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Beyond Phonics: Neuroaesthetic and Symbolic Divergence in Culturally Responsive Dyslexia Screening

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ABSTRACT: Recent advances in neuroscience and educational technology have challenged the traditional phonological-deficit model of dyslexia, revealing the profound influence of visual-symbolic processing, neuroaesthetic resonance, and cultural context in the reading brain. This article interrogates prevailing assessment paradigms by synthesizing research on the Visual Word Form Area (VWFA), cross-linguistic literacy systems, and emerging neurodiversity frameworks. The study addresses the urgent need to reconceptualize dyslexia as a heterogeneous divergence in symbolic processing—rooted as much in neuroaesthetic and visuospatial alignment as in phonemic awareness. Existing screeners, predominantly optimized for English and other Latin-based scripts, systematically neglect the cognitive realities of learners in multilingual and script-diverse societies, notably India, where more than 20 official scripts coexist and pedagogical infrastructure remains limited. Through an interdisciplinary review of neuroscience, visual culture, eye-tracking, typography, and cross-script cognition, we introduce the NeuroSymbolic Pattern Model (NSPM) as a new framework for inclusive, technology-enhanced dyslexia screening. Drawing on technological innovations such as AI-driven eye-tracking and neuroadaptive interfaces, the paper advocates for multimodal, script-responsive, and strength-based assessments. By decentering Anglocentric norms and integrating positive language approaches, this research advances a global, precision-education agenda capable of supporting neurodivergent learners across linguistic and cultural divides. The significance of this study lies in its call for educational equity, diagnostic accuracy, and embracing cognitive diversity as a foundational principle in the design of next-generation literacy screening tools.

KEYWORDS: Dyslexia, neuroaesthetics, visual word form area, culturally responsive screening, symbolic processing

1. INTRODUCTION

For much of the twentieth century, the dominant explanatory model for dyslexia rested on the notion of a core phonological deficit—a disruption in the cognitive processes responsible for the representation, manipulation, and retrieval of speech sounds (Snowling, 1998; Uppstad & Tønnessen, 2007). This theory, widely influential in English-language literacy research, framed dyslexia as a specific language-based disorder characterized by deficits in phoneme awareness and rapid automatized naming. The phonological deficit theory continues to shape both diagnostic protocols and intervention strategies in many educational systems, particularly those focused on alphabetic orthographies (Share, 2021). However, its explanatory power diminishes when applied across languages with differing phonological transparency and script structure, such as logographic or syllabic systems. Recent critiques highlight the theory's limited predictive value and lack of falsifiability, arguing that its apparent success stems more from conceptual vagueness than from empirical robustness (Zoccolotti, 2022). Furthermore, cross-linguistic analyses reveal that while phonological deficits may be common, their diagnostic salience varies significantly depending on language-specific properties, suggesting that phonology alone cannot capture the full spectrum of dyslexic profiles (Zhang et al., 2022). To address these epistemological and diagnostic shortcomings, recent scholarship has begun to reconceptualize dyslexia not as a unitary phonological deficit, but as a divergence in symbolic cognition and visual processing. This alternative framework foregrounds the role of the visual word form area (VWFA), a region in the left fusiform gyrus that recycles object-Recognition circuitry for reading (Canário, Jorge, & Castelo-Branco, 2020). Neuroscientific evidence now demonstrates that deficits in this area can correlate more strongly with reading difficulties than do phonological impairments alone, particularly in languages where phoneme-grapheme correspondence is inconsistent or absent (Ishida, 2025; Männel et al., 2017; Serniclaes & Sprenger-Charolles, 2015; Zoccolotti, 2022). Moreover, as Widmann et al. (2012) pointed out, some individuals with dyslexia exhibit relatively intact phonological awareness, while struggling with tasks requiring visual-symbolic fluency or pattern recognition, suggesting

Alternate cognitive pathways to reading difficulty. This reframing emphasizes dyslexia as a heterogeneous neurocognitive condition, shaped as much by visual and aesthetic alignment with script features as by phonological skills. Across the globe, dyslexia continues to be conceptualized and diagnosed through frameworks which prioritize phoneme-grapheme correspondence and alphabetic fluency, often rooted in Latin-script orthographies. This linguistic and visual bias marginalizes learners whose reading challenges stem not from phonological processing alone, but from divergences in symbolic interpretation, spatial encoding, or line differentiation. The dominance of standardized testing formats further compounds this disparity, penalizing visual-processing differences while failing to capture strengths in spatial, pattern-based, or kinesthetic symbol use.This paper posits the act of reading is not simply a phonetic occurance, but a symbolic and aesthetic one—an interaction between neural shape recognition, script structure, and culturally embedded visual literacy. By drawing on neuroaesthetics, cross-script visual design, and multisensory technology is the potential for a new diagnostic model: the NeuroSymbolic Pattern Model (NSPM). This model challenges deficit-based norms in dyslexia screening and invites pedagogical frameworks that affirm the symbolic richness of all learners, regardless of script or language. Through this lens, we advocate for assessments which understand cultural variation, neurological difference, and alternative visual fluencies.

Aims and Structure of the Study : This study poses two interrelated questions central to the reconceptualization of dyslexia in the twenty-first century. First, to what extent do prevailing phonological models overlook or misclassify learners whose difficulties stem from symbolic, visual, spatial, or cultural dissonance rather than phoneme-grapheme decoding? Second, how can emerging technologies and neuroscientific insights—including biometric feedback, neuroadaptive typography, and AI-driven gaze analysis—be harnessed to design screening tools that account for this broader spectrum of cognitive variation?

By addressing these questions, the article aims to construct a framework that is inclusive of neurasthenic and symbolic divergences, responsive to linguistic and cultural heterogeneity, and attuned to sensory-accessible design. In particular, this research advances the argument that the current Anglocentric, phonologically anchored diagnostic paradigms are insufficient for assessing dyslexia across global, multiscript, and multilingual contexts—especially in regions such as India, where over 20 official scripts coexist and dyslexia testing protocols remain linguistically and technologically underdeveloped. This critique draws from interdisciplinary sources, including visual neuroscience, neuroaesthetics, cognitive psychology, educational design, and AI-enhanced diagnostic methodologies. Central to this approach is the development and justification of a Neuroinclusive Symbol Processing Model (NSPM), which integrates the latest findings on the Visual Word Form Area (VWFA), tactile-symbolic encoding through 3D modular letter tools, script- and culture-specific font design (e.g., Aptos' curved terminals), and neuroadaptive screening technologies that respond to user gaze patterns and visual stress indicators.

