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Speech Delay in Children: Causes, Impacts, and Interventions

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Abstract

Speech delay manifests as a pattern observed in children encountering verbal communication challenges, stemming from a restricted vocabulary or a slower speech development relative to peers. Language difficulties manifest in various forms, encompassing hearing loss, autism, disruptions in expressive or receptive language development, and medical or physiological ailments. This discourse undertakes an academic examination of speech delay and disorder in children, accentuating its ramifications on social, mental, and educational facets of growth. Genetic influences, notably the *FOXP2* factor, contribute significantly to speech impairments, while environmental determinants such as early language development contexts and socio-economic status exert discernible impacts. The imperative of early identification and expeditious intervention is underscored, necessitating tailored treatment objectives commensurate with the severity of the child's condition. The pivotal roles played by parents, educators, and speech therapists emerge prominently, pivotal in cultivating favorable outcomes and steering children toward their developmental aspirations with efficacy. The present review article highlights the causes, the effects, and the early intervention of speech delay issues in children's development. Additionally, it highlights the role of technology in enhancing speech therapy for children who suffer from speech pathology diseases. When children's speech is processed by supported technologies and pertinent feedback is given, therapies can be more successful.

Introduction

Speech is a unique characteristic of humans that has been a key factor in the evolution of our race. However, speech delay is a pattern in which the child has difficulties using language orally, such as unclear vocabulary or speech, and is developing at a slower rate than other children his age. Language disorders include hearing loss, autism, delays in developing expressive or receptive words, and mental or physiological conditions (Lina & Suryana, 2018). According to research conducted in the United States, the number of children who exhibit speech delay ranges from 5% to 8% at the age of 4.5 (Amalia *et al*., 2024). Kang & Drayna

(2011) reported that aphasia, stuttering, articulation problems, dyspraxia, and other speech function inadequacies are all connected to specific verbal impairments; therefore, children are most frequently affected by communication disorders. (Primary language and/or speech disorders can have an impact on one or more of the following categories: phonology (the child's preferred sound rhythm), vocabulary (words that a child is able to utter and comprehend), grammar (how that phrase is put together), morphology (meaningful word modifications to indicate, such as mood), and narrative skills (being able to tie together a number of thoughts). and pragmatic language (the capacity to discern what others are trying to say and engage in successful conversation) (Adam, 2012).

Early in life, children learn to use both receptive and expressive words. As they progress through school, most kids develop their language in a fairly systematic way, but some children struggle to keep up with their peers (Bishop, 2017). According to research, up to 60% of children with speech and language impairments do not fully catch up with their classmates, and these children are at a higher risk of long-term social, emotional, behavioral, and cognitive issues (Shriberg *et al*., 2003, Wooles *et al*., 2018). It has been demonstrated that language problems have a significant long-term effect: communication issues impede social, mental, and academic growth. These issues raise the risk of behavioral disorders, which eventually leads to adult unemployment and mental health problems (Conti-Ramsden *et al.*, 2008). Speech, language, and reading problems in children may significantly impact wellbeing both immediately and over time. However, a child's future treatment outcomes can be significantly enhanced by early detection of communication disorders and proper intervention (Plomin, 2001, Low & Charlton, 2017). Speech and language impairments are among the most frequent developmental issues in children. Such difficulties are classified as 'primary' if they have no known cause, and secondary if they are caused by another ailment, such as hearing and neurological damage, as well as developmental, behavioral, or emotional issues (Kumar, 2022). Thus, speech and language disorders inflence a child's development but can be solved through early identification, intervention, supporting children's long-term social and academic, as well as emotional growth. Thus, severe speech and language difficulties can lead to serious, long-term cognitive, social and academic consequences, and large societal and economic costs.

Biological causes of speech delay and disorder

Language and learning disorders are significantly influenced by genetic variables, and identifying the underlying genes can help define the fundamental neural pathways at play. Using this knowledge, we can identify disorders and the deficits in perception and processing that accompany them. For instance, early molecular genetic research on dyslexia seems to point to abnormalities in neuronal and axonal migration. Furthermore, additional research on people with these gene abnormalities may help identify recognizable cognitive impairments caused by neurological dysfunction (Smith, 2007). Inaddition, using linkage investigations and molecular genetic analysis, variations in the *FOXP2* gene were detected in a large family with many individuals who had verbal dyspraxia. Researchers now have a fresh avenue of research to pursue into the mechanisms and processes behind the origin of human speech as a result of the identification that the *FOXP2* gene encodes a transcription factor in the forkhead domain. Techniques: genetic alterations were discovered in related families by connection and gene candidates *GNPTAB, GNPTG,* and *NAGPA* in stuttering studies, which target the lysosomal enzyme pathway, indicating a key for inherited defects in cellular metabolism in this condition. Many loci linked to specific linguistic impairments have been identified through linkage

studies, and candidate gene association studies are working to identify causal mutations at these loci. Even though genetic outcomes have only been found in a small portion of language impairments to date, the tremendous progress gained by genetic techniques is persisting to show possibilities for searching for speech illnesses (Kang & Drayna, 2011). Additionally, the *FOXP2* locus was found in a second separate case of speaking dysfunction (CS) because of a de novo balanced translocation between chromosomes 7 and 5 (Lai *et al.,* 2001).

