Nordic Welfare Centre

The Pediatric Brain Based Auditory and Visual Impairment (P-BAVI)

Professional manual and checklist

Contents

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The Pediatric Brain Based Auditory and Visual Impairment (P-BAVI) – Professional manual and checklist

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Foreword

Understanding how children perceive and make sense of the world is one of the greatest challenges in the fields of sensory impairment, neurodevelopment, and education. While considerable advances have been made in our understanding of Cerebral Visual Impairment (CVI) and Auditory Processing Disorder (APD), much less attention has been given to children whose difficulties arise from the combined interaction of visual and auditory processing challenges.

This publication represents an important contribution to addressing that gap. Through the concept of Brain-based Auditory and Visual Impairment (BAVI), the authors invite us to look beyond traditional diagnostic boundaries and consider how auditory and visual processing may interact within a complex neurological framework. In doing so, they offer a perspective that is both clinically relevant and deeply meaningful for children, families, educators, and professionals seeking to understand everyday functioning rather than isolated symptoms.

The development of the Pediatric Brain-based Auditory and Visual Impairment (P-BAVI) checklist reflects a growing recognition that many children experience challenges that cannot be adequately explained by hearing status, vision status, or developmental diagnoses alone. For some children, the difficulty lies in how sensory information is perceived, integrated, interpreted, and used. These challenges may affect communication, learning, social participation, mobility, emotional regulation, and overall development.

For professionals working in the field of deafblindness, this work is particularly significant. Functional deafblindness is often characterised not only by the combined impact of reduced hearing and vision, but also by the complex ways in which sensory information is accessed and processed. Understanding brain-based auditory and visual processing difficulties may therefore offer valuable insights into the diverse presentations of functional deafblindness and help explain why some individuals experience challenges that extend beyond what can be predicted from sensory measurements alone.

This publication should not be viewed solely as a checklist manual. Rather, it may serve as a complementary resource within broader assessment processes and multidisciplinary discussions concerning functional deafblindness, neurodevelopmental conditions, and sensory processing difficulties. By encouraging systematic observation and reflection, it provides a framework for recognising patterns that might otherwise remain unnoticed and for identifying individuals who may benefit from further assessment and tailored support.

The authors bring together extensive expertise from the fields of deafblindness, cerebral visual impairment, auditory processing, assessment, and education. Their combined experience is evident throughout this work, which balances clinical knowledge, theoretical perspectives, and practical application. The result is a publication that challenges established thinking while remaining firmly grounded in the realities faced by children and the professionals who support them.

As our understanding of BAVI continues to evolve, this publication offers an important starting point for discussion, research, and practice. It reminds us that meaningful support begins with meaningful understanding. By helping us recognise the complexity of brain-based sensory processing difficulties, it takes an important step towards ensuring that children with these challenges are seen, understood, and supported in ways that respect their individual strengths, needs, and potential.

We commend the authors for their vision, dedication, and willingness to explore a field that remains largely uncharted. It is my hope that this publication will contribute to greater awareness, stimulate further research, and ultimately improve the lives of children whose experiences have too often remained difficult to explain.

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Director

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Acknowledgements

The development of this publication reflects the combined expertise, experience, and commitment of professionals who have dedicated many years to advancing our understanding of sensory processing, cerebral visual impairment, auditory processing, cognition, and deafblindness.

The authors bring together perspectives from clinical practice, research, education, and multidisciplinary assessment. Their collective work represents a unique convergence of knowledge from fields that have often developed separately, yet which are increasingly recognised as deeply interconnected in the lives of children and adults with complex sensory and neurodevelopmental needs.

