Journal Website

Article history:
Received 14 March 2026
Revised 06 June 2026
Accepted 11 July 2026
Initial Publication 14 July 2026
Final Publication 01 September 2026

Psychological Research in Individuals with Exceptional Needs

Volume 4, Issue 3, pp 1-16

E-ISSN: 3060-6713

A Comparative Examination and Analysis of Conceptual Frameworks and Intelligence Assessment Instruments in Blind and Low-Vision Adolescents: Challenges, Approaches, and Requirements

Elham. Aghamohamadi[1], Asghar. Minaei[2*], Noorali. Farrokhi[2], Salar. Faramarzi[3], Jalil. Younesi[2]

[1] Ph.D. Student in Educational Measurement and Evaluation, Allameh Tabataba'i University, Tehran, Iran
[2] Faculty Member, Department of Educational Measurement and Evaluation, Allameh Tabataba'i University, Tehran, Iran
[3] Faculty Member, Department of Psychology and Education of Children with Special Needs, University of Isfahan, Isfahan, Iran

*** Corresponding author email address**: asghar_minaei@atu.ac.ir

Article Info

Article type:
Review Article

How to cite this article:
Aghamohamadi, E., Minaei, A., Farrokhi, N., Faramarzi, S., & Younesi, J. (2026). The Effectiveness of Mindfulness Training for Mothers on Parenting Stress and the Quality of the Parent–Child Relationship in Families with a Child with Autism. *Psychological Research in Individuals with Exceptional Needs, 4*(3), 1-16.
https://doi.org/10.61838/kman.prien.5806

ABSTRACT

The aim of the present study was to comparatively examine and analyze the conceptual frameworks and intelligence assessment instruments used with blind and low-vision adolescents, identify existing challenges and limitations, and explain the requirements for designing tests appropriate to the cognitive and sensory characteristics of this group. This study was conducted using a qualitative approach based on thematic synthesis. For this purpose, a systematic search of scientific sources was carried out in reputable national and international databases. Studies published between 2003 and 2025 were reviewed. From an initial pool of 83 documents, after applying the inclusion and exclusion criteria and assessing methodological quality, 31 studies, including 24 international studies and 7 national studies, were selected for final analysis. The data were analyzed according to the stages of thematic synthesis, including initial coding, extraction of descriptive themes, and formation of analytical themes. The analysis of the studies led to the identification of 11 main themes, including spatial visualization intelligence, verbal–auditory intelligence, auditory–tactile memory, nonvisual information processing, nonverbal–tactile reasoning, emotional–social intelligence, executive functions, adaptive and practical intelligence, musical–auditory abilities, neurological–sensory components, and methodological challenges in intelligence assessment. The results showed that some of these components overlap with the dimensions of Cattell–Horn–Carroll theory, whereas others require conceptual reinterpretation or expansion within the context of blindness. The findings also indicated that many existing instruments, due to their implicit or explicit reliance on visual processing, face limitations in construct validity, assessment fairness, and adaptation to the characteristics of individuals with visual impairment. The findings of the study suggest that intelligence assessment in blind and low-vision adolescents requires a transition from purely adaptive approaches toward evidence-based conceptual frameworks aligned with the cognitive and sensory characteristics of this group. Accordingly, Cattell–Horn–Carroll theory can provide an appropriate foundation for developing indigenous, multisensory tests free from visual bias and can facilitate more accurate assessment of the cognitive abilities of these individuals.

Keywords: *intelligence, blind and low-vision adolescents, intelligence assessment instruments, cognitive and sensory characteristics, psychometrics.*

1. Introduction

Intelligence assessment has traditionally occupied a central position in psychology, education, rehabilitation, and clinical decision-making, yet its conceptual and methodological foundations become especially complex when applied to adolescents who are blind or have low vision. Intelligence is not a single fixed entity that can be captured independently of context, task demands, sensory access, and developmental experience; rather, it is a multidimensional capacity involving learning, adaptation, reasoning, problem-solving, symbolic processing, and the flexible use of experience in changing environments (Sternberg, 2018). Contemporary discussions of intelligence increasingly emphasize that cognitive ability should be understood through dynamic, functional, and adaptive models rather than through narrow task performance alone (Resnick, 2024). More recent theoretical work has further argued that defining intelligence requires attention to biological adaptation, information processing, goal-directed behavior, and the capacity to act effectively under environmental constraints (Vitas et al., 2026). Therefore, when intelligence is assessed in blind and low-vision adolescents, the central question is not merely whether conventional tests can be administered with adaptations, but whether those tests validly represent the cognitive abilities of individuals whose learning, perception, and interaction with the environment occur through nonvisual sensory pathways.

The Cattell–Horn–Carroll theory has become one of the most influential frameworks for conceptualizing cognitive abilities because it organizes intelligence into broad and narrow abilities such as fluid reasoning, crystallized knowledge, working memory, processing speed, auditory processing, and visual-spatial processing (Schneider & McGrew, 2018). Empirical and psychometric research has supported the relevance of this framework for interpreting cognitive tests and integrating results across assessment batteries (Keith & Reynolds, 2010). Cross-battery assessment approaches have also expanded the practical application of this model by emphasizing the need to interpret cognitive performance through theoretically grounded ability domains rather than isolated test scores (Flanagan et al., 2013). However, the application of this framework to blind and low-vision adolescents requires careful reconsideration because several CHC domains, particularly visual-spatial processing and processing speed, are commonly operationalized through visually loaded tasks. This creates the possibility that test performance may reflect visual access, task format, and sensory familiarity rather than the intended cognitive construct.

The limitations of conventional intelligence assessment for people with visual impairment have been recognized for several decades. The Cognitive Test for the Blind was one of the important attempts to validate an instrument specifically designed to assess intellectual functioning in blind individuals, showing that intelligence assessment can be made more appropriate when the sensory characteristics of the target population are considered in test construction (Nelson et al., 2002). Later reviews emphasized that standard IQ tests are often insufficient for estimating intelligence in blind individuals because many subtests depend on visual materials, visual scanning, image-based reasoning, or motor-visual coordination (Raczy & Korczyk, 2018). Similarly, research on intelligence scales for children with visual impairment has shown that performance may vary according to the type and degree of visual disability, indicating that assessment results must be interpreted in relation to the sensory and developmental profile of the child rather than through norms developed mainly for sighted populations (Campos & de Cassia Nakano, 2018). Recent literature on adapting intelligence tests for individuals with visual impairment has further highlighted persistent challenges in administration, interpretation, construct equivalence, and the professional judgment required when standardized tools are modified (Lamper et al., 2026).

A major reason why intelligence assessment in blind and low-vision adolescents requires specialized attention is that visual impairment alters the pathways through which cognitive development unfolds. Studies of children and young people with vision impairment have shown that equitable development depends on access to a balanced curriculum, specialized instruction, mobility training, social participation, assistive technology, and educational environments that compensate for reduced visual access (McLinden et al., 2022). Developmental evidence also indicates that language, cognition, social adaptation, and exploratory behavior in children with vision impairment are interrelated over time, meaning that cognitive functioning cannot be separated from sensory experience and environmental opportunities (Veldhorst et al., 2026). In educational contexts, blind learners may rely more heavily on verbal mediation, auditory memory, tactile exploration, and sequential processing, especially in tasks that sighted students complete through visual observation (Czerwinska & Piskorska, 2018). Rehabilitation and employment research similarly shows that functional outcomes among people who are blind or visually impaired are shaped not only by cognitive ability but also by accessibility, environmental support, training, adaptive skills, and social opportunity (Bell & Silverman, 2018). These findings suggest that intelligence assessment must be ecologically valid and sensitive to the lived conditions of visual impairment.

Neuroscientific research has provided strong evidence that blindness is associated with cross-modal plasticity and reorganization of cortical functions. Early work showed that auditory language processing can activate occipital regions in congenitally blind individuals, suggesting that cortical areas typically described as "visual" may participate in nonvisual cognitive processing when visual input is absent (Roder et al., 2000). Subsequent findings indicated that speech processing activates the visual cortex in congenitally blind humans, further demonstrating that the brain's functional organization is shaped by sensory experience (Roder et al., 2002). Research on environmental sound memory has also shown evidence of cross-modal compensation among blind adults, particularly in auditory memory and recognition processes (Roder & Rosler, 2003). Amedi and colleagues demonstrated that visuo-haptic object-related activation in the ventral visual pathway reflects the capacity of cortical systems to process object information beyond a strictly visual modality (Amedi et al., 2001). Later evidence showed that early visual cortex activation was associated with superior verbal memory performance in blind individuals, linking neural reorganization to cognitive performance (Amedi et al., 2003). More recent theoretical work has proposed task selectivity as a broad principle of brain organization, suggesting that cortical regions may be defined more by computational function than by sensory input alone (Amedi et al., 2017). This view is consistent with the idea of a cognitively pluripotent cortex, according to which cortical regions can support diverse cognitive functions depending on developmental experience and sensory access (Bedny, 2017).

