motor movements.

With these theories, neurolinguistic research into language processing in children with ASD becomes crucial to understanding the brain mechanisms related to language comprehension and usage in the context of autism. This study employs a systematic literature review approach to summarize key findings, research trends, methods used, and

gaps in neurolinguistic research related to language processing in children with ASD. The results of this review are expected to serve as a useful basis for future research and interventions to support language development in children with ASD.

Neurolinguistic research on language processing in children with Autism Spectrum Disorder (ASD) has grown significantly over the last decade. However, the diverse research approaches and findings often make it challenging for researchers to gain a comprehensive overview of the field. Therefore, this study aims to conduct a systematic literature review to summarize and evaluate trends, main topics, and the most commonly used methods in neurolinguistic research on language processing in children with ASD. Additionally, this study seeks to identify gaps or underexplored research areas that can serve as a guide for future research in this domain.

The objectives of this study are to (1) Identify trends in neurolinguistic research publications on language processing in children with Autism Spectrum Disorder (ASD) over the past 10 years, (2) Discover the most frequently studied themes or main topics in neurolinguistics related to language processing in children with ASD, (3) Describe the most commonly used methods and approaches in neurolinguistic research on language processing in children with ASD, and (4) Identify research gaps or areas that have not been explored within the field of neurolinguistics related to language processing in children with ASD.

The problem-solving plan designed through a systematic literature review (SLR) approach in this study includes: (a) Creating graphs or tables showing trends in the number of publications over time to understand the development and popularity of this topic over the last decade. (b) Developing classifications of main topics into categories most frequently discussed to provide an overview of the primary directions in neurolinguistic research related to ASD. (c) Compiling tables or diagrams displaying the most commonly used methods and their frequency to provide insights into the dominant research approaches in neurolinguistics related to ASD. (d) Listing research gaps or underexplored areas in the form of bullet points that can serve as recommendations for future research in the field of neurolinguistics and ASD.

3. METHODS

This research employs the Systematic Literature Review methodology in accordance with the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) criteria. A literature review is a research approach employed to gather data or sources pertinent to a specific issue, utilizing information from many sources such journals, books, theses, and other scholarly works (Sarmawati & Ghozali, 2020).

The data utilized in this study is derived from scientific published databases, both national and international, including Google Scholar, Scopus, Publish or Perish, and Web of Science. The utilized keywords are neurolinguistic, autism, and language processing.

The technique and data collecting for the systematic literature review assessment (PRISMA) comprises four steps: identifying the journals for inclusion in the meta-analysis; screening; determining eligibility; and final inclusion.

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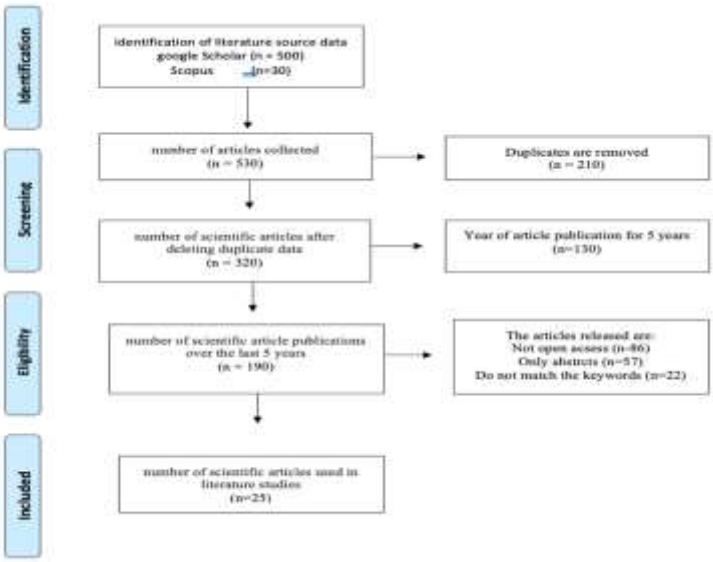
Figure 1. Chart flow PRISMA



4. RESULTS AND DISCUSSION

Trends in Neurolinguistic Research Publications on Language Processing in Children with ASD Over the Last 10 Years

Based on the 25 scholarly articles used in this study, the trends in publications within the field of neurolinguistics related to language processing in children with ASD over the past ten years show several key themes and patterns:

Table 1. Trends in Neurolinguistic Research Publications on Children with AS Over the Last 10 Years