The neurogenic pathways that underpin our unmatched ability for spoken language are starting to be revealed by researchers. The complicated genomic syntheses that underlie this involve many different molecular functions. While uncommon protein-coding variations of the transcriptional factor *FOXP2* that seriously impair speech sound sequencing variations of frequent genetic vulnerability have an insignificant impact on genes, such as specific types of language impairments are correlated with the genes *ATP2C2*, *CNTNAP2*, and *CMIP*. The relationships between genes and the brain are being uncovered using animal models and cellular simulations. Interdisciplinary study at several levels is necessary to comprehend molecular connections, functional roles in the biology of neural cells, and consequences for the structure and activity of the brain. (Graham & Fisher, 2013).

Hoed & Fisher (2020) indicate that gene-driven research on other neurodevelopmental syndromes has revealed a blending of diagnostic categories, with some risk genes being shared by autism, intellectual impairment, and speech disorders. Converging evidence suggests that regulatory genes are co-expressed during the earliest stages of human brain development, indicating that etiological pathways may be amenable to study in developing neural models like cerebral or ganoids.When the language growth of a child is below normal for no apparent reason, it is considered to have a particular language disorder (SLI). The research that discovered SLI using theoretically motivated assessments of underlying cognitive deficits rather than conventional clinical criteria provided the most compelling evidence for genetic influences. (Bishop, 2006). Also, at the population level, gender was the most effective biological predictor of linguistic delays (Korpilaht *et al.,* 2016).

Males have a higher chance of linguistic disorders and DLD than girls. There are significant sex-dependent changes in brain development and structure, which can influence the individual vulnerability to risk factors. Sex differences are essentially determined by the presence (or lack) of sex hormones, which influence many aspects of cellular and synaptic development. Interactions between hormone surge timing, genetic expression, and (auditory) input may all influence the timing of developmental processes essential to language learning (Boerma *et al.,*2023). It is unknown how much a comparable etiology contributes to temporary language delay in infancy, despite the fact that genes significantly influence the emergence of specific linguistic disabilities (Bishop *et al.,* 2006). Genetic effects can be used to explain why children's conversational linguistic abilities are what they are. This finding offers an alternative interpretation of past research that children's natural speech varies according to how often they are exposed to different languages in the world around them (DeThorne *et al.,* 2008).Hence, Language and learning impairments are influenced by genetic and neurodevelopmental factors.

Environmental causes of speech delay and disorder

Early vocabulary development delays may be decreased by the protective environment, which includes young children in multiple language contexts that promote regular possibilities for reading, playing, and exchanging books (Collisson *et al.,* 2016). Early language delay appears to be primarily environmental in origin (Bishop *et al.,* 2003). Furthermore, the social status of both parents also had an impact on how well a child would speak (Korpilaht *et al.,* 2016).

Moreover, the growth of children of the same age will be hampered, and the child's social interactions and playing abilities will suffer. The idea is that if a child's language development differs from the degree of language development of other children his age, the child will encounter difficulties in social interaction. Children may be able to benefit from being bilingual (using both languages). However, parents and educators should think about how to implement it properly to avoid confusing kids and affecting their delayed speech (Lina& Suryana, 2018). Abida (2024) showed that screen time increases language and speech delays in children by 2.64 times compared to no screen time, with statistical significance. Only 5% (12/233) of studies investigated the effects of nutrition, toxin exposure, stress, and hormones on infant language development, despite the fact that we know from other domains that such factors have a significant impact on child development (Caspi *et al* 2007). Therefore, negative influences surrounding children may cause speech delay. Therefore, environmental factors, such as early contact, parental social standing, bilingualism, and screen time, all have a substantial impact on language development, emphasizing the importance of balanced therapies that adjust to individual requirements.

Corelation between genetics and environment

Many studies addressing epigenetic regulation of gene expression in sustaining the effects of early life experiences. Current research suggests that so-called epigenetic mechanisms of gene regulation, which alter gene activity without changing the order of their DNA sequence, may explain how early life experiences can leave indelible chemical marks on the brain and influence both physical and mental health later in life even after the initial trigger has passed (Dudley *et al.,* 2011).Language development demands both basic cognitive mechanisms for language acquisition and a rich social milieu in which learning occurs. Traditionally, researchers saw the effects of nature and nurture as separate. However, recent breakthroughs in genetic research have altered the theoretical discussion to one in which genetic and environmental factors play both direct and indirect roles in language teaching (Onnis *et al*., 2018). For instance, a study found that the genetic propensity for negative emotionality and surgency affects children's early language ability differently. Specifically, birth parent's negative emotionality appears to hurt children's early expressive vocabulary, whereas birth parents' surgency seems to influence children's early preliteracy skills positively. This study also discovered that maternal warmth and parental sensitivity have positive effects on language development that are unaffected by common genetic effects, as well as evocative effects of birth parent negative emotionality on warmth. Taken together, these results show not only how children's individual, genetically driven traits can affect emergent language, but also how important the early caregiving environment is for language development after accounting for specific genetic influences. (Cheung *et al.,* 2024).A study discovered that the effect of early food on children's IQ was controlled by genotype. Early breast feeding was connected with a mean IQ increase of about 6 points for children carrying a certain gene. Early breast feeding

was not linked to IQ differences in children who did not carry that particular gene. Such factors are only now being investigated in relation to developmental speech-language disorders (Mahurin & Amborse, 2013).