The neurocognitive literature therefore challenges any assessment model that assumes identical sensory routes for identical cognitive constructs. Structural and functional brain imaging studies have shown that the brain adapts to blindness through changes in connectivity, recruitment of occipital regions, and altered sensory-cognitive organization (Hirsch et al., 2015). Spatial cognition research has similarly demonstrated that visual experience contributes to, but does not fully determine, the neural basis of spatial representation (Pasqualotto & Proulx, 2012). Studies on spatial skills in individuals with visual impairment have shown that residual vision can influence spatial performance, but nonvisual spatial coding remains a meaningful and assessable domain (Papadopoulos et al., 2011). Further research on spatial coding has indicated that individuals with visual impairment may use alternative coding strategies to represent and navigate space (Papadopoulos et al., 2012). Iranian evidence comparing spatial memory and spatial orientation among blind, low-vision, and sighted individuals has also shown important differences across groups, supporting the need for culturally and contextually appropriate assessment of spatial cognition (Rajabi & Alimoradi, 2016). Multisensory training research has demonstrated that spatial perception can be improved in visually deprived children, particularly when rehabilitation targets audio-tactile integration and nonvisual spatial learning (Cappagli et al., 2017). Recent developmental research has further clarified that audio-tactile spatial integration develops through the interaction of vision, touch, and hearing, reinforcing the need to distinguish visual-spatial ability from nonvisual spatial intelligence (Tonelli et al., 2026).

Working memory, executive functioning, and auditory-tactile processing are also central to intelligence assessment in this population. A systematic review and meta-analysis of verbal and spatial working memory in blind adults showed that age at blindness onset may influence cognitive performance, suggesting that developmental timing is an important factor in interpreting memory outcomes (Sepulveda-Palomo et al., 2024). Recent evidence on children and adolescents has shown that the severity of visual impairment can affect working memory and executive function, indicating that cognitive profiles may differ across degrees of visual loss (Correia et al., 2026). Psychometric research on WISC-IV verbal scales among blind students has shown that verbal subtests can provide useful information but must be interpreted carefully in terms of construct coverage and sensory fairness (Chen et al., 2021). At the same time, advances in multimodal and multisensory cognitive assessment indicate that future tools should integrate auditory, tactile, verbal, and interactive formats to reduce construct-irrelevant barriers (Niemann et al., 2018). Broader debates about measuring intelligence also argue that static test performance is insufficient unless assessment captures abstraction, generalization, learning efficiency, and adaptability across novel tasks (Chollet, 2019). New approaches to understanding intelligence and cognitive ability processes similarly emphasize multidimensional and process-oriented models over narrow score-based interpretations (Yildirim & Kaya, 2025).

In addition to cognitive and neuropsychological considerations, the design of intelligence assessment for blind and low-vision adolescents must account for clinical, educational, and technological developments in the field of visual impairment. Visual impairment itself is not a uniform condition; it varies by etiology, severity, onset, progression, residual vision, ocular surface health, and access to treatment or screening (Argueso, 2022). Recent protocols for community-based AI-assisted visual impairment screening indicate that emerging technologies may improve early detection, operational efficiency, and service accessibility, although their implications for psychological assessment still require careful investigation (Chen et al., 2026). Integrative review evidence on neuropsychomotor development tools for children with visual impairment has shown that available instruments remain heterogeneous and that many do not fully capture the developmental specificities of this population (Brandao et al., 2024). Research on auditory and early language deprivation has also shown that neuroplasticity must be understood multidimensionally, because sensory and language experiences can have dissociable effects on cognitive development (Liu et al., 2026). Current theories of cross-modal plasticity further suggest that binding mechanisms may enable the integration of information across sensory systems, which has direct implications for designing audio-tactile and multisensory intelligence tasks (Park & Celikel, 2026).

From a methodological perspective, a systematic and conceptually rigorous review of the existing literature is necessary because the field contains diverse evidence from psychometrics, cognitive psychology, neuroscience, education, rehabilitation, and developmental science. Qualitative inquiry provides a suitable foundation for interpreting complex, heterogeneous bodies of literature when the objective is to identify meanings, patterns, and conceptual relationships rather than merely aggregate effect sizes (Creswell & Poth, 2016). Thematic synthesis is especially appropriate for this purpose because it enables the line-by-line coding of studies, the construction of descriptive themes, and the development of higher-order analytical themes across multiple sources (Thomas & Harden, 2008). In addition, the PRISMA 2020 statement provides a transparent framework for reporting systematic review processes, including search, screening, eligibility, and inclusion procedures (Page et al., 2021). Quality appraisal is also essential, and the Critical Appraisal Skills Programme has been recommended as a useful tool for strengthening qualitative evidence synthesis when applied critically and transparently (Long et al., 2020). The growing use of computer-adaptive and validity-focused screening models further reinforces the importance of classification accuracy, construct validity, and measurement fairness in assessment development (Shen et al., 2026).

Taken together, the reviewed literature indicates that intelligence assessment in blind and low-vision adolescents should move beyond the simple adaptation of sighted norms and visually based test materials. Existing theoretical models such as the Cattell–Horn–Carroll framework remain valuable because they provide a structured vocabulary for cognitive abilities, but their application to visual impairment requires reinterpretation of spatial, nonverbal, processing-speed, and memory constructs through auditory, tactile, verbal, kinesthetic, and adaptive pathways. Neuroscientific evidence shows that blindness can reorganize cognitive processing through cross-modal plasticity, while educational and rehabilitation studies show that real-world functioning depends on adaptive skills, environmental access, and culturally appropriate supports. Therefore, a valid approach to intelligence assessment in this group must be theoretically grounded, psychometrically defensible, developmentally sensitive, multisensory, and free from visual bias. The aim of the present study was to comparatively examine and analyze conceptual frameworks and intelligence assessment instruments for blind and low-vision adolescents, identify existing challenges and limitations, and explain the requirements for designing tests appropriate to the cognitive and sensory characteristics of this group.

2. Methods and Materials

The present study was conducted with the aim of critically analyzing conceptual frameworks for intelligence assessment in individuals with visual impairment, comparing commonly used intelligence assessment instruments for blind and low-vision adolescents, identifying existing challenges in the assessment process, and extracting the essential components required for the development of valid, fair, and culturally and cognitively appropriate tests for this group. Considering the nature of the research

E-ISSN: 3060-6713

objective, a qualitative systematic review approach combined with thematic synthesis was employed. Thematic synthesis is an appropriate method for integrating, comparing, and reinterpreting findings from multiple studies, particularly when the purpose is to develop conceptual frameworks and generate analytical themes that extend beyond the findings of individual studies (Thomas & Harden, 2008). This approach made it possible to examine the theoretical, methodological, and psychometric dimensions of intelligence assessment in adolescents with visual impairment and to synthesize evidence related to cognitive, sensory, and cultural considerations in test development.

A systematic search of scientific sources was conducted in major international databases, including Web of Science, ScienceDirect, Scopus, ProQuest, and Emerald Insight, as well as Persian databases such as SID, Magiran, Noormags, and Civilica. The search strategy included combinations of Persian and English keywords, including "intelligence," "intelligence assessment," "intelligence test," "visual impairment," "blindness," "low vision," and "cognitive assessment." The search covered studies published between 2003 and 2025. This time frame was selected because, from the early 2000s onward, advances in cognitive science, neuroimaging, and contemporary multidimensional models of intelligence, particularly the Cattell–Horn–Carroll framework, led to important theoretical and methodological developments in the cognitive assessment of individuals with visual impairment (Flanagan et al., 2013; Schneider & McGrew, 2018). In this regard, empirical studies have also indicated that contemporary neuroscience-informed and multifactorial assessment frameworks can improve the accuracy of cognitive measurement in individuals with visual impairment by incorporating neuropsychological indicators and reducing sensory bias in standardized instruments, thereby increasing convergence between neuroimaging findings and psychometric assessments (Chen et al., 2026).