No.	**Trend** publikasi penelitian neurolinguistik anak ASD dalam 10 tahun terakhir
1	Peningkatan Fokus pada Gangguan Persepsi Leksikal dan Semantik
2	Pendekatan Interdisipliner yang Semakin Meningkat
3	Penggunaan Teknologi Pencitraan Otak dan Teknik Elektrofisiologis
4	Model Terapi dan Intervensi Bahasa untuk ASD
5	Analisis Data Scientometric untuk Memetakan Produksi Penelitian
6	Studi tentang Pemulihan dan Pengembangan Bahasa Kedua pada Anak Bilingual dengan ASD
7	Kajian Literatur dan Analisis Pustaka tentang Neuroanatomi dan Neurofisiologi dalam Pemrosesan Bahasa

Increase in Focus on Lexical and Semantic Perception Disorders

Research in neurolinguistics has increasingly explored disorders in lexical and semantic perception in children with ASD. This research aims to understand how children with ASD process word meanings, sentence perception, and how these impairments affect their ability to communicate effectively.

Rising Interdisciplinary Approaches

Several studies have begun integrating approaches from various disciplines, such as neuropsychology, psychiatry, clinical linguistics, and cognitive science, to form more comprehensive models of assessment and intervention for children with ASD. This trend reflects the need for a holistic approach to understanding the diverse spectrum of ASD symptoms.

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Use of Brain Imaging and Electrophysiological Techniques

Some studies have used brain imaging techniques, such as fMRI and EEG, to map the brain areas active during language processing in children with ASD. These technologies provide deeper insights into brain mechanisms and may help identify areas that may be dysfunctional in individuals with ASD.

Language Therapy and Intervention Models for ASD

Recent research trends also show the development of language therapy models specifically designed for children with ASD, including behavioral approaches, speech therapy, and the use of Neuro-Linguistic Programming (NLP) to enhance motivation and engagement in language therapy.

Scientometric Data Analysis to Map Research Output

Some studies in the past decade have used scientometric analysis to evaluate and map neurolinguistic research trends. Through this analysis, it was found that neurolinguistic research in ASD is concentrated in specific regions such as North America, Europe, and Australia, showing an uneven distribution.

Studies on Language Recovery and Second Language Development in Bilingual Children with ASD

Research on aphasia and language disorders in bilingual individuals with ASD has also become an increasingly studied topic. This research aims to understand how first and second language recovery occurs and how linguistic approaches can support this recovery process.

Literature Review and Analysis on Neuroanatomy and Neurophysiology in Language Processing

Literature reviews on neuroanatomy and neurophysiology involved in language processing also form an important part of this research trend. These studies provide a strong theoretical foundation for understanding the locations and functions of brain networks involved in language processing in children with ASD.

Overall, the research trends over the past decade show an increasing interest in understanding brain mechanisms related to language in children with ASD, the use of modern technology for brain activity mapping, and the development of more comprehensive and evidence-based intervention models.

Main Themes or Topics Most Frequently Studied in Neurolinguistics Related to Language Processing in Children with ASD

Based on the research publication trends in neurolinguistics related to language processing in children with Autism Spectrum Disorder (ASD) over the past 10 years, the researchers identified several main themes or topics frequently studied in the field of neurolinguistics, particularly related to language processing and developmental disorders in children, as shown in **Table 2** below:

Table 2. Main Themes or Topics Most Frequently Studied in Neurolinguistics Related to Language Processing in Children with ASD

No.	Main Themes or Topics Most Frequently Studied in Neurolinguistics Related to Language Processing in Children with ASD
1	Language Processing in Children with Autism Spectrum Disorder (ASD)
2	The Influence of Neurolinguistics in Language Teaching
3	Syntactic Disorders and Language Units in Children with Intellectual Disabilities
4	The Role of Working Memory in Language Transfer Based on Gender
5	Linguistic Therapy Models for Bilingual Aphasia
6	The Relationship Between Emotions and Language Processing (Affective Neurolinguistics)
7	Neuroanatomy and Neurophysiology in Language Processing
8	Language Development in the Context of Early Childhood Education

9	Neuro-Linguistic Programming (NLP) Techniques to Enhance Student Motivation
10	Scientometric Analysis in the Field of Neurolinguistics

Language Processing in Children with Autism Spectrum Disorder (ASD). Many studies focus on understanding lexical perception disorders, semantics, and verbal expression in children with ASD. These studies often use neurolinguistic approaches to assess delays or difficulties in language, as well as the neuropsychological factors that influence language development in children with ASD.

