Artificial Intelligence Based Therapy for Speech-Language Childhood Assimilation

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ABSTRACT

A communication clutter that interferes in a child's throughout performance is labeled as Speech-Language disorder which makes it arduous for a standard conversation. Speech impairment and language impairment are the two types of childhood assimilation classified. Speech impairment is a constraint in which the excellence in producing speech sounds is undermined. The predicament in catching others' ideas, thoughts and feelings is relegated as Receptive Language Impairment and the distress in expressing one's own idea is delineated as Expressive Language Impairment. The above two of these impediments are congregated together and entitled as Language Impairment. The cardinal challenging hurdle for the kids with impairment is their inadequacy in social interaction. As an outcome, there is a pivotal prerequisite to establish NLP applications which support the disabled children by tracking the impediment at a prior phase. The errand of this article is to give a therapy for the kids who suffer from both language and speech impairment using NLP techniques. An algorithm, which automatically analyzes the child's intensity of impairment based on their age group by considering various semantic and structural attributes into account is designed. . The model also classifies the type of disorder and the intensity of the impairment afflicted and thereby providing a specific and systematic training to the children to overcome their ailment.

Keywords: *speech impairment; expressive language impairment; receptive language impairment; therapy; artificial intelligence; natural language processing.*

INTRODUCTION

In phonology, assimilation is elucidated as a process by which the pronunciation of one sound tends to become more like a nearby sound. It is discovered that one in every twelve children are affected by Speech-Language impediments. Language is defined as a measure of intelligence and therefore Language delays are more serious than speech problems. Assimilation doesn't always guarantee speech or language impairment. Enigma with speech and language in children usually appear in the production and awareness of sounds, words, syllables and sentences. Adding on, they may also face intricacies in communicating and learning. This means that a prior and protracted obtrusion is vital to the overall advancement of children with speech and linguistic disorders. Children with communication difficulty usually do not own the capability to be socially successful or to make friends. Communicative act incorporates emotional responses, explanations, social actions, or evaluations. Communication can be one among verbal or nonverbal and is categorized based on the communicative style and content. Nonverbal communication includes

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actions more than speech and verbal communication holds speech more than actions. Majority suffering from speech-language chaos find nonverbal communication more relaxed than verbal communication.

Various levels in the development of language include:

Stage 1: Attention and Listening

Attention And Listening is the very basic phase in the language development pyramid where the child pays attention to what people say and shows the willingness to listen to speech.

Stage 2: Play

Followed by the primary stage is the playing phase where the child is expected to make sounds while playing.

Stage 3: Understanding

In this stage the child listens to the conversation and understands what is being said.

Stage 4: Talking

This is the stage where the child responds to what is interpreted in phase three. The child develops basic communication skills at this level.

Stage 5: Pragmatics

Pragmatics is a level which makes sure that what is being said by the child is what the child actually meant.

Stage 6: Speech Sounds

The child is expected to develop all kinds of speech sounds and communication with the developed speech sounds.
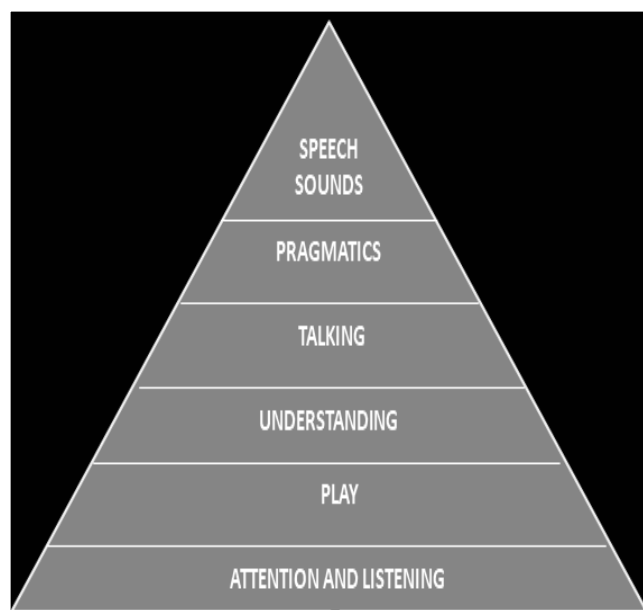
Fig. 1. Language Developmental Communication Pyramid

