

***AI-POWERED HANDWRITING ANALYSIS:
THE KEY TO SPOTTING DYSLLEXIA AND DYSGRAPHIA AT EARLY
STAGE***

Dr Javnika S Sheth

Hod Of Psychology,

Shah K S Arts and V M Parekh Commerce College, Kapadwanj

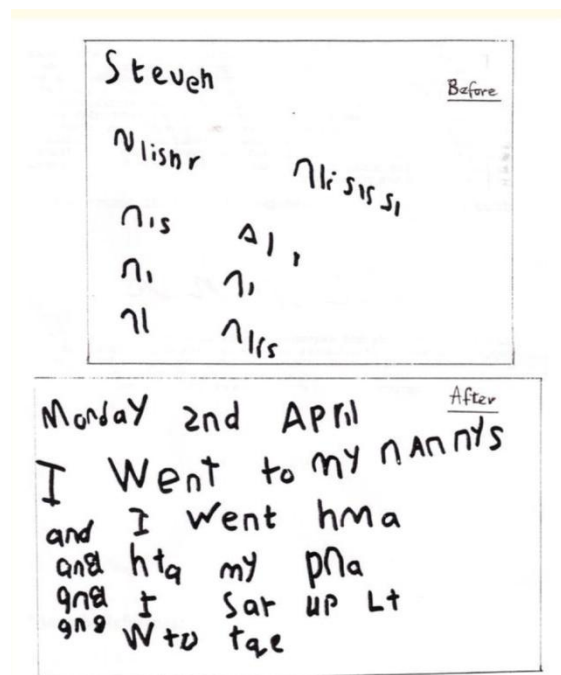
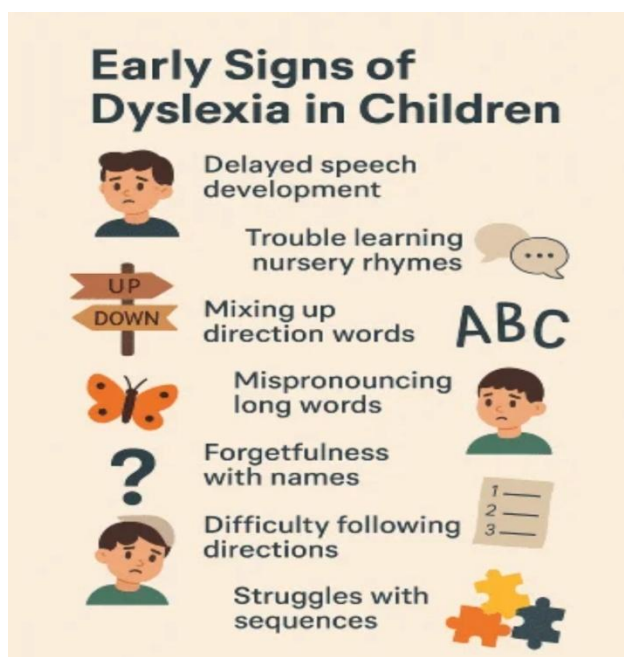
Abstract:

Dyslexia and dysgraphia are two specific learning disabilities (SLDs) that are prevalent among children. To minimize the negative impact these SLDs have on a child's academic and social-emotional development, it is crucial to identify dyslexia and dysgraphia at an early age, enabling timely and effective intervention. The first step in this process is screening, which helps determine if a child requires further instruction or a more in-depth assessment. Current screening tools are expensive, require additional administration time beyond regular classroom activities, and are designed to screen exclusively for one condition, not for both dyslexia and dysgraphia, which often share some common behavioural characteristics. Most dyslexia screeners focus on speech and oral tasks and exclude writing activities. However, analysing children's writing samples for behavioural signs of dyslexia and dysgraphia can offer valuable insights into the screening process, which can be time-consuming. As a solution, artificial intelligence (AI) tools that could boost the efficiency of screening and aid practitioners such as speech-language pathologists (SLPs), occupational therapists, general educators, and special educators by simplifying their tasks. This paper reviews current screening methods employed by practitioners, the use of AI-based systems in identifying dyslexia and dysgraphia, and the handwriting datasets available to train such systems. The paper also outlines a framework for developing an AI-integrated screening tool that can identify writing-based behavioural indicators of dyslexia and dysgraphia in children's handwriting. This framework can be used in conjunction with current screening tools like the Dysgraphia and Dyslexia Behavioural Indicator Checklist (DDBIC).