The study selection process was conducted in accordance with the PRISMA 2020 guideline for systematic reviews (Page et al., 2021). The initial search identified 83 records. After removing duplicate sources and screening titles and abstracts, irrelevant studies were excluded. The full texts of the remaining articles were then reviewed according to predefined inclusion and exclusion criteria. Finally, 31 studies, including 24 international studies and 7 national studies, were selected for final analysis. The inclusion criteria consisted of a focus on intelligence assessment or cognitive abilities, direct or indirect relevance to blind or low-vision individuals, presentation or evaluation of intelligence assessment instruments, alignment with contemporary approaches to cognitive assessment, and publication within the specified time frame. The exclusion criteria included lack of access to the full text, absence of conceptual relevance to the research topic, and insufficient methodological quality. Therefore, the final sample of documents provided a focused and evidence-based foundation for analyzing intelligence assessment frameworks and tools in adolescents with visual impairment.

The main data collection tool in this study was a systematic document extraction protocol designed to identify, organize, and synthesize information from the selected studies. This protocol included bibliographic information, study objectives, methodological design, target population, type of visual impairment addressed, intelligence or cognitive assessment instruments used, theoretical framework, assessed cognitive domains, psychometric characteristics, reported strengths and limitations, and implications for assessment fairness and test development. Particular attention was given to whether the reviewed instruments relied on visual processing, whether they included auditory, tactile, verbal, or nonvisual components, and whether they were appropriate for blind and low-vision adolescents in terms of construct validity, cultural relevance, and sensory accessibility.

To evaluate the methodological quality of the selected studies, the Critical Appraisal Skills Programme checklist was used for qualitative studies, while quality appraisal criteria appropriate for review and descriptive studies were applied according to the type of each document (Long et al., 2020). The appraisal process was conducted independently by two researchers familiar with qualitative research methodology, psychometrics, and cognitive assessment. Any disagreements between the evaluators were resolved through discussion and final consensus. Only studies that met at least 70% of the quality appraisal criteria were included in the final synthesis. This quality control procedure was intended to strengthen the credibility of the review and ensure that the extracted themes were based on methodologically acceptable evidence. The use of both international and national sources also allowed the study to capture broader theoretical developments while considering the contextual and cultural requirements of intelligence assessment in Persian-speaking settings.

Data analysis was conducted based on the thematic synthesis procedure proposed by Thomas and Harden

E-ISSN: 3060-6713

(2008). In the first stage, the full texts of the selected studies were reviewed carefully and coded line by line. Initial codes were assigned to concepts related to intelligence constructs, cognitive abilities, sensory compensation, auditory and tactile processing, verbal reasoning, executive functions, adaptive functioning, emotional and social intelligence, psychometric limitations, and methodological challenges in the assessment of individuals with visual impairment. In the second stage, similar and related codes were organized into descriptive themes. These descriptive themes reflected recurring patterns across the reviewed studies and provided a structured representation of how intelligence and cognitive abilities have been conceptualized and measured in blind and low-vision adolescents. In the third stage, through constant comparison and integration of descriptive themes, higher-order analytical themes were developed. This process enabled the identification of shared patterns, conceptual differences, existing assessment challenges, and key requirements for designing valid and fair intelligence assessment instruments for blind and low-vision adolescents.

To enhance the credibility and dependability of the findings, strategies proposed by Lincoln and Guba (1985) were applied, including continuous review of data, constant comparison of codes, use of diverse national and international sources, documentation of all stages of analysis, and checking agreement between evaluators. The analytical process was documented in detail to increase transparency and allow for reviewability and potential replication. Although dependence on the quality of previous studies and heterogeneity in their methods were unavoidable limitations of this review, the use of thematic synthesis made it possible to provide a comprehensive and evidence-based understanding of the current state of intelligence assessment in blind and low-vision adolescents. This analytical approach also supported the extraction of conceptual and methodological requirements for developing indigenous, multisensory, and visually unbiased intelligence assessment tools aligned with the cognitive and sensory characteristics of this population.

3. Findings and Results

The descriptive profile of the reviewed evidence showed that the final corpus of the study consisted of 31 eligible documents selected from an initial pool of 83 records. Since the present study was designed as a qualitative systematic review with thematic synthesis, demographic reporting refers to the characteristics of the selected studies rather than individual participants. Of the 31 studies included in the final analysis, 24 studies were international and 7 studies were national. The reviewed documents were published between 2003 and 2025 and covered a broad range of theoretical, empirical, psychometric, neurocognitive, and applied perspectives on intelligence assessment and cognitive functioning in blind and low-vision individuals. The selected studies addressed different but interrelated domains, including intelligence testing, cognitive assessment, verbal and auditory processing, tactile reasoning, spatial cognition without vision, working memory, executive functioning, adaptive behavior, sensory compensation, neuropsychological functioning, and methodological issues in the assessment of individuals with visual impairment. Because the included studies differed in terms of design, target group, age range, assessment tools, and theoretical orientation, participant-level demographic aggregation was not possible. However, the thematic focus of the review was restricted to findings that were conceptually relevant to intelligence assessment in blind and low-vision adolescents.

The systematic analysis of the selected texts through thematic synthesis indicated that the cognitive abilities associated with blind and low-vision adolescents could be organized into a set of major themes and subthemes. Overall, 61 initial codes were extracted from the selected studies. After conceptual integration and comparison of overlapping codes, these codes were classified into 11 central themes. These themes reflected cognitive, sensory-perceptual, emotional-social, neuropsychological, adaptive, and methodological dimensions of intelligence assessment in individuals with visual impairment. The extracted structure showed that intelligence assessment in this population cannot be reduced to a simple adaptation of visually based tests. Rather, it requires attention to alternative pathways of cognitive processing, particularly auditory, tactile, verbal, spatial, and adaptive mechanisms through which blind and low-vision adolescents perceive, organize, reason about, and respond to information.

E-ISSN: 3060-6713

Table 1

Thematic Structure of Intelligence-Related Components in Blind and Low-Vision Adolescents