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Social stress is one of the primary agents which brews it indurates enough for children with communication disorder. These impediments have got the potential to influence the success of the child in day to day activities in a resentful manner. Prior intercession of a speech-language pathologist can create a great variation in the social and academic progress of the child as well as bringing about an affirmative change that lasts a lifetime. Children with communication disorders may not speak at all, or may possess a restricted vocabulary for their age from which some have difficulty in grasping simple things like directions or are even incapable of naming objects. Majority of the children with speech impediments are able to speak by the time they enter school but are inept when compared with typically developing children. Often the symptoms of communication disorder resemble other medical conditions which have to be noted. Predominantly, children fall under two classes. Taking the age factor into account, typically developing children perform according to the expected level then impaired children who lag in behind some sort of communication disorder and can be either speech impediment or language impairment or suffers from both the impediments. Treatment for the children influenced by both disorders is a real challenge. Developmental speech and language assimilation are the common cause for speech and language disorder in kids. The denouement of unattended Speech-Language impairment in children might bring on behavioral hitches, intellectual complications, barricade in reading where the child may even fail in academic level fulfillment. Therefore an adequate model is to be evolved which investigates whether the child is afflicted by any communication chaos. The proposed model primarily classifies the child either as typically developing child or impaired child based upon the intelligence test given to the child followed by a fine grain classification phase in which if the child is suffering from any sort of disorderliness, the system again classifies the impairment into various categories. The variegated fine grain classification is of three categories which include two types of language impairment namely Expressive Language Impairment and Receptive Language Impairment followed by Speech Impairment. The below depicted are variegated childhood impairment scenarios. A preliminary assimilation of the disorder results in an effortless rectification of the disorder.

Speech and literacy are scrupulously related to one another. Spoken language endows the substratum for the augmentation of reading and writing, and vice versa. Alternatively, spoken and written language has a reciprocal connectivity in each one building on the other to bring about language and literacy competence. Speech therapy is a clinical strategy specially developed for the children suffering from communication ailments, aiming at bettering their language and speech expertise. The kids with speaking adequacy may struggle in accomplishing their speech. It is corroborated that children with speech-language impairments frequently possess complexity learning to write and read just like children with reading and writing problems have complexity with spoken language. A preliminary stage detection of the communication disorder might expedite a relatively painless emendation of the chaos.
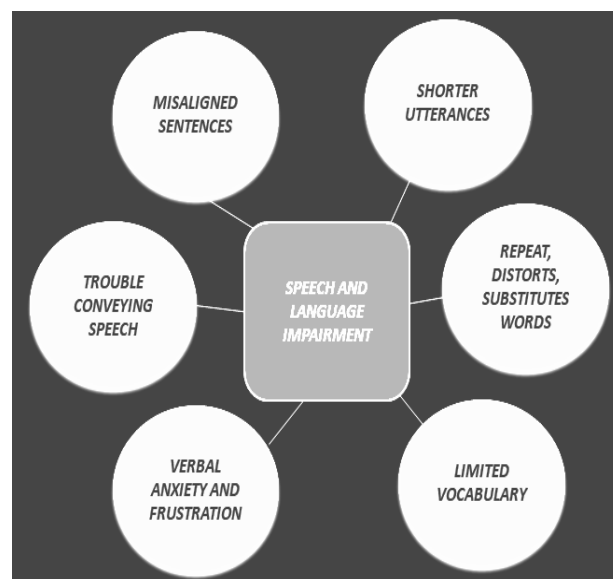

Fig. 2. Speech and Language Impairment Syndrome

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Causes of Speech Language Disorders:

- Hearing loss
- Speech language developmental disorder
- Prematurity
- Intellectual disabilities
- Autism

The objective of this article is to figure out whether the kid is impaired or not. The apportionment of the type of impairment the kid is suffering from, either expressive LI or receptive LI. Computation of the intensity of disorder in terms of percentage and providing felicitous training to the kids based on the diagnosed impairment intensity. The training model is based upon 2 levels, the basic level and the advanced level. If the age of child to be examined is older, then the child is given an advanced level training, else base level training. If the intensity of assimilation diagnosed is less than the threshold value, then the child is perfect and hence a therapy session is not necessary to be undergone.