The methodology is predicated on triangulating recent empirical research, comparative analysis of global literacy practices, and the evaluation of "inclusive" diagnostic tools such as multimodal, language-neutral screeners. This model prioritizes precision education—diagnostic processes tailored to individual cognitive profiles, linguistic backgrounds, cultural scripts, and sensory processing styles. Through reframing dyslexia as a spectrum of divergences in symbolic and aesthetic processing rather than a uniform phonological deficit, the NSPM facilitates more equitable identification and support for neurodivergent learners. This perspective challenges entrenched Anglocentric and phonocentric biases in conventional screeners, contending that a genuinely inclusive and scientifically valid approach must honor both the universality and the cultural specificity of reading acquisition and impairment. The significance of this work lies in its potential to reshape not only diagnostic paradigms, but also the cultural narratives and pedagogical practices that inform how literacy and cognitive diversity are understood—and supported—worldwide.

II. THEORETICAL FOUNDATIONS: THE VISUAL WORD FORM AREA AND NEUROAESTHETICS

Neuroscience of the VWFA and the Neuronal Recycling Hypothesis : The VWFA, or orthographic recognition cortex, situated in the left ventral occipitotemporal cortex, is central to skilled reading among literate individuals. Neuroimaging studies demonstrate that this region is selectively activated by written words and letter strings, while adjacent areas are tuned for objects and faces, indicating a domain-specific adaptation unique to literate brains (Agrawal & Dehaene, 2024; Zhan et al., 2023; Glezer et al., 2021). This specialization emerges only after sustained exposure to written language, illustrating the remarkable plasticity of the brain in accommodating cultural inventions such as literacy. This script-sensitive area is located among high-level visual recognition regions supports the "neuronal recycling" theory, which posits that neural circuits evolved for object

And face recognition are co-opted and transformed for reading (Hannagan et al., 2021; Li, Hiersche, & Saygin, 2024; Dehaene & Cohen, 2007). Importantly, this neural repurposing is constrained by the topography of the visual cortex, explaining the consistent anatomical placement across individuals and cultures.Computational modeling lends strong support to the neuronal recycling framework, showing that artificial neural networks trained for object recognition can be retrained for script recognition, producing units analogous to letter- and word-selective neurons (Hannagan et al., 2021; Marinai, Gori, & Soda, 2005; Ahr, Borst, & Houdé, 2016). Such models reveal the statistical structure of high-level vision (such as lines, intersections, T-junctions) providing a pre-adapted scaffold for reading, which is then refined through reading experience. Cross-script neuroimaging studies further clarify this specialized cortical territory for written words is not innately hardwired for language, but is instead shaped by script exposure, with bilingual readers displaying microstructural adaptation to each orthography (Agrawal & Dehaene, 2025; Lee, Dalle Ore, & Hervey-Jumper, 2024; Vinogradova & Cardin, 2024). Thus, the boundaries and tuning of the region are dynamic, adapting to the visual complexity and statistical properties of each writing system while preserving a universal architecture.

The implications for dyslexia research are significant: structural or functional deficits in the VWFA are now robustly linked to persistent reading difficulties that phonological interventions alone cannot remediate (Hills et al., 2005; Kershner, 2024; Parkins-Maliko, 2021). Individuals with diminished or absent activity in this fusiform reading area often exhibit marked impairments in rapid, holistic word recognition, suggesting the need for broader assessment and intervention models that include visual-symbolic and neuroaesthetic dimensions. By foregrounding the centrality and adaptability of this region, contemporary neuroscience advances a more pluralistic and culturally inclusive model of reading development and its disorders. This convergence of neuroanatomical, computational, and cross-linguistic findings urges a move beyond Anglocentric frameworks toward recognition of diverse pathways to literacy and their potential disruptions.

The Neuroaesthetic Dimension: Symbolic Line Patterns and Emotional Resonance The neuronal alphabet hypothesis posits that certain visual primitives—such as horizontal and vertical strokes, junctions, and closed contours—are universally favored in writing systems due to their alignment with the pre-existing biases for shape perception in the brain. These features, encoded by the visual cortex, form the structural basis for letters across diverse scripts, from Latin alphabets to Chinese logographs, highlighting a biological predisposition to recognize culturally constructed line forms that echo natural environmental patterns (Hannagan et al., 2021; Dębska et al., 2023; Changizi et al., 2006). Deviations from these elemental features (such as excessive ornamentation, unusual line arrangements, or dense visual complexity) can impose additional cognitive load and reduce legibility. This neurobiological foundation explains why certain scripts and typefaces are experienced as aesthetically pleasing or more “readable” across cultures (Jurman, 2025). For individuals with dyslexia, such visual complexity can further strain orthographic integration and symbol decoding, especially when the demands of the script are poorly matched to their visual processing strengths. The neuronal alphabet framework, therefore, bridges visual neuroscience and script design, underscoring the foundational role of aesthetic perception and line pattern fluency in literacy development.

Aesthetic fluency and emotional resonance in symbol recognition introduce a critical dimension to reading often overlooked by phonological or linguistic models. Empirical research shows that the perception of line patterns, especially those associated with meaningful cultural symbols, activates not only the VWFA but also networks for emotional appraisal and embodied cognition—including limbic and parietal circuits (Zeki, 2013; Kawabata & Zeki, 2004; Hutson & Hutson, 2024). Reading, therefore, is not merely symbolic decoding but a multi-sensory and affective experience, shaped by personal, cultural, and neural alignments with the visual features of the text. For many readers, preferences regarding font, layout, and line density can dramatically influence comprehension and engagement. Dyslexic individuals often report discomfort with visually dense lines, irregular spacing, or embellished typefaces, which supports the growing consensus that visual comfort is not incidental but integral to efficient reading (Dunne, 2024). The emerging field of neuroaesthetics illuminates how symbolic fluency and emotional alignment with script design can either facilitate or hinder literacy, suggesting that aesthetic factors may determine whether reading is perceived as accessible or alienating (Voz & Voz, 2025).