Main theme	Subthemes and initial codes	Conceptual meaning in blind and low-vision adolescents	Implication for intelligence assessment
Spatial visualization intelligence	Nonvisual spatial understanding, tactile visualization, mental mapping, orientation without vision, spatial relations through touch and hearing	This theme refers to the ability to construct, manipulate, and use spatial representations without reliance on visual input. In blind and low-vision adolescents, spatial cognition may be formed through tactile exploration, auditory cues, bodily movement, environmental familiarity, and mental mapping.	Intelligence tests should not assess spatial ability only through visual patterns, blocks, pictures, or diagrams. Spatial assessment should include tactile maps, object manipulation, auditory-spatial tasks, route learning, and nonvisual spatial reasoning.
Verbal-auditory intelligence	Vocabulary, verbal comprehension, auditory concept formation, oral reasoning, verbal abstraction, listening-based inference	This theme reflects the central role of language and auditory input in cognitive processing. In individuals with visual impairment, verbal and auditory channels often become major pathways for acquiring knowledge, organizing concepts, and solving problems.	Assessment tools should include strong verbal and auditory components, but they should avoid overestimating intelligence solely because of verbal fluency. Tasks must distinguish between verbal knowledge, reasoning, memory, and educational exposure.
Auditory-tactile memory	Auditory working memory, tactile memory, sequential recall, short-term memory, memory for verbal and nonvisual information	This theme refers to the capacity to encode, retain, and retrieve information received through auditory and tactile channels. It includes memory for sounds, spoken information, tactile patterns, object features, and sequential nonvisual stimuli.	Cognitive assessment should include memory tasks that are accessible through hearing and touch. Visually loaded memory tasks should be replaced or supplemented with auditory-tactile formats that preserve the target construct.
Nonvisual information processing	Auditory attention, tactile discrimination, speed of auditory processing, speed and accuracy of tactile processing, selective attention to nonvisual stimuli	This theme represents the ability to process information efficiently through nonvisual sensory channels. It includes speed, accuracy, attention, and discrimination in response to auditory and tactile stimuli.	Processing-speed tasks should be redesigned carefully, because conventional timed visual tasks are often inappropriate. Nonvisual processing speed should be measured through auditory and tactile tasks while considering motor demands and familiarity with assistive materials.
Nonverbal-tactile reasoning	Tactile problem-solving, pattern detection through touch, object-based reasoning, nonverbal inference, tactile classification	This theme refers to reasoning abilities that do not depend primarily on spoken language or visual perception. In blind and low-vision adolescents, nonverbal reasoning can be expressed through tactile pattern recognition, object manipulation, classification, analogy, and problem-solving.	Nonverbal intelligence should not be equated with visual performance. Tests should provide tactile and manipulable alternatives to visual matrices, block designs, and figure-based reasoning tasks.
Emotional-social intelligence	Emotion recognition through voice, interpretation of tone, tactile and auditory social cues, nonvisual social interaction, interpersonal adaptation	This theme refers to the ability to understand, regulate, and respond to emotional and social information without relying on facial expressions or visual social cues. Voice, speech rhythm, touch, contextual information, and interpersonal experience may play compensatory roles.	Intelligence assessment should consider emotional and social competencies as important adaptive dimensions, especially because conventional tools may ignore nonvisual forms of social understanding.
Executive functions and problem-solving	Planning, organization, cognitive control, inhibition, flexibility, goal-directed behavior, problem-solving in nonvisual contexts	This theme includes higher-order cognitive processes that regulate behavior and thinking. For blind and low-vision adolescents, executive functioning is especially important for organizing environmental information, using assistive tools, planning movement, and solving daily problems.	Assessment batteries should include tasks measuring planning, working memory, inhibition, flexibility, and problem-solving in ecologically valid and nonvisual conditions.
Adaptive and practical intelligence	Environmental adaptation, independent functioning, use of assistive devices, daily living skills, practical problem-solving, mobility-related cognition	This theme refers to the practical application of cognitive abilities in real-life settings. It includes the capacity to adapt to environmental demands, use tools and technologies, manage daily tasks, and function independently.	Intelligence assessment should include adaptive and practical components rather than relying only on abstract cognitive tasks. Ecological validity is essential in evaluating the real-world cognitive competence of blind and low-vision adolescents.
Musical-auditory abilities	Rhythm perception, pitch discrimination, auditory pattern recognition, sound sequencing, musical memory	This theme includes sensitivity to sound structures, rhythm, pitch, and auditory patterns. These abilities may be particularly salient in some individuals with visual impairment because of heightened reliance on auditory processing.	Assessment frameworks should recognize musical-auditory abilities as a meaningful cognitive domain, especially when auditory discrimination and pattern recognition are relevant to broader cognitive functioning.
Neurological-sensory components	Sensory compensation, neuroplasticity, cross-modal reorganization, auditory-tactile	This theme refers to the neuropsychological and sensory foundations of cognitive functioning in individuals with visual	Test interpretation should consider neuropsychological mechanisms and sensory pathways. Intelligence assessment

	integration, neural adaptation to visual deprivation	impairment. It emphasizes that visual deprivation may be associated with compensatory mechanisms and reorganization of sensory and cognitive processing.	should avoid assuming that cognitive processing follows the same sensory route in sighted and visually impaired populations.
Methodological challenges and test bias	Visual bias, construct underrepresentation, construct-irrelevant variance, lack of sensory accessibility, cultural mismatch, insufficient norms, inadequate adaptation	This theme refers to limitations in current intelligence assessment instruments. Many existing tools explicitly or implicitly rely on vision, which may reduce validity, fairness, and interpretability when used with blind and low-vision adolescents.	Test development should move beyond superficial adaptation and should focus on construct-valid, culturally appropriate, multisensory, and visually unbiased instruments with suitable normative data.

As shown in Table 1, the thematic synthesis revealed that intelligence in blind and low-vision adolescents is expressed through multiple cognitive and sensory pathways. The first group of themes concerned alternative cognitive abilities in the domain of spatial processing. Spatial visualization intelligence included nonvisual spatial understanding, tactile visualization, mental mapping, and orientation without vision. This finding indicates that spatial ability remains a relevant cognitive construct in individuals with visual impairment, but its expression differs from that of sighted individuals. Rather than depending on visual imagery, spatial reasoning in this group may be mediated through tactile exploration, auditory localization, bodily movement, and accumulated environmental experience. The second theme, verbal-auditory intelligence, showed that language and auditory input play a central role in cognitive organization among blind and low-vision adolescents. Vocabulary, verbal comprehension, and oral reasoning may serve not only as indicators of crystallized knowledge but also as compensatory channels for concept formation and reasoning. The third theme, auditory-tactile memory, emphasized the importance of working memory and recall processes based on nonvisual input. The fourth and fifth themes, nonvisual information processing and nonverbal-tactile reasoning, indicated that cognitive efficiency and reasoning can be assessed through auditory and tactile modalities, provided that the tasks are designed to measure the intended construct rather than visual performance. The sixth theme, emotional-social intelligence, showed that emotional and interpersonal understanding may develop through voice, tone, touch, verbal context, and social experience rather than facial or visual cues. The seventh and eighth themes, executive functions and adaptive-practical intelligence, highlighted the role of planning, organization, cognitive control, environmental adaptation, and independent functioning in real-life cognitive performance. The ninth theme, musical-auditory abilities, reflected the importance of auditory pattern processing, rhythm, and pitch discrimination. The tenth theme, neurological-sensory components, showed that intelligence assessment in this group should be interpreted in relation to sensory compensation and neuropsychological adaptation. Finally, the eleventh theme demonstrated that methodological limitations and test bias remain central barriers to fair assessment. Overall, Table 1 indicates that the assessment of intelligence in blind and low-vision adolescents requires a multidimensional, multisensory, and construct-sensitive framework rather than a direct transfer of visually based intelligence tests.

The second level of analysis examined the relationship between the extracted themes and the Cattell–Horn–Carroll framework. The comparison showed that a considerable part of the identified abilities overlaps with the broad abilities described in this model, while some components require reinterpretation or conceptual expansion in the context of blindness and low vision. In particular, alternative spatial intelligence corresponds conceptually to spatial abilities in the Cattell–Horn–Carroll framework, but in adolescents with visual impairment, this ability is realized through tactile, auditory, kinesthetic, and environmental processing rather than visual representation. Verbal-auditory intelligence overlaps with crystallized knowledge and auditory processing, while auditory-tactile memory functions as a nonvisual expression of working memory. Nonvisual information processing and musical-auditory abilities are closely related to auditory processing, but their assessment requires tasks that do not impose visual demands. Nonverbal-tactile reasoning can be understood as a reinterpretation of fluid reasoning under conditions of absent or reduced visual input. In contrast, emotional-social intelligence, adaptive-practical intelligence, and neurological-sensory components are not directly represented as broad abilities in the Cattell–Horn–Carroll framework and therefore emerged as complementary dimensions for intelligence assessment in this population.