SPEECH IMPAIRMENT

When a child is inadequate at producing speech sounds correctly and fluently according to the corresponding word pronunciation or has some sort of problem with the voice, then the child is expected to have a speech disorder. The organs like vocal cords, muscles, nerves, and other structures within the throat will be affected by speech affliction. Speech is the primary medium through which we communicate with one another. Speech impairment is an affliction in which the capability to generate speech sounds that are obligatory to communicate with others are on the blink. Speech impediments are disordered articulation which is different from language discombobulation. The complexity of Speech impairment varies from mild to severe in the manner that mispronouncing at intervals to not being able to pronounce at all. Some of the major reasons for disordered speech are proven to be devitalizing of speech muscles caused by injured nerves, throat cancer, upward movement of stomach's acid etc. Speech impairment can result in a contradictory impression on social development of the child which may lead to social isolation, humiliation and embarrassment. Articulation, childhood apraxia of speech, stuttering, disfluency and voice disorders are the most common speech disorders analyzed.

VARIOUS TYPES OF SPEECH IMPAIRMENT AND CORRESPONDING THERAPY

Articulation Disorder

Articulation disorders are entitled as the deformity and the dispossession of speech sounds where the child experiences agitation pronouncing blend sounds which can be caused due to physical complications such as neurological disorders, hearing loss, etc. In articulation impairment the child's hardship is at phonological level, which means the obstruction is in the creation of individual speech sounds. In a phonological chaos, the hardship is at phonemic level. The disorder is diagnosed in such a manner that if the distinctive words developed by the child are not as up to the age then the child could have an Articulation Disorder. The therapy for articulation deals with making the child pronounce speech sounds they cannot produce, starting from making them produce individual letter utterance and then blending with words. Articulation therapy is the process of teaching speech sounds that they are unable to produce.

The process of articulation therapy includes seven stages:
1. Isolation
2. Syllables
3. Words
4. Phrases
5. Sentences
6. Reading

7.   Conversation

Speech Apraxia in Children

Apraxia of speech in children is a type of speech impairment. Speech apraxia is afflicted by those who suffer from damaged muscles associated with mouth or tongue where they cannot move the muscles to the appropriate place to make right sounds, even though their muscles are not weak. The major cause for this disorder is the unwillingness of the child's brain to send messages to the mouth. The major aim of an Apraxia therapy for children is to make them say words, sounds and sentences clearly. CAS therapy takes time and the main thing which matter is the support given to the child giving the kid
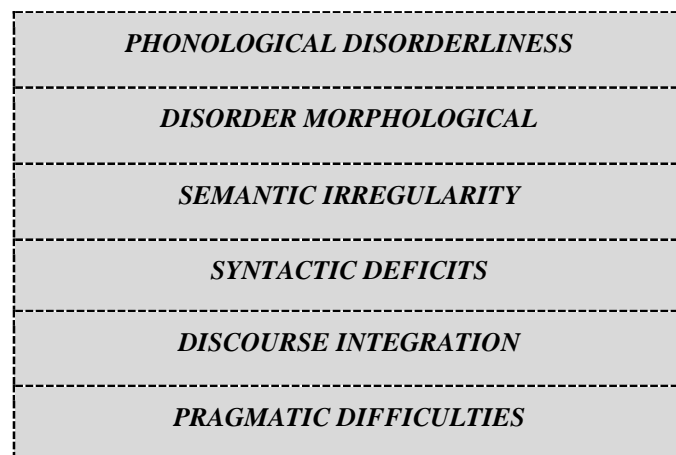
Fluency disorder

A fluency disorder is often referred to as stuttering. The major symptom of stuttering includes prolongation of single sounds and repetition of the same sound in a speech. The goals of speech therapy for stuttering include reducing the frequency of stuttering, giving a low stress atmosphere to the child, using proper communication skills such as eye contact or phrasing. In most of the children, one of the major reasons for stuttering is unconfident and therefore building confidence in the child plays a vital role in the therapy.