Perceptual overwhelm and visual stress are significant, though often underrecognized, contributors to reading difficulty, particularly in dyslexic populations. Symptoms such as text blurring, motion illusions, eye strain, and headaches during reading point to disruptions in visual processing rather than solely phonological deficits (Wilkins, 2003; Griffiths et al., 2016; Hutson & Hutson, 2024). Standard black-on-white text, crowded lines, or ill-suited fonts can create hostile environments for visual processing, disrupting eye movement and

Microfixation patterns and leading to interrupted, effortful reading. While tools such as colored overlays and adjustable formatting have shown efficacy in reducing visual stress, these accommodations are rarely included in mainstream screening or intervention protocols (Tooze, 2022). As a result, many dyslexic learners are underserved or misdiagnosed by assessments that ignore the role of visual environment. Recognizing visual stress as a neurobiological and affective constraint reframes literacy as a sensory and emotional encounter, advocating for neuroadaptive design and symbol-sensitive screening that validate diverse pathways to literacy and recognize visual-symbolic divergence as a legitimate, even generative, aspect of neurodiversity.

III. CROSS-LINGUISTIC AND CULTURAL PERSPECTIVES ON DYSLEXIA

Dyslexia Across Writing Systems: Alphabetic, Logographic, and Syllabic Scripts : The processing of written language across cultural scripts reveals significant variability in how the VWFA responds to different orthographic systems. High-resolution neuroimaging studies demonstrate that while the region is consistently involved in reading across writing systems, its fine-grained functional organization can differ depending on the visual demands of the script (Qu et al., 2022). For instance, English–French bilinguals, whose two languages use alphabetic scripts, show overlapping activation within the visual letterform area for both languages, suggesting shared neural substrates for visually similar scripts (Marano et al., 2025). However, English–Chinese bilinguals exhibit distinct neural patches within the region that selectively respond to Chinese characters, with some of these patches even overlapping with face-processing areas, highlighting the greater visual complexity of logographic scripts (Bai et al., 2011; Li et al., 2024; Zhan et al., 2022). These findings indicate that while there is a universal architecture for reading, the word-recognition region demonstrates language-specific tuning that reflects the visual and structural properties of the script.

Further empirical evidence supports this script-dependent organization in bilingual and multiscript readers. In early Chinese–Korean bilinguals, fMRI studies revealed substantial overlap in regional activation when processing Chinese and Korean characters, with no significant differences in the amplitude or spatial distribution of activation between the two scripts (Bai et al., 2011). This finding suggests that when scripts share similar visual structures, as Chinese and block-structured Korean Hangul do, the same area may efficiently support both within a unified neural territory. Conversely, scripts with divergent visual profiles—such as the English alphabet and Chinese logographs—are more likely to develop partially distinct cortical territories for each language, even within the same individual (Zhan et al., 2022). This adaptive neural plasticity enables the brain to accommodate contrasting orthographic demands but also underscores the necessity of considering script-specific factors in both research and educational assessment.

In addition to script structure, the cultural and linguistic context further shapes VWFA specialization. In multilingual societies where individuals navigate multiple orthographies from early childhood, such as in parts of East Asia or the Indian subcontinent, neuroimaging studies have begun to reveal nuanced patterns of co-activation and differentiation within the area depending on script familiarity, reading proficiency, and visual complexity (Zhan et al., 2023). For instance, the left fusiform gyrus in Chinese readers displays heightened sensitivity not only to stroke order and radical position but also to visual symmetry and character frequency, which influence how quickly, and accurately written forms are recognized (Li et al., 2024; Zhan et al., 2022). Such findings reinforce the view that dyslexia cannot be universally characterized by alphabet-based models alone. Instead, an inclusive approach must account for how different writing systems—alphabetic, syllabic, and logographic—interact with neural architecture and reading development across cultural and linguistic boundaries.

The Indian Context: Multilingualism, Script Diversity, and Assessment Gaps : Further adding linguistic complexity is the communicative ecosystem in India, which is among the most complex globally, encompassing over twenty-two officially recognized languages and hundreds of regional dialects (Chakraborty, 2025). These languages are written in diverse scripts, most of which descend from the ancient Brahmi script and fall into the category of abugidas or alphasyllabaries. Unlike alphabetic systems where individual letters correspond to phonemes, abugidas encode syllables with attached vowel markers, and their intricate visual design poses unique challenges for early literacy acquisition (Islam & Khatun, 2024). Common Indian scripts—such as Devanagari, Kannada, Telugu, Tamil, and Malayalam—feature visual complexity, ligatures, and large symbol inventories, which are not adequately addressed by English-centric screeners developed for alphabetic scripts (Vasudevan et al., 2023; Pandey & Jha, 2016; Share & Daniels, 2016). The oversimplified categorization of scripts along a shallow-to-deep orthographic continuum fails to capture these distinctive structural properties. As such, the standard literacy assessments used in India often lack the sensitivity to detect reading difficulties that emerge from script-specific processing challenges (Banumathi et al., 2023).

Despite India's extensive multilingualism, there remains a significant absence of pedagogical and diagnostic infrastructure for non-Latin scripts. Tools such as the Dyslexia Assessment for Languages of India – Dyslexia Assessment Battery (DALI-DAB) have made strides in addressing this gap by incorporating screening protocols for Hindi, Marathi, Kannada, and English, yet the full diversity of scripts used in Indian classrooms remains unrepresented (Rao et al., 2021). Screening studies in Kerala, for example, have shown that children make more spelling errors in Malayalam than in English, despite the transparent phonology of Malayalam—a discrepancy attributed to the complex visual structure and large character set of the script (Dhanya, Kaimal, & Nedungadi, 2022). Similarly, in Tamil-speaking populations, the lack of regional language apps for dyslexia screening has hindered early identification, prompting recent efforts to develop AI-based tools tailored to local language contexts (Banumathi et al., 2023). These findings highlight a crucial issue: while phoneme-grapheme mapping may be straightforward in many Indian languages, visual-symbolic complexity introduces unique barriers to fluent reading that are inadequately addressed in current educational and clinical practices.