Dyslexia:

Dyslexia is a difficulty with the way the brain processes written and spoken language. It mostly affects reading and may be referred to as a "reading disorder." However, it can also

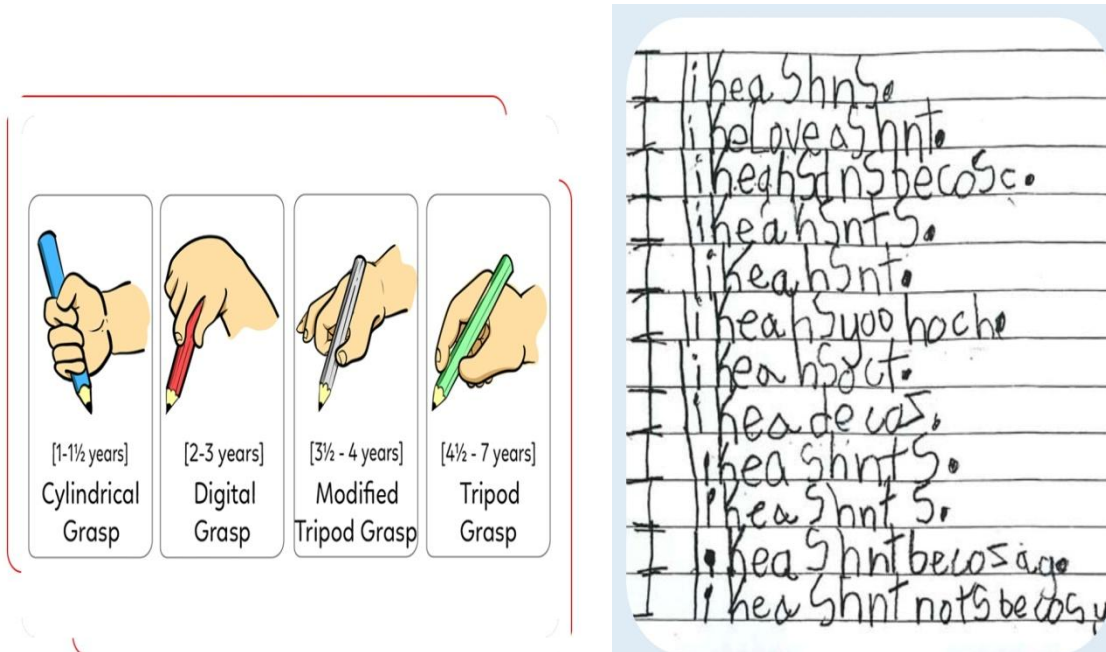
affect writing, spelling and speaking. In addition, dyslexia can impact social skills, listening comprehension, time management memory and navigation or sense of direction. The exact cause of dyslexia has not been identified. We do know that differences in genetics, the anatomy of the brain, and the activity between language-processing centres in the brain play a role in this learning disorder. Dyslexia is a lifelong condition that a child will not outgrow. A common misbelief about dyslexia is that it's a vision problem, but that's not the case. Rather, the brain of children who have dyslexia reverses or inverts the information it receives from the eyes. It is also important to know that dyslexia is not a result of laziness or lack of intelligence.



Dysgraphia:

Dysgraphia is difficulty with the physical act of writing. It can affect handwriting or typing on a keyboard. Dysgraphia is not a disorder of expressing oneself. However, it causes children to focus a great deal on physically transcribing words. This, in turn, can affect how they think about and convey ideas. Dysgraphia can be a result of dyslexia, motor skill (movement) coordination or problems understanding space (spatial awareness). Having dysgraphia does not mean that a student is lazy or that they lack intelligence. Dysgraphia, which involves the mechanical skills of writing, is only half the story when it comes to writing challenges. Sometimes a child has difficulty using the language or concepts involved to express themselves in writing. This is called disorder of written expression. The condition may also be referred to as a written language disorder. Disorders of written expression can

co-occur with other learning disabilities, along with Neuro developmental disorders such as attention-deficit/hyperactivity disorder (ADHD). It is estimated that about 60% of children with ADHD meet criteria for written language disorder by 19 years old. That's compared with about 12% of those without ADHD.

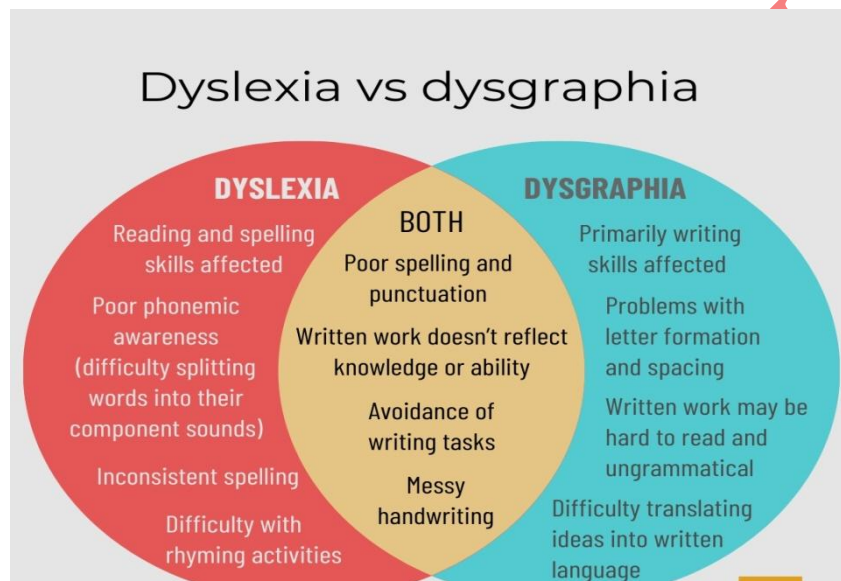


Handwriting analysis using AI:

Handwriting analysis using AI has emerged as a viable tool for the early detection of dyslexia and dysgraphia. The technology can identify several indicators, including misspelling, poor letter formation, and writing disorder. The AI models can identify motor difficulties through writing speed, pressure, and pen movement analysis as well as visual analysis of inconsistencies like irregular spacing and inconsistent letter size, common in people with these conditions. Moreover, AI can read cursive handwriting and digitize it, enable detection of common errors such as misspelling and letter reversal, and even determine underlying cognitive issues by reading grammar and vocabulary. Handwriting has consistently demonstrated unique and subtle features in comparison to the handwriting of dyslexic persons, including letter reversal and motor coordination issues that are amazingly revealing in describing neurological processing. As algorithms for the dyslexia detection become increasingly sophisticated, their applicability in the real world and their effect in regards of fairness are severely constrained by the size, calibration, and diversity of training data. This underlines a key gap for research: that there is a need for large representative datasets that are culturally and linguistically diverse to harness the maximum potential of AI for the diagnosis of dyslexia internationally, especially in multilingual environments such as

India. For AI-based dyslexia screening tools to achieve broad confidence and usage by educators, parents, and clinicians, high accuracy is not enough. These challenges underscore a critical research direction: the development of systems that are not only inclusive but also capable of leveraging multimodal indicators of dyslexia to enhance reliability and generalizability.

AI-powered handwriting analysis tools are revolutionizing the identification of dyslexia and dysgraphia:



Key Features of AI Handwriting Analysis Tools:

- **Letter and Word Recognition:** AI algorithms analyze handwriting samples, identifying patterns in letter and word formation, spacing, and alignment.
- **Stroke Analysis:** AI examines the pressure, speed, and direction of strokes, detecting irregularities in writing patterns.
- **Error Pattern Detection:** AI identifies specific error patterns, such as letter reversals, substitutions, or omissions, common in dyslexia and dysgraphia.

Indicators of Dyslexia:

- **Letter Reversals:** AI detects frequent letter reversals (e.g., "b" and "d" confusion).
- **Spelling Errors:** AI identifies consistent spelling mistakes, such as phonetic spelling or word omissions.

- Irregular Writing Speed: AI detects irregular writing speed or pauses, indicating processing difficulties.

Indicators of Dysgraphia:

- Irregular Letter Spacing: AI detects inconsistent letter spacing or sizing.
- Poor Handwriting Quality: AI identifies irregular handwriting, such as uneven strokes or slant.
- Difficulty with Copying: AI detects struggles with copying text, indicating fine motor or visual processing issues.

How AI Analysis Helps:

- Early Identification: AI-powered tools can identify early signs of dyslexia and dysgraphia, enabling timely interventions.
- Personalized Support: AI analysis informs tailored support strategies, addressing specific challenges.
- Monitoring Progress: AI tracks progress, adjusting interventions as needed.

Some popular AI-powered handwriting analysis tools include:

- Dyslexia Detection Tools: Tools like Dyslexia Screener and Dyteactive use AI to analyze handwriting and detect dyslexia.
- Handwriting Analysis Software: Software like Graphology and WritePad use AI to analyze handwriting patterns.

AI-Powered Tools:

- Dyslexia Screener: An AI-powered tool that analyzes handwriting and detects dyslexia.
- Dyteactive: A game-based AI tool that detects dyslexia and provides personalized interventions.
- WritePad: AI-powered handwriting analysis software that identifies writing patterns and provides feedback.

Interventions for Dyslexia:

- Phonics-Based Interventions: Targeted phonics instruction to improve reading skills.
 - Multisensory Instruction: Multisensory approaches, like Orton-Gillingham, to engage multiple senses.
 - Assistive Technology: Tools like text-to-speech software and dyslexia-friendly fonts.
- Interventions for Dysgraphia
- Occupational Therapy: Targeted exercises to improve fine motor skills and handwriting.
 - Writing Accommodations: Accommodations like extra time or writing aids to reduce writing stress.
 - Digital Writing Tools: Tools like speech-to-text software or writing apps with AI-powered feedback.

Dyslexia Screening AI Tools:

- Dyslexia Test: An AI-powered platform offering preliminary dyslexia screening for adults, assessing reading and writing challenges.
- Dystech App: A groundbreaking app using AI and machine learning to screen for dyslexia and motor dysgraphia, providing quick and affordable testing.
- Mindgrasp.ai: An AI learning assistant supporting reading comprehension and studying, tailored for dyslexic readers.
- Lexy: An engaging learning app using AI to support readers with dyslexia and other neurodivergent reading challenges.

Dysgraphia Screening AI Tools:

- AI-Powered Handwriting Analysis: Tools using artificial neural networks (ANNs) to analyze digital handwriting characteristics, detecting dysgraphia with high accuracy.
- Speech Recognition Apps: AI-powered apps transcribing spoken words into written text, assisting children with dysgraphia in improving writing skills

These AI-driven tools are transforming the way we identify and support individuals with dyslexia and dysgraphia.

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