Voice disorder

Voice disorders are medical conditions which include poor quality of speech, loudness or abnormal pitch. Sound is created by the vocal cords and is passed through the mouth, nose and throat. The shape and size of the throat, nose, mouth and the shape and size of the vocal cords determines the sound of each individual voice. Any sort of deformity to those organs lead to voice disorder. So as a preliminary stage, if a child is diagnosed with a voice disorder a thorough checking of the organs is advised before entering into the therapy stage. Treatment for voice disorders includes direct and indirect approaches. Direct approach typically concentrates on the voice producing procedure whereas indirect approach focuses on the modification of psychological, behavioral and physical environment in which voicing occurs.

LANGUAGE IMPAIRMENT

Language impairment in children is defined as the onerousness in finding out the right word in a conversation which makes it difficult for the child to communicate with the world in an appropriate manner. Children affected by language impairment fail to put words at the right place and thus find hardship forming clear sentences and this interfere in the communication. Language impairment deals with the way that a child understands the content and how the kid is expressing it. The field of language impairment is radically categorized into six streams.

PHONOLOGICAL DISORDERLINESS
DISORDER MORPHOLOGICAL
SEMANTIC IRREGULARITY
SYNTACTIC DEFICITS
DISCOURSE INTEGRATION
PRAGMATIC DIFFICULTIES

Fig.3. Stages of language development as a disorder

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The stages in natural language processing are as follows:

Phonology is the first stage which implies the basic pronunciation of letters in a word followed by morphological analysis where the individual words in a sentence are broken down and non-word tokens are detached from the words. A structural form of the sentence is deprived in the syntactic analysis phase and the relationship between each word is analyzed. In semantic analysis, proper meaning is assigned to the structure created by syntactic analysis. Discourse integration implies the relationship among sentences stating the relationship between the current and previous sentence. Pragmatic analysis is a reinterpreting stage where the structure formed is again interpreted for the assurity that what was interpreted was what was actually said.

The main objective of language therapy model is the maximum advancement of the impaired child's language skills to a greater extend and to diminish the impact of the impairment by teaching the kid how to communicate in a simpler way which includes:

- Proper speech production
- Making the language fluent
- Improvising the quality of voice
- Augmenting effective communication

Receptive language impairment and expressive language impairment are the two kinds of language impairment which differ from each other.

Receptive Language Impairment:

Receptive language is exemplified as the excellence in grasping and the ability to receive information. Impairment which entails brain barricade is grouped as Receptive Language Impairment. Children with receptive language impairment will retain strain in grasping what others are saying and to interpret the matter in the correct way. The children even find it burdensome to decode even simple instructions or in ordering the information perceived and will be possessing poor listening skills which will affect their day to day life activities in a detrimental way.

This class includes:

- Poor listening and reading skills.
- Hardship following oral directions
- Trouble understanding humour
- Interpreting figurative language
- Comprehending complex sentences
- Complexity in responding to queries appropriately

Expressive Language Impairment:

The expertise in communication is termed as expressive language which is developed after receptive language. Children with Expressive Language Impairment experience trouble making conversations. They may understand what others convey and can pronounce words correctly but struggle expressing them although they have a proper functioning brain.