The issue is further complicated by rigid "native language" requirements and the lack of cross-script diagnostic frameworks. Many state-level literacy interventions are administered in the state's dominant language, which may not reflect the learner's primary home language or the script in which they have higher fluency. In multilingual classrooms, children often switch between scripts (such as Devanagari and Latin or Malayalam and English, while receiving instruction and assessments only in one, often English. This monolingual approach can result in misdiagnosis or underdiagnosis of dyslexia in children who exhibit literacy challenges in one script but not another (Dhanya, Kaimal, & Nedungadi, 2022; Prabhu et al., 2024). The absence of protocols that assess biliteracy or multiscript fluency means that educators lack the tools to distinguish between language learning delays and genuine neurocognitive impairments. Furthermore, the pressure to perform in English—a deep orthography—can obscure learning profiles that might otherwise be functional in a more visually regular or transparent script, masking the true nature of the reading challenge.

Visual-Symbolic Processing Versus Phonological Decoding : Shifting to a broader neurocognitive lens reveals that many of these script-dependent difficulties may arise from visual-symbolic processing demands rather than phonological deficits alone. Eye-tracking studies in logographic and syllabic scripts demonstrate that dyslexic readers exhibit longer fixation times, more regressions, and more erratic saccadic movements compared to typical readers—patterns which suggest difficulties in visual integration rather than phoneme decoding (Zhan et al., 2022). In Indian scripts, where the visual complexity of aksharas (syllabic units) requires precise spatial parsing, these difficulties may be compounded, particularly when scripts include nested diacritics, conjuncts, or ligatures. Moreover, evidence from Kannada-speaking learners shows that the lack of phonological processing tools aligned with script features limits the ability to detect subtle forms of dyslexia, such as sub-lexical or letter-position variants (Prabhu et al., 2024). This necessitates a reassessment of the diagnostic paradigm that currently privileges phonemic accuracy over visual-symbolic fluency.

Non-phonological factors such as visual memory, pattern recognition, and symbol overload have increasingly been recognized as critical dimensions of dyslexia, particularly in visually dense scripts. For example, studies have shown that poor readers in Malayalam experience higher orthographic error rates despite the phonological transparency of the script, pointing to visual stress and overload as key variables (Dhanya, Kaimal, & Nedungadi, 2022). Additionally, children with dyslexia often demonstrate strengths in spatial reasoning or artistic abilities—attributes that suggest their difficulties lie not in symbol decoding per se, but in the aesthetic alignment between cognitive style and script structure (Zakaria et al., 2024). The rigid application of phonological models to these learners may not only miss the root of the difficulty, it may also pathologize what is fundamentally a perceptual mismatch between learner and literacy environment. A neuroaesthetic approach reframes dyslexia as a divergence in symbol interaction, emphasizing the importance of aligning script features with individual perceptual and cognitive profiles.

This reframing has profound implications for literacy policy and educational equity in multilingual societies. If reading acquisition is as much a visual and emotional process as a phonological one, then screening tools must be designed to reflect the structural and aesthetic realities of diverse scripts. This includes integrating multimodal tasks—such as visual pattern replication, glyph tracing, or symbol-matching games—into standard assessments to capture a fuller picture of symbolic fluency (Yap, Aruthanan, & Chin, 2025). Furthermore, it advocates for the development of culturally and linguistically responsive screeners that evaluate reading skills across scripts rather than within isolated orthographies (Toki, 2024). Such innovations could reduce false negatives in languages with transparent phonology, but complex visual architecture and could better support biliterate children navigating alphabetic and abugida scripts concurrently. Recognizing dyslexia through this broader lens invites a more inclusive model of literacy development, one which validates diverse neural and cultural pathways to reading.

IV. EMERGING TECHNOLOGIES AND NEUROINCLUSIVE SCREENING MODELS

Eye-Tracking and Artificial Intelligence in Dyslexia Assessment : Eye-tracking and AI-driven technologies are transforming dyslexia assessment by enabling scalable, neuroinclusive, and culturally responsive diagnostic methods. Unlike traditional phonological screeners, which often rely on subjective observation or alphabetic normativity, these technologies capture real-time visual processing patterns that reveal symbolic fluency and orthographic misalignment across diverse cognitive profiles. Platforms such as Lexplore and UCSF's Multitudes illustrate this shift: they leverage AI-enhanced gaze analysis to flag atypical reading behaviors in both monolingual and multilingual contexts (McGinley et al., 2021; Toki, 2024). Lexplore, for example, uses infrared eye-tracking and machine learning to identify early signs of reading difficulty by detecting prolonged fixations, regressions, and inefficient saccades—metrics that are especially salient for learners whose decoding struggles may stem from visual-symbolic divergence rather than phonological deficit (Tavakoli, 2021).

Such platforms operationalize the principles of the Neuroinclusive Symbol Processing Model (NSPM) by highlighting the perceptual and aesthetic routes through which reading takes place. Eye-tracking allows the precise measurement of fixation duration, saccade length, scan path variability, and spatial sequencing, features which together encode how the brain negotiates symbol-to-meaning relationships. Dyslexic readers often show longer fixations, increased regressions, and non-linear gaze patterns, indicating disruptions in visual-symbolic fluency even when phonological awareness is preserved (Svaricek et al., 2025). These oculomotor signals—interpreted through convolutional neural networks and heatmap visualizations—can now distinguish between attentional lapses, orthographic confusion, and symbolic overload with unprecedented granularity (Gracheva & Shalileh, 2023). Importantly, this precision enables strength-based diagnostics. For instance, a student who processes visual stimuli through spatial or proprioceptive channels may benefit from the integration of AI-informed gaze data with tactile tools, such as 3D-printed letter formation kits, or from typography that reduces visual interference, as seen in Microsoft's neuroadaptive Aptos font redesign. These innovations reflect the broader neuroaesthetic imperative: diagnostic tools should adapt to—not pathologize—variations in how learners visually and symbolically engage with written language.