E-ISSN: 3060-6713

Table 2

Correspondence Between Extracted Themes and the Cattell–Horn–Carroll Framework

Extracted theme	Closest relation to the Cattell–Horn–Carroll framework	Type of relationship	Interpretation for intelligence assessment in blind and low-vision adolescents
Spatial visualization intelligence	Visual-spatial processing	Reinterpreted correspondence	This theme corresponds to spatial ability, but the sensory route differs. In blind and low-vision adolescents, spatial cognition should be assessed through tactile, auditory, kinesthetic, and environmental tasks rather than visual materials.
Verbal-auditory intelligence	Crystallized knowledge and auditory processing	Direct and expanded correspondence	This theme overlaps with acquired knowledge, language development, verbal reasoning, and auditory processing. However, its role may be more central in individuals with visual impairment because language and hearing often compensate for reduced visual access.
Auditory-tactile memory	Short-term memory and working memory	Functional correspondence	This theme corresponds to memory systems in the Cattell–Horn–Carroll framework, but it emphasizes auditory and tactile encoding, maintenance, and retrieval rather than visual memory.
Nonvisual information processing	Processing speed and auditory processing	Reinterpreted correspondence	This theme is related to processing efficiency, but conventional visual processing-speed tasks are not appropriate. Assessment should focus on the speed and accuracy of auditory and tactile information processing.
Nonverbal-tactile reasoning	Fluid reasoning	Reinterpreted correspondence	This theme represents reasoning, pattern detection, and problem-solving without reliance on visual materials. It can be considered a tactile and nonvisual expression of fluid reasoning.
Emotional-social intelligence	Not directly represented as a broad ability	Complementary dimension	This theme extends beyond the traditional cognitive structure of the Cattell–Horn–Carroll framework and reflects the importance of emotion recognition, social interpretation, and interpersonal adaptation through nonvisual cues.
Executive functions and problem-solving	Related to working memory, fluid reasoning, and cognitive control processes	Cross-cutting cognitive dimension	Executive functions are not always represented as a single broad intelligence factor in the Cattell–Horn–Carroll framework, but they influence performance across reasoning, memory, planning, and adaptive tasks.
Adaptive and practical intelligence	Not directly represented as a central broad ability	Complementary and ecological dimension	This theme reflects real-world cognitive functioning, environmental adaptation, use of assistive technology, and independent performance. It adds ecological validity to intelligence assessment.
Musical-auditory abilities	Auditory processing	Direct and expanded correspondence	This theme is closely related to auditory discrimination, rhythm perception, pitch processing, and sound pattern recognition. It may represent an important nonvisual cognitive strength in some blind and low-vision adolescents.
Neurological-sensory components	Not a psychometric ability factor, but related to neurocognitive foundations	Foundational explanatory dimension	This theme does not represent a separate intelligence factor but explains how sensory compensation, neural reorganization, and cross-modal processing may support cognitive functioning.
Methodological challenges and test bias	Not part of the theoretical ability structure	Methodological and psychometric dimension	This theme identifies limitations in the application of intelligence tests, including visual bias, construct underrepresentation, lack of appropriate norms, and insufficient cultural or sensory adaptation.

As presented in Table 2, the extracted thematic structure showed both convergence with and extension beyond the Cattell–Horn–Carroll framework. Several themes could be meaningfully aligned with broad cognitive abilities in this model, but their assessment requires sensory reinterpretation. Spatial visualization intelligence, for example, corresponds to spatial processing but cannot be measured validly through visual diagrams or picture-based items when the target population consists of blind or low-vision adolescents. In this group, spatial ability is more appropriately evaluated through tactile exploration, auditory-spatial localization, mental mapping, and orientation-based tasks. Similarly, verbal-auditory intelligence overlaps with crystallized knowledge and auditory processing, but its prominence in individuals with visual impairment suggests that language may serve as a major cognitive organizing system. Auditory-tactile memory corresponds to short-term and working memory, but the relevant tasks must involve nonvisual encoding and retrieval. Nonvisual information processing and musical-auditory abilities are also consistent with auditory processing, although they require careful differentiation between sensory discrimination, cognitive processing speed, and accumulated training or experience. Nonverbal-tactile reasoning represents one of the most important reinterpretations of the Cattell–Horn–Carroll framework, because it shows that fluid reasoning can be expressed through tactile and object-based problem-solving rather than

E-ISSN: 3060-6713

visual matrices or abstract visual patterns. At the same time, emotional-social intelligence, adaptive-practical intelligence, and neurological-sensory components appear to extend beyond the conventional boundaries of the Cattell–Horn–Carroll model. These themes indicate that intelligence assessment in blind and low-vision adolescents should include not only core cognitive abilities but also nonvisual social cognition, daily adaptive functioning, sensory compensation, and neuropsychological mechanisms. Finally, the methodological theme of test bias does not represent an intelligence domain, but it is essential for evaluating whether existing instruments validly and fairly measure intelligence in this population.

The overall pattern of findings indicates that the cognitive structure relevant to blind and low-vision adolescents is composed of three interrelated categories. The first category includes components that are broadly consistent with the Cattell–Horn–Carroll framework, such as verbal-auditory intelligence, auditory-tactile memory, nonvisual information processing, musical-auditory abilities, and aspects of executive functioning. The second category includes components that correspond to existing intelligence constructs but require reinterpretation within a nonvisual sensory context, such as spatial visualization intelligence and nonverbal-tactile reasoning. The third category includes additional or complementary components that are not fully captured by traditional psychometric models of intelligence, including emotional-social intelligence, adaptive-practical intelligence, neurological-sensory components, and methodological challenges related to test bias. This three-part structure suggests that intelligence assessment in blind and low-vision adolescents must be simultaneously theory-based, sensory-sensitive, and ecologically valid. A valid assessment framework should therefore preserve the psychometric strengths of established intelligence theories while modifying the sensory format, task structure, interpretation criteria, and normative assumptions of existing instruments.

The findings further showed that many current intelligence assessment instruments face important limitations when used with blind and low-vision adolescents. These limitations are not limited to the visible presence of pictures, visual symbols, blocks, visual patterns, or diagrams. More importantly, many tests contain implicit visual assumptions in their design, administration, scoring, timing, and interpretation. For example, a task may appear adaptable by replacing visual materials with tactile materials, but the cognitive demand of tactile exploration may differ substantially from the demand of visual scanning. In such cases, the adapted task may no longer measure the same construct in the same way. Similarly, timed performance tasks may underestimate the abilities of blind and low-vision adolescents if they fail to account for the additional time required for tactile exploration, orientation to materials, or use of assistive strategies. Therefore, the findings emphasize that fair assessment requires more than surface-level adaptation. It requires construct-level equivalence, sensory accessibility, appropriate norms, cultural compatibility, and careful interpretation of performance in relation to the individual's sensory experience and educational background.

In summary, the thematic synthesis demonstrated that intelligence in blind and low-vision adolescents should be conceptualized as a multidimensional construct expressed through verbal, auditory, tactile, spatial, executive, adaptive, emotional-social, and neuropsychological pathways. The results support the use of the Cattell–Horn–Carroll framework as a useful theoretical foundation, but they also show that this framework should be expanded and reinterpreted when applied to individuals with visual impairment. The final thematic model indicates that valid intelligence assessment in this group requires the development of indigenous, multisensory, visually unbiased, and psychometrically sound instruments. Such instruments should be able to assess core cognitive abilities while recognizing the alternative sensory routes through which blind and low-vision adolescents acquire knowledge, solve problems, regulate behavior, interact socially, and adapt to their environment.

4. Discussion

The present study was conducted to comparatively analyze conceptual frameworks and intelligence assessment instruments for blind and low-vision adolescents, identify the main challenges in assessment, and extract the essential components required for developing valid, fair, and sensory-appropriate intelligence tests for this population. The thematic synthesis of 31 selected studies led to the extraction of 61 initial codes and their organization into 11 central themes: spatial visualization intelligence, verbal-auditory intelligence, auditory-tactile memory, nonvisual information processing, nonverbal-tactile reasoning, emotional-social intelligence, executive functions, adaptive and practical intelligence, musical-auditory abilities, neurological-sensory components, and methodological challenges in intelligence assessment. This thematic structure indicates that intelligence in blind and low-vision adolescents is not adequately represented by conventional visually based test formats and should instead be understood as a multidimensional construct shaped by nonvisual sensory processing, adaptive functioning, neurocognitive reorganization, and culturally appropriate assessment conditions. This finding is consistent with contemporary theories that define intelligence as a dynamic capacity for adaptation, learning, reasoning, and flexible problem-solving rather than a fixed score derived from standardized tasks (Sternberg, 2018). It also aligns with newer conceptualizations that emphasize intelligence as an adaptive and functionally organized system through which individuals respond effectively to environmental constraints (Vitas et al., 2026).

One of the most important findings of the study was that many cognitive abilities identified in blind and low-vision adolescents overlap with the Cattell–Horn–Carroll framework, but this overlap is not direct or unmodified. The results showed that verbal-auditory intelligence, auditory-tactile memory, nonvisual information processing, musical-auditory abilities, and some executive processes can be conceptually aligned with CHC domains such as crystallized knowledge, auditory processing, working memory, processing speed, and fluid reasoning. This supports the continued relevance of CHC theory as a general framework for organizing cognitive abilities (Schneider & McGrew, 2018). Previous psychometric research has shown that CHC theory provides a powerful interpretive structure for understanding cognitive test performance across ability domains (Keith & Reynolds, 2010), and cross-battery assessment models have further demonstrated that intelligence assessment becomes more meaningful when test results are interpreted in relation to theoretically defined cognitive abilities rather than isolated subtest scores (Flanagan et al., 2013). However, the present findings indicate that in the context of blindness and low vision, CHC abilities must be reinterpreted through nonvisual channels; otherwise, the assessment may measure sensory access rather than cognitive capacity.