Particular acknowledgement is due to Jude Nicholas, whose longstanding work in cognitive assessment and deafblindness has contributed significantly to our understanding of how meaningful assessment can reveal strengths, abilities, and developmental potential that may otherwise remain hidden. John Ravenscroft's international leadership and research in childhood visual impairment and cerebral visual impairment have helped shape contemporary understanding of brain-based visual processing difficulties and their impact on everyday functioning. Anne Schoone has contributed extensive expertise in dynamic assessment, deafblindness, and CHARGE syndrome, continuously emphasising the importance of recognising individual learning potential and development. Christine Sauvé Guindon has, through her work in deafblindness and cerebral visual impairment, helped broaden the discussion regarding the relationships between visual and auditory processing and their implications for functional deafblindness. [researchgate.net], [frontiersin.org], [edwebprofi...s.ed.ac.uk], [deafblindi...tional.org], [cdpsurdicecite.org], [ca.linkedin.com]

Together, the authors challenge us to look beyond traditional diagnostic categories and consider how brain-based auditory and visual processing influence participation, communication, development, and quality of life. Their work represents an important contribution to the growing international effort to better understand the complex realities of individuals whose challenges cannot be explained through sensory measurements alone.

It is our hope that this publication will encourage continued dialogue, collaboration, and research across disciplines, and that it will ultimately contribute to more accurate assessments, more responsive services, and a deeper understanding of functional deafblindness and brain-based sensory processing differences.

1. General Introduction

The term Brain based Auditory and Visual Impairment (BAVI) can be used when an underlying neurological disorder is affecting the functioning of both vision and hearing. The eyes and ears may function from normal/near-to-normal to decreased levels, but the visual and auditory systems of the brain do not consistently process or interpret what the eyes see, and the ears hear. Along these lines, BAVI could occur in people with typical/near-to-normal hearing and vision as well as in people with combined vision and hearing loss/deafblindness.

Deafblindness is a disorder of combined vision and hearing loss, also known as dual sensory loss. Deafblindness has a varying combination of visual and hearing impairment in the same individual. The variables that influence this diversity include the severity of each sensory impairment (ranging from residual low vision to no light perception; hard of hearing to no sound perception), the order of onset (vision loss first, hearing loss first, simultaneous onset), and the timing of the onset (congenital sensory impairments, acquired sensory impairments, age-related dual sensory loss) (Dammeyer, 2014; Wittich, & Dumassais, 2025).

Deafblindness is a highly heterogeneous disorder. The most common causes of deafblindness in children and young adults are hereditary syndromes, such as CHARGE syndrome, Cornelia de Lange syndrome, Usher syndrome and Stickler syndrome, followed by cases with prenatal/congenital complications, such as cytomegalovirus infection, postnatal/non-congenital complications, such as meningitis and complications of prematurity, such as ischemia or hypoxia (Matsunaga, 2021).

A child with deafblindness with varying degrees of vision and hearing loss may have accompanying auditory and visual processing problems due to central nervous system disturbances. Underlying neurological disorders that impact the central nervous system, such as epileptic seizures, brain malformations or a concomitant brain injury may lead to difficulties in processing visual and auditory information in children with combined vision and hearing loss (Nicholas, 2020).

The likelihood of a proportion of children with visual processing difficulties also having auditory processing difficulties can be high. De Witt et al. (2018) have raised the question regarding the possible overlap between children with Cerebral Visual impairment (CVI) and children with Auditory Processing Disorder (APD). Given the difficulties in identification and diagnosis, it is not difficult to see why most children with visual processing disorders might not appear on the radar for auditory processing disorders (Aitken, 2010). Furthermore, there a very few data sets which contain this group, often it is either a CVI or APD problem.

To grasp the disorder of Brain based Auditory and Visual Impairment (BAVI), it is crucial to understand how the brain processes visual and auditory input in a bottom-up manner (upward neural pathways) and how the brain concurrently uses top-down processes (downward neural pathways) to support the rapid perception and interpretation of visual and auditory information. The idea that top-down influences modulate bottom-up processing in both vision and audition is supported by extensive empirical and theoretical work (Chaudhuri, et al., 2026).