Scalability and cross-linguistic generalizability are also critical. Studies in Arabic, Mandarin, and Scandinavian orthographies demonstrate that AI-guided eye-tracking retains diagnostic accuracy when adapted to account for script complexity, visual density, and directionality (Ikermane & Mouatasim, 2023). This supports the development of modular, language-responsive algorithms trained on culturally specific reading strategies. Moreover, advances in camera-based eye-tracking using smartphones and tablets eliminate the need for specialized hardware, expanding access to diagnostic tools in under-resourced educational settings.In sum, the integration of eye-tracking into dyslexia screening represents more than a technical advance—it exemplifies a paradigmatic realignment. It operationalizes the NSPM's call for multimodal, culturally attuned, and neuroaesthetically informed diagnostics. By shifting focus from phoneme decoding alone to dynamic symbol navigation, these technologies enable a more equitable literacy landscape for neurodivergent and multiscript learners worldwide.

Multimodal, Language-Neutral Assessment Tools : Parallel to these developments, multimodal, language-neutral assessments are being designed to evaluate visual-symbolic fluency without relying on reading tasks. These tools test underlying cognitive abilities essential to literacy (such as pattern recognition, sequencing, and symbol manipulation) using abstract visual stimuli, puzzles, or game-based interfaces. "Reading-free" diagnostics, for example, assess children's ability to replicate symbol patterns or navigate mazes, which serve as proxies for symbol integration and working memory (Svaricek et al., 2025). Such tasks are particularly valuable in multilingual environments where learners may not yet be fluent in the language of instruction, or where cultural stigma inhibits the disclosure of literacy difficulties. These visual-symbolic assessments offer an inclusive framework that accommodates diverse cognitive profiles and does not penalize students for linguistic background.

Sensory processing and visual stress assessments have also become integral to emerging screening models. Many individuals with dyslexia experience discomfort from conventional text formats, leading to perceptual overwhelm, eye strain, and headaches. Tools such as ReadEZ and other visual ergonomics platforms now integrate dynamic testing for optimal font size, color overlay, spacing, and contrast (Arbelaez Garces et al., 2024). These interfaces can adjust in real time based on user feedback or biometric indicators, thereby identifying cases where visual stress—not phonological deficit—is the primary reading barrier (Toki, 2024). AI-driven screening systems are increasingly incorporating these features to generate holistic reader profiles that inform personalized accommodations, reducing misdiagnosis and supporting inclusive intervention strategies.

Synthesizing these technologies is the proposed NSPM, a framework designed to integrate multiple modes of input and deliver adaptive, equity-focused dyslexia assessment. The first component, Eye-Tracking Symbol Processing Analysis (ET-SPA), utilizes gaze data to evaluate symbol recognition and spatial scanning efficiency across scripts. The second, Neuroaesthetic Pattern Recognition Task (NPRT), assesses fluency with culturally salient symbol sets and tests aesthetic preference alignment—a key factor in visual-symbolic processing. The third, the Adaptive Multiscript AI Assessment Engine (AMAE), dynamically shifts between scripts and adjusts difficulty based on user performance, enabling side-by-side comparisons of reading in different languages. Together, these tools offer a nuanced profile of symbol interaction, visual fluency, and script-specific strengths or vulnerabilities.

The Neuroinclusive Symbol Processing Model (NSPM) : NSPM operates on key principles: cultural responsiveness, script diversity, and neurocognitive adaptability. Unlike static screeners which assume a singular path to literacy, this model recognizes that individuals process symbols differently based on neural architecture, cultural exposure, and perceptual style. Its algorithms are designed to weight performance across different modalities (i.e. visual, auditory, tactile) and to adapt testing pathways based on user engagement. This ensures that assessments reflect a learner's authentic interaction with symbols rather than their ability to perform on conventional reading tasks. The model is particularly well-suited for neurodivergent learners, whose profiles may include asynchronous development in memory, perception, and executive function. As well, the regional customization is one of the greatest assets. The model includes culturally specific symbol sets—from Indigenous glyphs to regional scripts like Kannada, Arabic, or Adinkra—and adjusts tasks to match local orthographic norms. In pilot trials, incorporating regional symbols improved engagement and reduced diagnostic anxiety among learners, especially in minoritized language communities (Toki, 2024). The addition of these culturally resonant features allows educators to identify not just impairments, but also strengths that might otherwise be missed—such as superior visuospatial reasoning or affinity for symbol-art mapping. This positions NSPM as a tool for diagnosis, and also for empowerment, aligning assessment with lived experiences and neurocognitive realities of learners.

The fusion of cutting-edge technology with inclusive pedagogy allows the NSPM to represent a shift in how dyslexia is conceptualized and assessed. Its multimodal and script-responsive design dismantles the phonological hegemony that has long dominated the field, offering instead a vision of literacy as a fluid, multi-sensory, and culturally situated skill. As technologies like eye-tracking, machine learning, and neuroadaptive interfaces become more accessible, models like NSPM will be essential for ensuring that early diagnosis and intervention reflect the diversity of human cognition and linguistic expression. In doing so, NSPM contributes not only to clinical accuracy, but also to educational justice.

V. METHODOLOGY

Interdisciplinary Synthesis Approach : The methodology of this study is anchored in a deliberate interdisciplinary synthesis, integrating insights from neuroscience, neuroaesthetics, visual literacy, and cross-cultural pedagogy. This approach allows for a holistic exploration of dyslexia as a multifactorial condition influenced not only by phonological deficits but also by visual-symbolic processing, aesthetic preference, and cultural script exposure. Neuroscientific foundations—particularly those related to the VWFA—were reviewed to establish a biological substrate for reading across scripts. In parallel, neuroaesthetic theory was employed to conceptualize reading as an emotionally resonant, symbolically mediated experience, thereby reframing dyslexia as a potential divergence in visual-cognitive fluency rather than a linguistic deficit alone. Visual literacy scholarship further informed this model by identifying the perceptual and cognitive demands placed on readers by different orthographic systems, especially those with high graphic density or nonlinear glyph structures. Finally, pedagogical frameworks rooted in multilingual education provided essential context for how children encounter, interpret, and are assessed across diverse writing systems.