The extracted theme of spatial visualization intelligence provides a clear example of the need for reinterpretation. In sighted populations, spatial ability is commonly assessed through visual patterns, block designs, figures, maps, and diagrams, but the findings of this study showed that blind and low-vision adolescents may construct spatial representations through tactile exploration, auditory localization, movement, environmental familiarity, and mental mapping. This interpretation is supported by studies showing that spatial cognition in individuals with visual impairment is influenced by residual vision, tactile-auditory experience, and alternative spatial coding strategies (Papadopoulos et al., 2011, 2012). Iranian evidence comparing spatial memory and spatial orientation among blind, low-vision, and sighted individuals also supports the view that spatial performance differs across sensory groups and should not be interpreted through sighted norms alone (Rajabi & Alimoradi, 2016). Similarly, evidence on the neural basis of spatial cognition suggests that visual experience contributes to spatial representation but is not the only basis for spatial cognition (Pasqualotto & Proulx, 2012). The finding that spatial intelligence can be expressed through nonvisual modalities is further reinforced by research showing that multisensory rehabilitation can improve spatial perception in visually deprived children (Cappagli et al., 2017) and that audio-tactile spatial integration has a developmental trajectory shaped by the contribution of vision, touch, and hearing (Tonelli et al., 2026).

Another major finding was the centrality of verbal-auditory intelligence in the cognitive profile of blind and low-vision adolescents. The synthesis showed that vocabulary, verbal comprehension, oral reasoning, auditory concept formation, and listening-based inference play an especially important role in cognitive functioning among individuals with visual impairment. This finding is consistent with evidence that auditory language processing activates regions typically associated with visual processing in congenitally blind individuals (Roder et al., 2000). Studies have also shown that speech processing can recruit the visual cortex in blind individuals, indicating that verbal and auditory functions may be supported by cross-modal neural reorganization (Roder et al., 2002). The association between early visual cortex activation and superior verbal memory performance in blind individuals further supports the role of reorganized neural systems in nonvisual cognition (Amedi et al., 2003). However, the prominence of verbal-auditory ability also creates a psychometric challenge. If verbal subtests are used as the main basis for estimating intelligence, assessment may overrepresent verbal knowledge and underrepresent other cognitive domains. Research on the psychometric properties of WISC-IV verbal scales among blind students supports the usefulness of verbal measures but also highlights the need for careful interpretation of construct coverage and score meaning (Chen et al., 2021).

The theme of auditory-tactile memory also emerged as a core component of intelligence assessment in this population. The findings showed that memory in blind and low-vision adolescents must be assessed through auditory and tactile encoding, maintenance, and retrieval processes rather than visual memory tasks. This result is aligned with research demonstrating cross-modal compensation in memory for environmental sounds among blind individuals (Roder & Rosler, 2003). It is also consistent with neuropsychological evidence that the blind brain may reorganize in ways that support enhanced processing of nonvisual information (Hirsch et al., 2015). A systematic review and meta-analysis of verbal and spatial working memory in blind adults showed that working memory capacity may be influenced by age at blindness onset, suggesting that memory performance should be interpreted in relation to developmental history and sensory experience (Sepulveda-Palomo et al., 2024). More recent evidence has also shown that visual impairment severity can affect working memory and executive function in children and adolescents, reinforcing the need to consider degree of impairment when interpreting cognitive scores (Correia et al., 2026).

The identification of nonvisual information processing and nonverbal-tactile reasoning as distinct themes indicates that conventional assumptions about processing speed and nonverbal intelligence are problematic when applied to adolescents with visual impairment. Many intelligence tests assess processing speed through visual scanning, symbol search, visual-motor coordination, or rapid written responses. In blind and low-vision adolescents, slower performance on such tasks may reflect the sensory demands of the test rather than reduced cognitive efficiency. This finding aligns with critiques suggesting that standard IQ tests are insufficient for measuring intelligence in blind individuals when tasks contain visual bias or construct-irrelevant sensory demands (Raczy & Korczyk, 2018). It also supports the argument that intelligence measurement should capture abstraction, learning, and generalization rather than performance on narrow task formats (Chollet, 2019). The theme of nonverbal-tactile reasoning further shows that fluid reasoning can be expressed through tactile pattern recognition, object-based classification, and nonvisual problem-solving. This interpretation is consistent with the idea that cortical organization may be determined by task selectivity rather than sensory modality alone (Amedi et al., 2017) and with evidence from blindness that cortical regions may be cognitively pluripotent and capable of supporting functions beyond their typical visual role (Bedny, 2017).

The results also highlighted emotional-social intelligence and adaptive-practical intelligence as important complementary dimensions that are not fully represented in traditional psychometric intelligence models. Blind and low-vision adolescents often interpret emotional and social information through voice, tone, verbal context, touch, and interactional patterns rather than facial expressions and visual gestures. Therefore, their social cognition may be underestimated if assessment tools privilege visual social cues. This finding is consistent with educational and developmental perspectives emphasizing that children and adolescents with vision impairment require access to a balanced curriculum that includes social participation, mobility, independent living, and adaptive skills (McLinden et al., 2022). Longitudinal evidence also indicates that language, cognition, social adaptation, and exploratory behavior are interrelated in children with vision impairment (Veldhorst et al., 2026). In applied contexts, rehabilitation and employment outcomes among people who are blind or visually impaired depend not only on cognitive ability but also on adaptive functioning, environmental access, training, and social opportunity (Bell & Silverman, 2018). Thus, intelligence assessment in this population should include ecological indicators of practical reasoning, independence, and real-world problem-solving.

The neurological-sensory theme identified in this study provides a biological and developmental explanation for why intelligence assessment must be reconceptualized in the context of visual impairment. The reviewed evidence indicates that blindness and low vision are associated with sensory compensation, cross-modal plasticity, and neural reorganization. Early evidence showed that the ventral visual pathway can be activated during visuo-haptic object processing, suggesting that object-related cognition is not exclusively visual (Amedi et al., 2001). Current theoretical perspectives also suggest that cross-modal binding may function as a mechanism enabling neural plasticity across sensory systems (Park & Celikel, 2026). Research on auditory and early language deprivation further shows that neuroplasticity is multidimensional and that sensory and language experiences may have distinct effects on cognitive development (Liu et al., 2026). These findings help explain why blind and low-vision adolescents may show cognitive strengths in auditory, tactile, verbal, and memory-based processing while also facing difficulties in tasks designed around visual assumptions.

A further important finding was the methodological theme of test bias and the need for sensory and cultural adaptation. The synthesis showed that many existing tools are limited not only because they contain visual items, but also because they embed visual assumptions in instructions, timing, scoring, norms, and interpretation. This finding is consistent with studies showing that intelligence test performance among children with visual impairment varies according to type and degree of disability (Campos & de Cassia Nakano, 2018). Literature on adapting intelligence tests for adults with visual impairment also demonstrates that clinicians face substantial challenges in modifying test materials while preserving construct validity and interpretive accuracy (Lamper et al., 2026). More broadly, the development of multimodal and multisensory cognitive assessment frameworks has been proposed as a way to reduce sensory barriers and improve accessibility in cognitive evaluation (Niemann et al., 2018). Evidence from neuropsychomotor assessment tools for children with visual impairment also shows that current tools remain heterogeneous and often insufficiently adapted to the developmental needs of this population (Brandao et al., 2024). These findings collectively indicate that superficial test adaptation is inadequate unless equivalence of construct, modality, difficulty, and interpretation is established.

The methodological rigor of the present study strengthens the credibility of the extracted themes. The use of thematic synthesis was appropriate because the research question required conceptual integration across heterogeneous studies rather than statistical aggregation alone. Thematic synthesis allows researchers to move from line-by-line coding to descriptive and analytical themes, making it suitable for developing conceptual frameworks from diverse qualitative and empirical evidence (Thomas & Harden, 2008). The study also followed systematic review principles consistent with the PRISMA 2020 framework, which strengthens transparency in search, screening, eligibility, and inclusion procedures (Page et al., 2021). Moreover, the use of quality appraisal procedures is consistent with recommendations for optimizing the value of the Critical Appraisal Skills Programme in qualitative evidence synthesis (Long et al., 2020). This methodological approach is also aligned with qualitative inquiry traditions that emphasize the interpretation of meanings, patterns, and conceptual relationships in complex bodies of evidence (Creswell & Poth, 2016). Therefore, the results can be interpreted as a structured synthesis of existing evidence rather than a simple narrative summary.