This class includes:

- Substandard sentence structure
- Restricted vocabulary

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- Grammatical errors
- Inefficient starting a conversation
- Difficulty in recalling information
- Hardship putting words forming sentence
- Trouble finding the appropriate word

The assimilation of the impairment as receptive and expressive is as follows:

| RECEPTIVE LANGUAGE DELAY	EXPRESSIVE LANGUAGE DELAY
Kids do not even recognize their own name even at the age of 12 months.	Kids do not even say one to two words at the age of 12 months.
Child does not look or point at objects at the age of 15 months.	A 'need' word like 'more' does not arise from the child at the age of 15 months.
Unable to follow simple instructions even by 18 months of age.	The kid will not be calling mom, dad even by 18 months of age.
Kid unable to point at objects when it is named even by 24 months.	Kid does not even use 25 words in a communication by 24 months.
Child does not respond loudly when called out or by nodding when asked questions at the age of 30 months	Child starts using only two word phrases at the age of 30 months.

Table.1. Diagnosis of Language Impairment in children

PROPOSED RESEARCH

The research is typically based on tracking down the language disorder which turns out to be a hindrance in their life stopping from success. The proposed model is a speech based therapy application which guides the children afflicted by impediments to overcome it without human intervention.

Proposed System Design:

The initial stage is the impairment verification phase, a binary classification problem which authenticates whether the child is afflicted by any sort of communication disorder. The disorder testing phase works by comparing the child's input to the image effectuated by the system and the output automated by the system deployed by deep learning techniques using convolutional neural networks.

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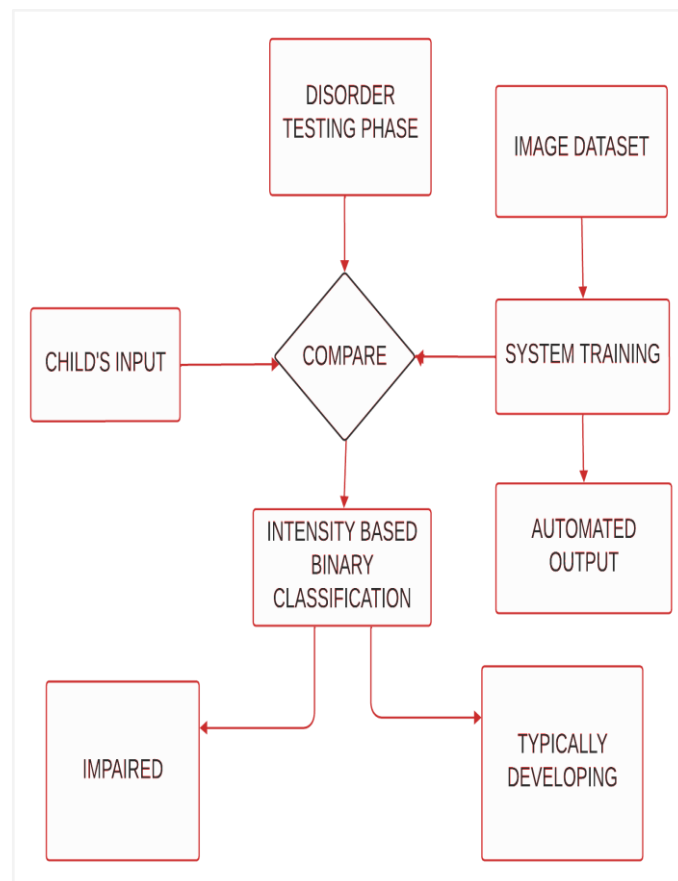
Fig. 4. Architecture of Intensity based diagnosis of disorder

Followed by the comparison, the percentage of exactness of the text framed by the child is measured and then the intensity of the imperfection in the child's input sentence is calculated by the system. If both the sentences are matching semantically and structurally with intensity less than the threshold value, the system endorses the kid as Typically Developing or else the child is classified as Impaired where typically developing children are those who accomplish proportionate to the expected standard and therefore a therapy session is not recommended.