Influence of Neurolinguistics in Language Teaching

Some articles discuss the application of neurolinguistics in language teaching, particularly the use of methods that stimulate both the left and right brain, such as learning with the SAVI approach (Somatic, Auditory, Visual, and Intellectual) or suggestopedia. This topic emphasizes how utilizing neurolinguistics can enhance the effectiveness of language learning.

Syntactic Disorders and Language Units in Children with Intellectual Disabilities

Research on syntactic disorders, such as word order and intonation, in children with intellectual disabilities or mental retardation has become a primary focus in several articles. This research aims to understand language difficulties in syntactic structure and how these barriers affect communication in children.

The Role of Working Memory in Language Transfer Based on Gender

Some articles examine how working memory influences second language abilities based on gender. This topic includes the analysis of the relationship between working memory capacity and fluency and accuracy in both planned and spontaneous language situations.

Linguistic Therapy Models for Bilingual Aphasia

Other articles discuss recovery and therapy models for individuals with bilingual aphasia, specifically how the recovery of the first and second languages occurs. This research identifies symptoms of aphasia and evaluates the effectiveness of linguistic therapy models for patients with aphasia.

The Relationship Between Emotions and Language Processing (Affective Neurolinguistics)

Several studies highlight how emotions interact with language processing in the brain. This topic, often referred to as affective neurolinguistics, includes research on the influence of emotions on lexical perception and morphosyntactic aspects.

Neuroanatomy and Neurophysiology in Language Processing

There is also research that focuses on the neuroanatomical structures involved in language processing, using neuroimaging techniques such as fMRI and EEG to understand the role of brain networks in understanding and producing language.

Language Development in the Context of Early Childhood Education

Some studies examine language development in children within the context of education, particularly how various areas of the brain support language skills such as speaking, listening, reading, and writing. This topic also includes implications for curriculum design that supports language development from early childhood.

Neuro-Linguistic Programming (NLP) Techniques to Improve Student Motivation

This topic involves the application of NLP techniques to increase motivation and self-confidence in at-risk students. This approach includes NLP techniques such as Progressive Relaxation and Circle of Excellence to support positive changes in students.

Scientometric Analysis in Neurolinguistics

Scientometric analysis is used to map the development of research in neurolinguistics, including publication distribution, countries involved, and

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frequently occurring keywords. This topic aims to evaluate knowledge production and key trends in the field of neurolinguistics.

These themes reflect the diverse focus of neurolinguistic research, encompassing studies on language disorders, language processing in normal and impaired conditions, as well as the application of neurolinguistics in education and language therapy.

Methods and Approaches Most Frequently Used in Neurolinguistic Research Related to Language Processing in Children with ASD

Based on the articles in this document, the following methods and approaches are applied in neurolinguistic research related to language processing and language disorders:

Table 3. Methods and Approaches Most Frequently Used in Neurolinguistic Research Related to Language Processing in Children with ASD

No.	Methods and Approaches Most Frequently Used in Neurolinguistic Research Related to Language Processing in Children with ASD
1	Observe and Matching Method
2	Qualitative Descriptive Method
3	Theoretical Analysis
4	Neuroimaging Techniques (fMRI and EEG)
5	Mixed Qualitative-Quantitative Approach
6	Case Study Method
7	Scientometric Analysis
8	Interdisciplinary Neuropsychological Approach
9	Content Analysis of Verbal Data from Children with Intellectual Disabilities
10	Neuro-Linguistic Programming (NLP)
11	Bibliographic Analysis and Literature Review

Observe and Matching Method

This method is used in studies analyzing the verbal expression abilities of children with autism through language usage observation. The method involves direct observation and referential analysis or matching to understand the linguistic context of children with ASD.

Qualitative Descriptive Method

Many studies use a qualitative descriptive approach to examine language development in children with developmental disorders such as Down Syndrome. This technique often involves interviews and observations to collect data on linguistic behavior.

Theoretical Analysis

Articles exploring the role of neurolinguistics in language teaching use a theoretical approach. Researchers discuss neurolinguistics concepts and learning models that stimulate both hemispheres of the brain without directly collecting empirical data.

Neuroimaging Techniques (fMRI and EEG)

Some studies use neuroimaging techniques like fMRI and EEG to observe brain activity during language processing. This approach allows for analysis of brain area activation during linguistic tasks such as grammaticality judgment and lexical decision-making.

Mixed Qualitative-Quantitative Approach

In studies on bilingual aphasia, a mixed-methods approach is applied to describe verbal expression and assess language proficiency using quantitative tools. This approach enables a comprehensive understanding of speech disorders from various linguistic aspects.