The findings also have implications for future technologies and assessment models. Recent approaches to intelligence and cognitive ability increasingly emphasize multidimensional, dynamic, and process-oriented models rather than static score-based interpretations (Yildirim & Kaya, 2025). At the same time, advances in screening technologies, including AI-assisted visual impairment screening, show that emerging tools may improve identification, service delivery, and accessibility, although their use in psychological and cognitive assessment requires careful validation (Chen et al., 2026). Similarly, research on computer-adaptive screeners highlights the importance of validity, classification accuracy, and fairness in assessment systems (Shen et al., 2026). However, technological innovation alone is insufficient if the conceptual foundation of assessment remains visually biased. Even biological and ophthalmological evidence reminds researchers that visual impairment is heterogeneous in origin, severity, and functional consequence, and therefore cognitive assessment must account for individual differences in residual vision, onset, progression, and sensory experience (Argueso, 2022). In this respect, the present findings support the development of indigenous, multisensory, culturally appropriate, and visually unbiased assessment tools grounded in both psychometric theory and the lived cognitive realities of blind and low-vision adolescents.

5. Conclusion

In sum, the results of the present study indicate that intelligence assessment in blind and low-vision adolescents requires a transition from purely adaptive use of existing sighted tests toward evidence-based conceptual frameworks designed around the cognitive and sensory characteristics of this group. The Cattell–Horn–Carroll model can provide a useful theoretical foundation, but its domains must be reinterpreted through auditory, tactile, verbal, spatial, adaptive, and neuropsychological pathways. The extracted themes demonstrate that intelligence in blind and low-vision adolescents is expressed through multiple modalities and cannot be validly captured by instruments that implicitly equate cognition with visual performance. Accordingly, valid assessment must integrate construct validity, sensory fairness, ecological relevance, cultural appropriateness, and appropriate normative interpretation. Such an approach can help reduce assessment bias, support more accurate

E-ISSN: 3060-6713

educational and clinical decision-making, and provide a stronger foundation for identifying the cognitive strengths and needs of adolescents with visual impairment.

The present study had several limitations. First, because the study was based on a qualitative systematic review and thematic synthesis, the findings depended on the quality, scope, and methodological rigor of previously published studies. Second, the reviewed studies were heterogeneous in terms of design, population, age group, degree of visual impairment, assessment instruments, theoretical framework, and reporting quality, which limited the possibility of direct comparison across all sources. Third, although both national and international studies were included, the number of national studies was limited, and this may restrict the extent to which the findings fully represent cultural, linguistic, and educational conditions in local contexts. Fourth, because many studies did not provide detailed information about onset of blindness, residual vision, educational background, assistive technology use, or rehabilitation history, it was not possible to analyze all individual and contextual factors that may influence intelligence assessment outcomes. Finally, the present study synthesized conceptual and empirical evidence but did not develop or validate a new assessment instrument; therefore, the proposed components require further empirical testing.

Future research should move from conceptual synthesis toward instrument development, validation, and norming for blind and low-vision adolescents. Future studies should design intelligence assessment batteries that include auditory, tactile, verbal, spatial, executive, adaptive, and emotional-social components and then examine their construct validity, reliability, measurement invariance, and predictive validity. It is also recommended that future research distinguish between congenital blindness, acquired blindness, low vision, and different degrees of residual vision, because these conditions may be associated with different cognitive and sensory profiles. Longitudinal studies are needed to examine how cognitive abilities develop over time in relation to educational access, mobility training, assistive technology use, family support, and rehabilitation experiences. Cross-cultural studies should also be conducted to determine whether the proposed themes are stable across different linguistic and educational settings. Finally, future studies should compare traditional intelligence tests, adapted versions, and newly designed multisensory instruments to determine which approaches provide the fairest and most accurate assessment of cognitive abilities in this population.

In practice, psychologists, educators, rehabilitation specialists, and test developers should avoid interpreting the intelligence of blind and low-vision adolescents solely through instruments designed for sighted individuals. Assessment should begin with a careful understanding of the adolescent's sensory status, onset and severity of visual impairment, educational history, communication mode, assistive technology skills, and daily functioning. Test selection and interpretation should prioritize construct validity, accessibility, and fairness rather than administrative convenience. Practitioners should use multisensory tasks, provide appropriate accommodations, avoid unnecessary visual demands, and interpret timed performance cautiously when tactile exploration or assistive methods are involved. Educational and clinical reports should describe both cognitive strengths and functional needs, with particular attention to verbal-auditory abilities, tactile reasoning, working memory, executive functioning, adaptive skills, and environmental problem-solving. At the policy and institutional level, there is a need to support the development of standardized, culturally appropriate, visually unbiased intelligence assessment tools that can guide educational placement, intervention planning, and rehabilitation services more accurately.

Authors' Contributions

Authors equally contributed to this article.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

Acknowledgments

We would like to express our gratitude to all individuals helped us to do the project.

Declaration of Interest

The authors report no conflict of interest.

E-ISSN: 3060-6713

Funding

According to the authors, this article has no financial support.

Ethics Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants.

References

Amedi, A., Hofstetter, S., Maidenbaum, S., & Heimler, B. (2017). Task Selectivity as a Comprehensive Principle for Brain Organization. *Trends in Cognitive Sciences*, *21*(5), 307-310. https://doi.org/10.1016/j.tics.2017.03.007

Amedi, A., Malach, R., Hendler, T., Peled, S., & Zohary, E. (2001). Visuo-Haptic Object-Related Activation in the Ventral Visual Pathway. *Nature Neuroscience*, *4*(3), 324-330. https://doi.org/10.1038/85201

Amedi, A., Raz, N., Pianka, P., Malach, R., & Zohary, E. (2003). Early Visual Cortex Activation Correlates with Superior Verbal Memory Performance in the Blind. *Nature Neuroscience*, *6*(7), 758-766. https://doi.org/10.1038/nn1072

Argueso, P. (2022). Human Ocular Mucins: The Endowed Guardians of Sight. *Advanced Drug Delivery Reviews*, *180*, 114074. https://doi.org/10.1016/j.addr.2021.114074

Bedny, M. (2017). Evidence from Blindness for a Cognitively Pluripotent Cortex. *Trends in Cognitive Sciences*, *21*(9), 637-648. https://doi.org/10.1016/j.tics.2017.06.003

Bell, E. C., & Silverman, A. M. (2018). Rehabilitation and Employment Outcomes for Adults Who Are Blind or Visually Impaired: An Updated Report. *Journal of Blindness Innovation & Research*, *8*(1). https://doi.org/10.5241/8-148

Brandao, A. D. O., Magalhaes, R. C., Rocha, A. L. L., Costa, N. D. O., Fernandes, L. C., & Vasconcelos, G. C. (2024). Assessment Tools for Evaluating Neuropsychomotor Development in Children with Visual Impairment: An Integrative Review. *Revista Brasileira de Oftalmologia*, *83*, e0059. https://doi.org/10.37039/1982.8551.20240059

Campos, C. R., & de Cassia Nakano, T. (2018). Intelligence Scale for Children with Visual Impairment-Professional Version: Performance by Type and Degree of Disability. *REXE. Revista de Estudios y Experiencias en Educacion*, *17*(33), 31-44. https://doi.org/10.21703/rexe.20181733ccampos32

Cappagli, G., Finocchietti, S., Baud-Bovy, G., Cocchi, E., & Gori, M. (2017). Multisensory Rehabilitation Training Improves Spatial Perception in Totally but Not Partially Visually Deprived Children. *Frontiers in Integrative Neuroscience*, *11*, 29. https://doi.org/10.3389/fnint.2017.00029

Chen, X., Lu, M., Bu, W., Wang, L., Wang, Y., Xu, Y., & Zhong, M. (2021). Psychometric Properties of WISC-IV Verbal Scales: A Study of Students in China Who Are Blind. *Journal of Visual Impairment & Blindness*, *115*(3), 228-241. https://doi.org/10.1177/0145482X211018520

Chen, Y., Koh, K. H., Ho, J. W. C., Yew, S. M. E., Goh, J. H. L., Lum, E., & Tham, Y. C. (2026). Evaluation of a Community-Based AI-Assisted Visual Impairment Screening Model for Performance, Operational Efficiency, Acceptability, Feasibility, and Costs: Protocol for a 2-Arm Pragmatic Randomized Controlled Trial. *Jmir Research Protocols*, *15*(1), e74164. https://doi.org/10.2196/74164

Chollet, F. (2019). On the Measure of Intelligence. *arXiv preprint arXiv:1911.01547*.