This synthesis involved an extensive literature review of primary and secondary research spanning several domains. Canonical and contemporary studies on the VWFA—including cross-linguistic fMRI evidence, neuronal recycling theory, and eye-tracking metrics—were triangulated with emerging research on neurodiversity, particularly as it intersects with literacy. Special emphasis was placed on studies demonstrating eye movement patterns as diagnostic indicators for reading disorders (Toki, 2024; Svaricek et al., 2025). The

Review also examined how neuroaesthetic considerations such as script legibility, symbol familiarity, and line density affect reader engagement and comprehension. Additionally, the comparative validity of conventional phonological screeners versus visual stress and symbol fluency screeners was assessed through meta-analyses, revealing significant discrepancies in diagnostic sensitivity, especially for learners operating outside alphabetic norms (Haridas et al., 2018). This cross-disciplinary approach enabled the development of a more culturally inclusive and cognitively diverse model for understanding and identifying dyslexia.

Comparative Case Study: Indian Multiscript Learners : To ground theoretical insights in real-world educational contexts, a comparative case study was conducted on dyslexia screening practices among multiscript learners in India. The study synthesized findings from several regional projects and diagnostic pilots across states including Kerala, Tamil Nadu, Karnataka, and Maharashtra. Using a combination of document analysis, practitioner interviews, and tool evaluations, the research identified widespread pedagogical gaps—particularly the overreliance on English-centric tools and the underdevelopment of script-responsive screeners for languages such as Kannada, Malayalam, and Hindi (Rao et al., 2021; Vasudevan et al., 2023). Many state education boards mandate early literacy assessments but fail to offer validated instruments in regional scripts, leading to uneven diagnostic coverage and frequent under-identification of dyslexia in local-medium schools. Moreover, children fluent in scripts like Devanagari or Tamil may be classified as "low performers" based on English reading metrics, despite exhibiting typical or even advanced visual-symbolic fluency in their native orthography.

Analysis of screening outcomes and field observations revealed both the promise and the limitations of current tools in these settings. While bilingual batteries such as the DALI-DAB have improved accessibility, their phonological focus remains misaligned with the visuo-orthographic challenges posed by abugidas and alphasyllabaries (Pandey & Jha, 2016). For example, in pilot assessments conducted in Malayalam-medium schools, students displayed greater orthographic error rates in Malayalam than in English—a counterintuitive result explained by Malayalam’s high letterform complexity and symbol crowding (Haridas et al., 2018). These findings were further supported by illustrative vignettes from Tamil Nadu, where children adept at decoding local script struggled with English-based assessments and were thus denied support services. In contrast, screening approaches that incorporated visual pattern tasks or gaze-based metrics revealed hidden fluencies, offering a more accurate and equitable assessment. This case study not only highlights the diagnostic blind spots of monolingual screeners but also reinforces the urgency of developing neuroinclusive, script-adaptable diagnostic frameworks.

VI. RESULTS AND ANALYSIS

Overemphasis on Phonological Processing in Current Screeners : An analysis of widely used dyslexia screeners reveals a persistent overreliance on phonological processing tasks (such as phoneme deletion, rapid automatized naming, and pseudoword decoding) inadequately capture the full spectrum of literacy difficulties, particularly in script-diverse and multilingual populations. In contexts such as India, where children often learn to read in abugida scripts like Devanagari or Malayalam, phonological screening often fails to detect visual-symbolic challenges that are orthographically and culturally specific (Vasudevan et al., 2023). Case studies from Malayalam-medium schools indicate that many students who perform poorly on English-language screeners show typical fluency in their native scripts, yet remain undiagnosed and unsupported due to the screeners’ linguistic and orthographic bias (Haridas et al., 2018). This misalignment leads to systemic under-identification of dyslexia in non-Western contexts, where phonological transparency in the script does not necessarily correlate with ease of reading acquisition. Consequently, these learners are frequently categorized as “low-performing” without consideration for the visual-symbolic and aesthetic dimensions of literacy development.The global literacy diagnostic landscape is further shaped by a deep-seated bias toward Latin-based scripts. English, as the dominant language in dyslexia research and assessment tool development, serves as the de facto standard for defining literacy success, despite being one of the most orthographically irregular languages (Share & Daniels, 2016). This Latin-script dominance not only skews the design of screeners but also influences educational policy and funding, privileging English-language learners over those using non-alphabetic systems. As a result, tools developed for English speakers are often poorly adapted to languages with complex visual-spatial configurations, such as Tamil or Arabic. The assumption that dyslexia manifests identically across scripts undermines the development of regionally responsive tools and reinforces an Anglocentric model of reading disorder. This bias has tangible consequences: learners in non-Latin scripts are often misdiagnosed, overdiagnosed, or left undiagnosed entirely, creating deep inequities in access to educational support.

Neuroaesthetic Divergence: Visual and Emotional Responses to Line Patterns : Emerging neuroaesthetic research suggests that dyslexia may, in part, reflect a divergence in how individuals emotionally and perceptually engage with visual-symbolic systems. Dyslexic readers often report a strong visceral response to line patterns, particularly in scripts with high visual density or unusual spacing, leading to perceptual stress, discomfort, and visual fatigue (Zeki, 2013; Wilkins, 2003). These emotional responses to written symbols are frequently ignored in traditional assessments, which rarely evaluate how learners feel about the visual appearance of text. Symbolic overload—characterized by difficulty processing crowded or complex letterforms—has been linked to increased cognitive load and avoidance behaviors, especially in environments where learners are forced to engage with scripts that are aesthetically misaligned with their perceptual preferences (Hutson & Hutson, 2024). This divergence suggests that reading difficulty is not merely a cognitive processing issue but also an affective mismatch between reader and symbol system.