Case Study Method

Case studies are frequently used in neurolinguistic research on children with ASD or cerebral palsy, enabling in-depth analysis of language abilities and cognitive aspects of specific individuals, including the use of interviews and observation techniques.

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Scientometric Analysis

Some studies use scientometric analysis to map knowledge production in the field of neurolinguistics. This approach uses tools like CiteSpace and VOSviewer to evaluate the distribution of research based on countries, universities, or key topics.

Interdisciplinary Neuropsychological Approach

Studies on neuropsychological assessment in children with ASD use an interdisciplinary approach that combines neuropsychology, psychiatry, clinical linguistics, and cognitive science, supplemented with neuroimaging and EEG tools for in-depth evaluation.

Content Analysis of Verbal Data from Children with Intellectual Disabilities

This approach is used to understand syntactic disorders by observing verbal recordings of children with intellectual disabilities. The method focuses on transcription and syntactic structure analysis to identify patterns of disorders.

Neuro-Linguistic Programming (NLP)

NLP is used as a technique to improve motivation in at-risk students. This technique involves NLP-based interventions, such as the Progressive Relaxation Technique, to support motivation and self-confidence enhancement.

Literature Review and Bibliographic Analysis

In some studies, a bibliographic analysis approach is used to compile data from existing literature, especially for studies related to neuroanatomy, neurophysiology, and other theoretical aspects in neurolinguistics.

Each of the above methods is selected based on the specific goals of the research, the research subject, and the focus on neurolinguistics and language processing. These approaches allow for a deeper understanding of how the brain processes language and the challenges faced by individuals with developmental disorders.

Research Gaps or Unexplored Areas in Neurolinguistics Related to Language Processing in Children with ASD

Based on the literature review conducted by the author, several research gaps were identified that could provide a foundation for unique contributions to be explored. Below are the gaps identified by the author:

Table 4. Research Gaps or Unexplored Areas in Neurolinguistics Related to Language Processing in Children with ASD

No.	Research Gaps or Unexplored Areas in Neurolinguistics Related to Language Processing in Children with ASD
1	Lack of Interdisciplinary Approaches
2	Limitations of Observation Methods and Articulation Analysis
3	Qualitative Descriptive Methodology Without Quantitative Measurement
4	Limited Use of Learning Methods in Language Therapy
5	Lack of Long-Term Outcome Evaluation

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Lack of Interdisciplinary Approaches

Many studies focus only on one aspect, such as psycholinguistics or neurolinguistics, and rarely combine both. However, combining these two approaches could provide a more comprehensive understanding of how cognitive and neurological factors interact in second language acquisition in children with ASD. By uniting these perspectives, we can gain a more holistic understanding.

Limitations of Observation Methods and Articulation Analysis

Observation methods (simak) and articulation analysis tend to be descriptive and do not explain how the brain processes a second language in greater depth. Therefore, it would be better to combine this method with neurological approaches, such as neuroimaging, to better understand how the brain functions when children with ASD learn a second language.

Qualitative Descriptive Methodology Without Quantitative Measurement

Qualitative descriptive approaches are good for describing verbal expressions and language symptoms in children, but they are less helpful in providing measurable and objective assessments. To understand the extent of a child's progress in second language acquisition, this approach needs to be combined with quantitative measurements so that the results are more measurable and clearer.

Limited Use of Teaching Methods in Language Therapy

Many studies still use traditional teaching methods and have not explored innovative approaches such as Accelerated Learning or Suggestopedia, which stimulate both hemispheres of the brain. This gap indicates the need for further research to test new learning models specifically designed for children with ASD in learning a second language.

Lack of Long-Term Outcome Evaluation

Many studies only evaluate the outcomes of second language learning in the short term, without considering the long-term effects. This gap can be filled by conducting longitudinal studies that assess the ongoing development of second language skills in children with ASD, to identify factors that support or hinder their language progress.

4. 5. CONCLUSION

This study effectively identified trends, primary issues, and commonly employed approaches in neurolinguistic research concerning language processing in children with Autism Spectrum Disorder (ASD) throughout the past decade. A thorough literature review revealed an increased emphasis on lexical and semantic perception, alongside the application of brain imaging technology in neurolinguistic research on ASD. This study's findings underscore the increasing focus on multidisciplinary methods and the creation of evidence-based, comprehensive linguistic therapy models to enhance language abilities in children with ASD.

These findings indicate the necessity for ongoing study in neurolinguistics, namely to enhance comprehension of cerebral mechanisms in language processing and to devise more efficacious intervention strategies. Future study should utilize transdisciplinary methodologies and neuroimaging technologies to enhance language development in children with ASD.

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