The disorder afflicted child is subjected to a therapy session through images to prostrate the disorder prior to which a fine grain classification is performed. Fine grain classification is the second phase which categorizes the impairment into two types namely, language impairment and speech impairment. Language impairment is further categorized as receptive or expressive where receptive includes children with brain hitch and as a result the intensity of disorder suffered by them will be the most. As a consequence, the therapy session should eventuate from the very basic level.
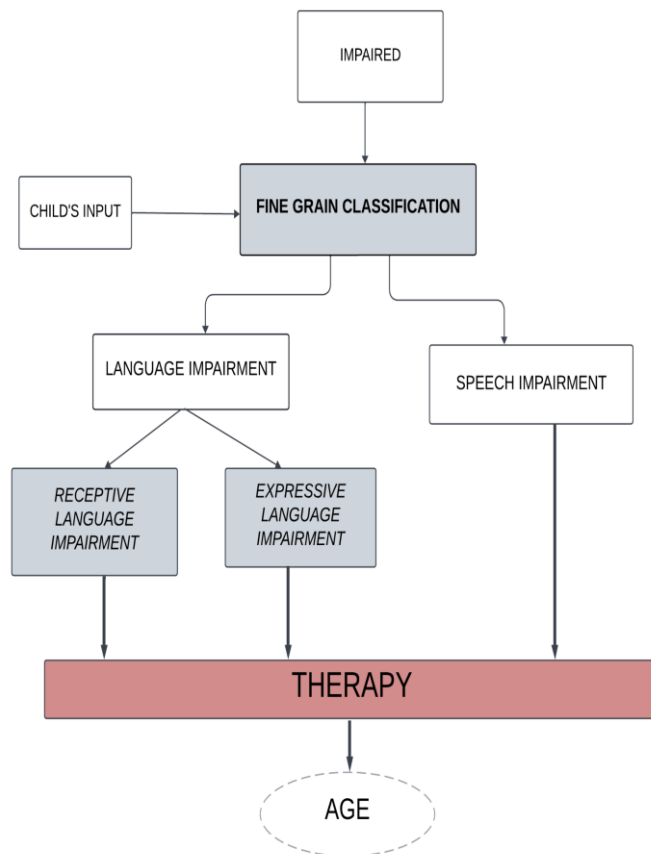
Fig. 5. Fine grain classification Architecture of the impairment

The age based therapy includes the children of age from five to thirteen which is partitioned into two stages. The impaired children from age from five to eight has to undergo basic level therapy session which has four different levels of training and on the other hand, if the age is in between nine to thirteen.

They have to be subjected to an advanced level training session which includes six levels of training.
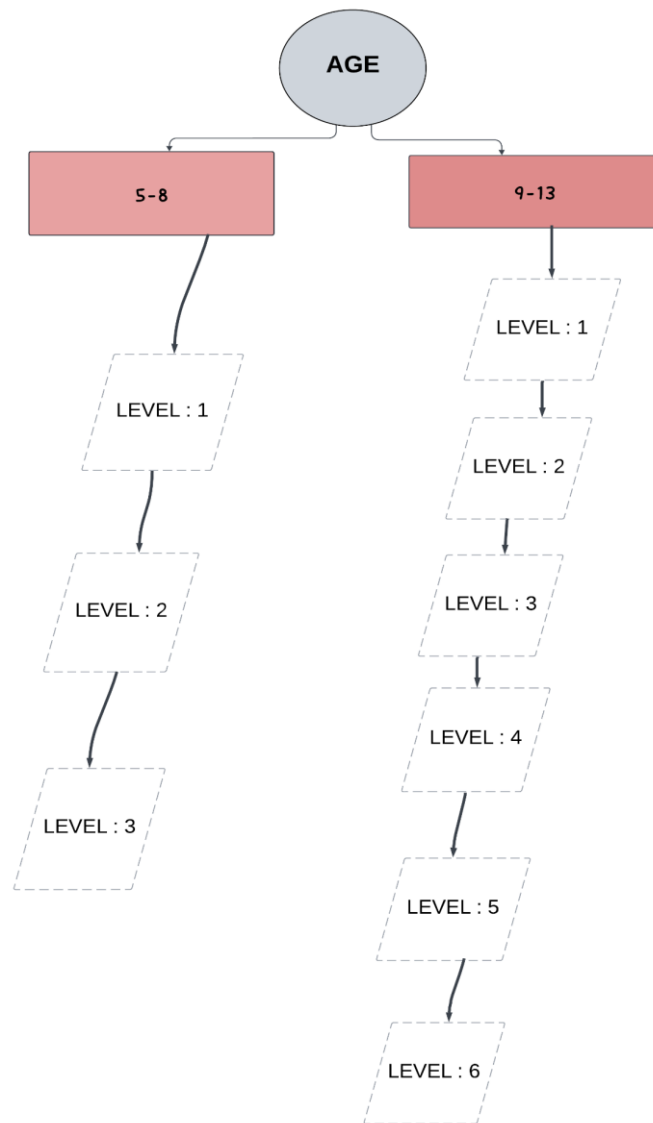
Fig. 6. Age based levels of therapy