Correia, K., Bara, T. S., Furlin, V., Prando, C., Iankilevich, P. G., & Cordeiro, M. L. (2026). Impact of Visual Impairment Severity on Working Memory and Executive Function in Children and Adolescents. *Frontiers in psychology*, *17*, 1827656. https://doi.org/10.3389/fpsyg.2026.1827656

Creswell, J. W., & Poth, C. N. (2016). *Qualitative Inquiry and Research Design: Choosing among Five Approaches*. Sage Publications.

Czerwinska, K., & Piskorska, A. (2018). Cognitive Functioning of a Blind Student in a Foreign Language Classroom. Forum Pedagogiczne,

Flanagan, D. P., Ortiz, S. O., & Alfonso, V. C. (2013). *Essentials of Cross-Battery Assessment*. John Wiley & Sons.

Hirsch, G. V., Bauer, C. M., & Merabet, L. B. (2015). Using Structural and Functional Brain Imaging to Uncover How the Brain Adapts to Blindness. *Annals of Neuroscience and Psychology*, *2*, 5.

Keith, T. Z., & Reynolds, M. R. (2010). Cattell-Horn-Carroll Abilities and Cognitive Tests: What We've Learned from 20 Years of Research. *Psychology in the Schools*, *47*(7), 635-650. https://doi.org/10.1002/pits.20496

Lamper, C., Onnink, M. L., van Buijsen, M., van der Aa, H. P., & van Munster, E. P. (2026). Adaptations and Interpretation of Intelligence Tests for Adults with Visual Impairment: A Literature Review and Interviews with Healthcare Professionals. *medRxiv*. https://doi.org/10.64898/2026.03.11.26347170

Liu, L., Tang, C., Chen, J., Lei, Y., Li, Y., & Ding, G. (2026). A Multidimensional Framework for Dissociating the Neuroplasticity of Auditory and Early Language Deprivation. *Communications Biology*. https://doi.org/10.1038/s42003-026-09900-8

Long, H. A., French, D. P., & Brooks, J. M. (2020). Optimising the Value of the Critical Appraisal Skills Programme (CASP) Tool for Quality Appraisal in Qualitative Evidence Synthesis. *Research Methods in Medicine & Health Sciences*, *1*(1), 31-42. https://doi.org/10.1177/2632084320947559

McLinden, M., Douglas, G., Hewett, R., Cobb, R., Keil, S., Lynch, P., & Thistlethwaite, J. S. (2022). *Promoting Equitable Access to Education for Children and Young People with Vision Impairment: A Route-Map for a Balanced Curriculum*. Routledge. https://doi.org/10.4324/9781003002321

Nelson, P. A., Dial, J. G., & Joyce, A. (2002). Validation of the Cognitive Test for the Blind as an Assessment of Intellectual Functioning. *Rehabilitation Psychology*, *47*(2), 184. https://doi.org/10.1037/0090-5550.47.2.184

Niemann, M., Prange, A., & Sonntag, D. (2018). Towards a Multimodal Multisensory Cognitive Assessment Framework. 2018 IEEE 31st International Symposium on Computer-Based Medical Systems,

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., & Moher, D. (2021). The PRISMA 2020 Statement: An Updated Guideline for Reporting Systematic Reviews. *bmj*, *372*.

Papadopoulos, K., Koustriava, E., & Kartasidou, L. (2011). The Impact of Residual Vision in Spatial Skills of Individuals with Visual Impairments. *The Journal of Special Education*, *45*(2), 118-127. https://doi.org/10.1177/0022466909354339

Papadopoulos, K., Koustriava, E., & Kartasidou, L. (2012). Spatial Coding of Individuals with Visual Impairments. *The Journal of Special Education*, *46*(3), 180-190. https://doi.org/10.1177/0022466910383016

Park, W. J., & Celikel, T. (2026). Binding as an Enabling Mechanism for Cross-Modal Plasticity. *Neuroscience &*

E-ISSN: 3060-6713

Biobehavioral Reviews, 106695. https://doi.org/10.1016/j.neubiorev.2026.106695
Pasqualotto, A., & Proulx, M. J. (2012). The Role of Visual Experience for the Neural Basis of Spatial Cognition. *Neuroscience & Biobehavioral Reviews*, *36*(4), 1179-1187. https://doi.org/10.1016/j.neubiorev.2012.01.008
Raczy, K., & Korczyk, M. (2018). Are IQ Tests Enough to Measure Intelligence in the Blind? Brief Review of Available and Potential Methods to Estimate Intelligence in the Blind. *Rocznik Kognitywistyczny*(11), 17-34.
Rajabi, S., & Alimoradi, K. (2016). Comparison of Spatial Memory and Spatial Orientation among Blind, Low-Vision, and Sighted Individuals. *Exceptional Children Quarterly*, *16*(3), 49-64.
Resnick, L. B. (2024). *The Nature of Intelligence*. Taylor & Francis.
Roder, B., & Rosler, F. (2003). Memory for Environmental Sounds in Sighted, Congenitally Blind and Late Blind Adults: Evidence for Cross-Modal Compensation. *International Journal of Psychophysiology*, *50*(1-2), 27-39. https://doi.org/10.1016/S0167-8760(03)00122-3
Roder, B., Rosler, F., & Neville, H. J. (2000). Event-Related Potentials during Auditory Language Processing in Congenitally Blind and Sighted People. *Neuropsychologia*, *38*(11), 1482-1502. https://doi.org/10.1016/S0028-3932(00)00057-9
Roder, B., Stock, O., Bien, S., Neville, H., & Rosler, F. (2002). Speech Processing Activates Visual Cortex in Congenitally Blind Humans. *European Journal of Neuroscience*, *16*(5), 930-936. https://doi.org/10.1046/j.1460-9568.2002.02147.x
Schneider, W. J., & McGrew, K. S. (2018). The Cattell-Horn-Carroll Theory of Cognitive Abilities. In *Contemporary Intellectual Assessment: Theories, Tests, and Issues* (pp. 163).
Sepulveda-Palomo, M., Del Rio, D., Villalobos, D., & Fernandez Gonzalez, S. (2024). Verbal and Spatial Working Memory Capacity in Blind Adults and the Possible Influence of Age at Blindness Onset: A Systematic Review and Meta-Analysis. *Neuropsychology Review*, 1-19. https://doi.org/10.1016/j.neuroimage.2019.01.073
Shen, L., Huang, Y., Ma, Z., Chen, M., Ma, C., & Clemens, N. H. (2026). How Accurate Are Computer-Adaptive Reading Screeners? A Systematic Review and Meta-Analysis of Validity and Classification Accuracy. *School Psychology Review*, 1-21. https://doi.org/10.1080/2372966X.2026.2633597
Sternberg, R. J. (2018). *The Nature of Human Intelligence*. Cambridge University Press.
Thomas, J., & Harden, A. (2008). Methods for the Thematic Synthesis of Qualitative Research in Systematic Reviews. *BMC medical research methodology*, *8*(1), 45. https://doi.org/10.1186/1471-2288-8-45
Tonelli, A., Senna, I., Amadeo, M. B., Setti, W., Domenici, N., Signorini, S., & Gori, M. (2026). The Development of Audio-Tactile Spatial Integration: Unraveling Vision's Contribution. *Developmental science*, *29*(1), e70094. https://doi.org/10.1111/desc.70094
Veldhorst, C., Kef, S., Vervloed, M. P., & Steenbergen, B. (2026). A Longitudinal Study of Development in Language, Cognition, Social Adaptation, and Exploratory Behaviour of Toddlers with Vision Impairment. *British Journal of Visual Impairment*, *44*(2), 327-341. https://doi.org/10.1177/02646196251345325
Vitas, M., Cvjetovic, S., & Dobovisek, A. (2026). A Possible Definition of Intelligence. *BioSystems*, 105776. https://doi.org/10.1016/j.biosystems.2026.105776
Yildirim, H., & Kaya, L. G. (2025). New Approaches and Theories in Understanding Intelligence and Cognitive Ability Processes. *Duzce University Journal of Science and Technology*, *13*(2), 913-931. https://doi.org/10.29130/dubited.1635523

E-ISSN: 3060-6713