Cultural and script-specific fluency pathways offer further evidence that visual engagement with writing systems is shaped by neuroaesthetic alignment. In visually balanced scripts like Kannada or syllabic scripts such as Japanese Kana, some dyslexic learners report fewer difficulties than in irregular alphabetic scripts, despite comparable phonological demands. These learners often demonstrate visual fluency when symbols are spatially and rhythmically consistent, suggesting that aesthetic affordances—such as symmetry, spacing, and shape complexity—can mediate reading proficiency (Zhang et al., 2022). In one illustrative case from Tamil Nadu, a student who struggled with English and Hindi assessments was able to rapidly learn and decode Tamil letters, not due to phonological ease but due to familiarity with the script's visual rhythm. These findings support a paradigm in which script-specific design elements interact with neurodivergent perceptual profiles to create divergent pathways to fluency. Rather than viewing such learners as "deficient," it becomes more accurate and equitable to view them as differently attuned to the aesthetic properties of written language.

Technological and Neuroinclusive Innovations : The rise of neuroinclusive technologies, particularly those grounded in artificial intelligence and real-time eye-tracking, has fundamentally reshaped the diagnostic landscape for dyslexia. Tools such as Lexplore and the UCSF Multitudes platform utilize oculomotor data—fixation durations, saccadic trajectories, regressions—to train machine-learning classifiers capable of detecting reading anomalies without reliance on verbal articulation or phoneme-grapheme decoding tasks (Toki, 2024; McGinley et al., 2021). These platforms capture implicit cognitive processes during reading, offering a less biased and more inclusive diagnostic modality. Crucially, these systems distinguish between phonological impairments and visual-symbolic processing difficulties by analyzing how learners visually navigate written language. As a result, early interventions can be tailored with greater precision and cross-linguistic adaptability, facilitating implementation in linguistically diverse and low-resource environments.

Beyond oculomotor analysis, next-generation screeners are integrating multimodal sensory and symbolic metrics. These include features such as visual stress calibration tools, adjustable font environments, color overlay customization, and neuroaesthetic alignment tasks that identify readers whose challenges lie in symbol differentiation or visual comfort rather than traditional phonological deficits. These screeners provide critical insight into perceptual stress patterns, such as difficulties distinguishing visually similar letterforms (e.g., b/d, p/q, म/भ in Devanagari) and offer responsive design adjustments rooted in user interaction data. In tandem, gamified assessments of symbolic fluency,

Rotational letter manipulation, and pattern-based learning enable culturally neutral diagnostics for multilingual learners whose reading development may follow non-standardized pathways. Such approaches reflect a shift toward a strengths-based model of neurodiagnosis, in which the objective is not solely the identification of impairment relative to Anglocentric norms, but rather the discovery of how individual learners encode, interact with, and make meaning from symbolic information. By foregrounding visual-symbolic processing, attention patterns, and neuroaesthetic resonance, these tools promote precision education that honors neurological diversity and cognitive difference. The scalability of these innovations—especially through the development of low-cost, webcam-based eye-tracking interfaces—ensures that these benefits can be extended to marginalized populations, including those without access to traditional clinical infrastructure.Together, these technologies form the operational foundation of the NeuroSymbolic Pattern Model (NSPM), redefining dyslexia screening as a dynamic, multimodal, and culturally situated process.

VII. RECOMMENDATIONS

Expanding the Scope of Dyslexia Screening To achieve diagnostic equity and neurocognitive inclusivity, dyslexia screening must move beyond phonological processing to encompass symbolic pattern recognition, line

Differentiation, visual stress response, and multimodal symbol fluency. This broader scope recognizes that dyslexia is not a singular phoneme-grapheme mapping disorder, but a heterogeneous divergence in symbolic interaction and visual processing, particularly pronounced in learners navigating complex orthographies such as Devanagari, Kannada, or Arabic. These scripts demand not only phonological decoding, but also the perceptual parsing of dense ligatures, conjuncts, and non-linear spatial arrangements. Assessment tools within the NeuroSymbolic Pattern Model (NSPM) should include culturally responsive tasks that evaluate abstract form engagement, sequential replication, and visual-symbolic differentiation. For instance, learners might be asked to distinguish among culturally familiar and unfamiliar glyphs, replicate rhythmic visual sequences, or manipulate 3D representations of letters and diacritics.

These methods are particularly effective for identifying learners with visual intelligence and pattern fluency who may underperform on traditional phonological tasks. By capturing these symbolic divergences, screeners can reduce false negatives and enable earlier, more precise interventions tailored to cognitive profiles rather than solely linguistic norms. In tandem with diagnostic tool innovation, there must be a pedagogical shift. Educators must be trained in neuroaesthetic learning strategies that honor perceptual, emotional, and symbolic diversity. Professional development should address how visual discomfort, perceptual overload, and aesthetic dissonance contribute to literacy challenges. For example, modules might explore the neurocognitive impacts of letterform density, typeface selection, line spacing, and script curvature on reading fluency. Teachers should also be equipped to identify when reluctance to engage with text reflects not behavioral resistance, but symbolic-perceptual mismatch. Cultural inclusivity further requires the integration of folk symbols, regional iconography, and visual storytelling into early literacy environments. By anchoring instruction in culturally resonant visual traditions, educators can scaffold symbol recognition in learners with limited language fluency or heightened visual sensitivity. This is particularly beneficial for multilingual classrooms, where emotional-symbolic engagement can serve as a bridge to language acquisition. Finally, digital screening platforms should reflect neurodivergent cognition styles, including F-pattern visual scanning and user interface preferences (Šola,2025). Learners often prioritize top-left alignment and vertical chunking in digital note-taking—a visual strategy rooted in efficiency and reduced cognitive load. NSPM-aligned interfaces should minimize horizontal scrolling and offer customizable, top-heavy layouts that match natural visual behavior. Empowering learners to shape their digital environments enhances engagement, autonomy, and diagnostic accuracy, reinforcing the model’s commitment to strengths-based precision education.

Culturally and Linguistically Responsive Assessment Development : The development of dyslexia assessment tools must adopt a culturally responsive framework that accounts for script directionality, orthographic transparency, and structural complexity. Unlike alphabetic scripts, many Indic and global scripts (e.g., Telugu, Arabic, Burmese) combine syllabic, logographic, and phonemic elements, include intricate diacritics, and exhibit high visual redundancy. Assessment tools for such scripts must evaluate the specific cognitive and perceptual load imposed by their visual structures. This includes not only phonological awareness but also visuospatial sequencing, radical placement, and visual-symbolic differentiation. Screeners must be adaptable to scripts with vertical stacking, bidirectional flow, or contextual glyph shaping, ensuring that directionality or script unfamiliarity does not compromise assessment validity.