Base level therapy for age groups five to eight.

The base level therapy is for children with disorder from age five to eight with impediment intensity above forty percent. Base level includes mainly four stages of therapy starting from the very basic object identification stage to sentence generation in a step by step manner so that the child could grasp easily in a systematic way.

Four stages in base level therapy:

1.   Single object identification

Single object identification is the very basic stage in base level therapy which verifies whether the child could name simple objects and this stage makes sure that the kid is not suffering from receptive language impairment. In case if the kid fails in identifying simple images, an object identification therapy is given till the kid learns.

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2.   List of identification of object information

List of objects identification is the second stage where the kid has to mention either the number of objects or list down the name of the objects or specify the color of the provided image..

3.   Framing simple sentences with single object

The third stage is the framing of simple sentences with a single object in which a simple object will be generated by the system to which the child has to frame basic sentences. This phase makes the child learn construction of basic sentences with a single object.

4.   Sentence generation with subject and object phrases

Sentence generation with subject and object is the final stage in base level therapy which moulds the child in framing sentences containing a subject and an object.

Advanced level therapy for age groups nine to thirteen.

The advanced level therapy is for children with disorder from age nine to thirteen with impediment intensity above the threshold value. Advanced level includes mainly six stages of therapy starting from the very basic object identification stage to complex sentence generation in a gradational procedure which reduces the complexity for the child.

Six stages in Advanced level therapy:

1.   Single object identification

Checks whether the child is aware of basic objects and if not a therapy for recognizing objects is provided.

2.   List of identification of object information

Checks whether the child is aware of listing out objects in an image and if not a therapy for recognizing objects and listing is provided.

3.   Framing of simple sentences with single object

This stage is a therapy for framing simple sentences. This stage is carried out with a single object which gives the child a basic awareness of where to use determiner, preposition and object.

4.   Sentence generation with subject and object phrases

A therapy for constructing sentences with a single subject and object is conducted where the child could be aware of how and where to use determiner, preposition, and noun.

5.   Sentence generation with subject, object and verb phrases

A therapy for forming sentences with subject, object and verb is conducted where the child could be aware of how and where to use determiner, preposition, verb, noun, and auxiliary.

6.   Description oriented analysis

The child is taught to use conjunctions combining two sentences.

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ENVISAGED RESEARCH

The prospected research work "Artificial Intelligence Based Therapy For Speech-Language Childhood Assimilation" would excogitate the seriate:

- A Binary Classification problem characterizing as typically developing or impaired
- Detection of impairment type.
- Calculation of the percentage of correctness of framed sentences and thus the degree of intensity measured.
- Considering the age group, providing speech based therapy.

RESULTS

A group of 10 children were taken for diagnoses with an impairment intensity of 80%. After the children underwent a testing session by the model, the reported intensity of impairment was 78% concluding that the accuracy of the model in testing is 98%. Followed by a training session reported the reduced disorder intensity to 40% by the model and that of 46% by the doctor. Therefore the accuracy of the model in testing refers to 94%.

CONCLUSION AND FUTURE WORK

Several deep learning, natural language processing features including syntactic and semantic, probabilistic and situational model features were explored. Adding to it came across various impairment types and the features. In the future, we plan to extend it as a tele-speech with video such that it connects to the internet and provides necessary assistance similar to customer care if needed.

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