Moreover, the disparities in etiology and longitudinal development patterns have implications for the efficacy of early infant intervention. Given the importance of environmental variables over genetics, treatments aimed at specific areas of language and communication at this age should be broad in scope, concentrating on the in-utero and home environments. In contrast, speech development therapies at this age, which may be more strongly influenced by genetics, should contain a targeted component that expressly focuses on speech rehabilitation (Law *et al.,* 2000). As individual genes and environments are identified, it is better to understand the complicated mechanisms by which genotypes interact with their surroundings to form phenotypes.

The intervention for speech delay and disorder

As an immediate intervention to be activated, early detection of speech impairments in children is essential. Different therapeutic goals are established based on the perceived level of difficulty a child is experiencing. While elements of expressive language are frequently the focus, many studies also pay attention to verbal comprehension and receptive language skills. In the past ten years, pragmatic language issues have also received more attention. The focus of a treatment plan may be on a particular feature of language or a combination of several. Many speech therapists view the children's social abilities, capacity to blend in with classmates, and aptitude for navigating the curriculum as significant outcomes (Low, 2017).

Children should be taught by their parents to repeat their less-clear phrases so that they are no longer confused when pronouncing them (Lina& Suryana, 2018). Khoiriyah (2016) proposes that teachers can aid in a child's development by guiding them toward their life's aspirations. Without the teacher's role, a child's interests, skills, abilities, and potential will not develop effectively in terms of guiding, teaching, and directing (Kovas *et al.*, 2005). It is essential that parents stimulate and supervise their children's growth, especially between the ages of 0 and 2 years, to minimize developmental difficulties, particularly speech delays (Ulfah *et al.*, 2024). Thus, early diagnosis of speech deficits is critical for timely intervention. Therapy focuses on expressive, receptive, and pragmatic language abilities to better social and academic outcomes.

Technological advances in treatment

The field of speech-language pathology is becoming more and more dependent on technology, yet little is currently known about how therapists use it. In 2016, the UK government conducted independent investigations and found that the most common condition affecting children is speech-sound problems. Therapy results are impacted by speech therapists' growing caseloads and lack of opportunity for individual practice. Therapies can be more effective when assisted technology is used to process children's speech and provide relevant feedback. The design of these aids is especially difficult since they need to have child-friendly interfaces and high-fidelity voice recognition at the phoneme level (Nayar, 2017). The delivery of services through technology-based platforms that enable long-distance interventions across populations, age ranges, and geographic regions is known as telepractice or teletherapy. In

helping populations with communication issues, telepractice specifically makes use of communication technology like online modules, videoconferencing, and computer software (Christopoulou *et al.*, 2022).

Combining artificial intelligence (AI) and healthcare provides a workable solution for treating challenging conditions like speech-sound dysfunction (SSD) in youngsters. People with SSD have benefited greatly from augmentative alternative communication or AAC, and AI-driven techniques have even greater potential to improve diagnosis and treatment. It also draws attention to recent advancements and possible future paths. By using AI and ML techniques, healthcare providers can increase early identification, improve communication outcomes for children with speech problems, and offer individualized therapy (Bhardwaj *et al.*, 2024).In their work, speech-language pathologists have embraced a wide range of technological innovations, including telemedicine and tablet software (apps) that facilitate intervention techniques (Roper *et al.*, 2022).Therfore, technological tools are transforming speech therapy by allowing for remote interventions, individualized treatments, and improved outcomes for speech-sound disorders. These techniques address barriers such as high caseloads while boosting accessibility and efficiency.

Methods

This study adopted the qualitative method by inductive approaches, dependent upon the secondary sources and published resources related to speech delay in children. Evidence was derived from Google Scholar, PubMed, and Science Direct.

Conclusion

Severe speech impairments cause poor reading, lower academic achievement, and negative psychosocial effects.Individuals' development is profoundly influenced by speech delay and related issues, primarily stemming from genetic and environmental factors. Parents and teachers can support a child's growth by helping them to pursue their goals in life. Successful therapeutic approaches necessitate early identification coupled with a diverse array of intervention strategies. Once supported technology processes children's speech and provides pertinent feedback, therapies can achieve greater success. A nuanced comprehension of speech delay and disorder is imperative for sustained long-term development, with optimal outcomes achievable through collaborative efforts among parents, educators, and speech therapists in the treatment process. As research continues to develop, further studies unraveling the complex relationship between genetic predispositions and environmental influences will be crucial in increasing our knowledge on speech development and intervention strategies.

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