Effective tools will rely on flexible design templates that can be localized without imposing Latin-script defaults. For example, modular diagnostic tasks might include stroke-order reproduction, glyph rotation detection, or culturally familiar pattern matching. These should be administered in home languages and scripts to capture authentic learning profiles, especially in regions where diglossia or multilingual instruction is common.

Such tools are best developed through transdisciplinary and community-based collaboration. Local educators contribute essential contextual knowledge about classroom realities and literacy traditions. Neurodivergent individuals can articulate sensory, symbolic, and emotional dynamics that are often overlooked by top-down screeners. Regional artists and typographers bring script-specific expertise, ensuring materials reflect culturally resonant aesthetics rather than generic symbols. Technologists and interface designers, especially those working in AI, can encode these insights into adaptive platforms that refine tasks in real time based on user interaction, gaze behavior, or visual stress indicators.

Color overlays (e.g., via See It Right or ReadEZ) have shown promise in reducing visual stress for some learners, but their efficacy is not neurologically or culturally universal. Visual comfort with specific hues can vary by environmental lighting, aesthetic norms, and script contrast needs. For example, overlays calibrated for

Latin alphabets may not suit scripts with denser stroke patterns or bidirectional flow. Adaptive screeners should integrate real-time visual calibration features (such as measuring blink rate or pupil dilation) to identify the optimal color contrast per learner. This ensures not only legibility but also emotional ease, aligning with neuroaesthetic principles of personalized, affective engagement with text (Griffiths et al., 2016).This participatory design model enhances both diagnostic rigor and cultural affirmation. Moreover, it allows for the emergence of emotionally engaging, visually intuitive tasks that honor the symbolic richness of global scripts. As a final consideration, culturally grounded assessments should integrate affective metrics—capturing a learner's comfort, confidence, and emotional alignment with text. This complements the neuroaesthetic processing approach embedded throughout the NSPM framework and ensures that screening tools resonate not only cognitively, but personally and culturally, with the diverse learners they aim to serve.

Positive Language and Neurodiversity Affirmation : A core recommendation is to embed strength-based, neurodiversity-affirming language into all stages of assessment and classroom support. Too often, dyslexia is framed solely as a deficit, emphasizing what a learner cannot do rather than recognizing alternative pathways to literacy. By shifting the diagnostic narrative toward one of cognitive variation, educators and clinicians can better support students whose minds process symbols differently. Screening tools should include reflective components that identify areas of symbolic strength—such as visual reasoning, creative glyph mapping, or spatial patterning—and present these as legitimate aspects of literacy. This reorientation affirms symbolic engagement is not monolithic and that traditional reading is only one instantiation of symbol fluency.

This reframing must also be mirrored in classroom interventions. For learners who struggle with conventional text, educators should offer alternative literacy paths such as visual storytelling, tactile letter formation, or audio-visual symbol pairing. For example, students with strong aesthetic fluency may thrive with script tracing through animation, digital drawing, or cultural calligraphy, while others may benefit from speech-to-symbol tasks using multimodal tools. These individualized interventions honor the unique strengths of neurodivergent learners, enabling them to engage with literacy in ways that feel accessible and empowering. By embedding these alternatives into curricular planning and support services, schools can move toward an inclusive literacy ecosystem which values symbol interaction in all its forms.

Implementing these recommendations requires systemic commitment to redefining what counts as literacy and who is considered literate. Rather than gatekeeping reading through narrow, alphabetic norms, institutions must cultivate environments where multiple cognitive styles, script experiences, and symbolic intelligences are not just accommodated but celebrated. This transformation begins with assessment—where learners first encounter institutional recognition of their reading profiles—and continues through pedagogy, materials design, and community engagement. By adopting multimodal, culturally responsive, and neurodiversity-affirming models, educators and researchers can build systems which reflect the full range of human literacy potential.

VIII. CONCLUSION

The evidence synthesized in this article necessitates a foundational reorientation in how dyslexia is assessed, understood, and addressed globally. The prevailing overreliance on phonological deficit models (particularly those grounded in Latin-script orthographies) has contributed to widespread diagnostic inequity, especially in linguistically diverse and visually complex script environments. As demonstrated through a multidisciplinary lens incorporating neuroscience, neuroaesthetics, symbolic cognition, and educational technology, dyslexia must be reconceptualized as a heterogeneous neurocognitive divergence shaped not solely by phoneme-grapheme correspondence, but also by the dynamic interplay of visual-symbolic fluency, aesthetic processing, and cultural script familiarity. At the heart of this shift is the Neuroinclusive Symbol Processing Model (NSPM), which advances a multimodal, culturally responsive, and technologically integrated approach to dyslexia screening. By embedding principles of neuroaesthetic design, adaptive eye-tracking, and symbolic pattern recognition into diagnostic protocols, NSPM moves beyond deficit-focused evaluation to a strengths-based framework which acknowledges the full spectrum of cognitive diversity. This model considers multiple writing systems, sensory profiles, and learning preferences, while also reflecting a commitment to accessible innovation grounded in real-world usability and cultural specificity.Future research and implementation efforts must prioritize cross-sector collaboration, involving neurodivergent individuals, educators, typographers, linguists, and technologists in the co-creation of diagnostic tools that are both rigorous and affirming. Crucially, the design of these tools should be informed by the lived experiences of learners navigating diverse symbol systems, particularly in under-resourced or multilingual contexts. As emerging technologies offer increasingly personalized and context-aware diagnostics, educational systems must evolve to ensure that equity, accessibility, and neurodivergent empowerment are treated not as optional enhancements, but as core design imperatives.

In reframing literacy not as a universal code, but as a spectrum of neurocognitive engagements with culturally mediated symbol systems, the NSPM sets a new precedent for educational diagnostics. Such a shift invites researchers, policymakers, and educators to imagine an accessible future where reading is not bound by rigid norms. Instead, knowledge is expanded through diverse modalities of perception, cognition, and expression. Only by building literacy systems which recognize and support this essential aspect of diversity, can academic systems fulfill the promise of truly universal education.

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