Bottom-up processing starts with raw visual and auditory sensory impressions (i.e., light and sound) and it is the primary system engaged in perceptual processing, laying the foundation upon which top-down cognitive processes can apply their interpretative influence. At its core, top-down processing emphasizes that perception is not a passive reception of environmental stimuli. Top-down processing helps prioritize and organize incoming information and it is shaped by the salience of the sensory stimuli, prior experiences and expectations. The brain doesn't passively receive information; it actively generates models of the world and predicts incoming sensory data and updates those predictions with experience (Clark, 2013). In this way, sensory perception is crafted and constructed rather than acting as a passive receiver of reality. Consequently, the brain continuously coordinates sensory inputs from vision and hearing, to create a complex interplay and an integrated perceptual experience, which is shaped by interconnected bottom-up and top-down processes of a unified system (Saghravanian, 2025).

Through this perspective, BAVI is considered a complex disorder of impaired processing of both visual and auditory information due to brain-related issues and involves difficulties in this unified system of bottom-up and top-down processing. The impaired processing of this integrative system due to BAVI may be consistent with the combined disruption of lower-order auditory and visual processing at earlier levels (i.e. capturing specific visual & auditory sensory impressions and initial interpretations) and higher-order auditory and visual processing at later stages (i.e., applying auditory & visual attentional-memory processes and complex interpretations).

The disruption in the neural interplay between auditory lower-order & higher-order processing, together with visual lower-order & higher-order processing may create a malfunction consistent with BAVI. However, the severity of the visual and auditory processing difficulties of BAVI may vary within and across children due to different etiologies and to the extent of brain malfunctions. Importantly, BAVI can significantly cause developmental delays because it impacts on how the brain processes auditory and visual information. These developmental delays may stem from difficulties in visual and auditory lower-order functions, jointly with visual and auditory higher-order functions. In this manner, pediatric BAVI could be considered as a neurodevelopmental disorder, since it may begin during childhood and affect how the brain develops

To emphasize the uniqueness of the behavioural characteristics of children with deafblindness and BAVI, we use the term "DB-BAVI". Children with DB-BAVI may not meet typical auditory and visual developmental milestones, often leading to challenges in motor skills (reaching, walking), communication and language, and cognition (learning, problem solving, understanding, comprehending). Especially, in a child with DB-BAVI, it is important to address the global impact of peripheral vision and hearing loss, together with central nervous system disturbances on the child for failing to meet typical developmental milestones.

Accordingly, it is necessary to develop an appropriate observational checklist to systematically record the presence or absence of specific behaviours associated with lower-order & higher-order auditory and visual processing. Especially for the purpose of identifying individuals who may be at risk for a BAVI disorder. As such, the Pediatric Brain based Auditory and Visual Impairment

(P-BAVI) observational checklist can be used as a preliminary step in the evaluation of a brain based visual and auditory impairment (BAVI), as a way of determining if further, more comprehensive assessment is necessary. Furthermore, results from the P-BAVI evaluation can be used to guide individualistic interventions.

The P-BAVI could be also applied to children with other clinical disorders, such as in children diagnosed with autism spectrum disorder (ASD). ASD is a neurodevelopmental disorder characterized by difficulties with social interaction and restricted, repetitive patterns of behaviour, and can be regarded as disorder related to brain development that affects how children see, hear and perceive others and especially how they socialize with others. Atypical auditory and visual based behaviours with perceptual deficits have been explored in individuals with ASD, suggesting an impact of disrupted lower-order & higher-order operations on sensory processing (Marco, et al., 2011). Besides, identifying lower-order & higher-order sensory processing may serve as valuable findings for targeting therapeutic interventions for ASD.

2. Disorders of visual and auditory processing and BAVI

Brain based Visual and Auditory Impairment (BAVI) is about how the brain causes combined auditory and visual processing difficulties. The notion of conceptualizing BAVI in a unified fashion, rather than as two distinct disorders incidentally presented in the same person, is relatively recent. Impairment as result of BAVI creates difficulties for a person to process and interpret both sound and vision in a separated or integrated manner. Thus, BAVI may create a functional impairment that is much more complicated than the combination of the two single processing impairments, Cerebral Visual impairment (CVI) and Auditory Processing Disorder (APD). However, BAVI may share some similar impairment characteristics with both CVI and APD.

Cerebral Visual impairment (CVI) is fundamentally a brain-based visual processing disorder that makes it difficult to process and understand visual information. CVI is widely used as an umbrella term for a wide variety of visual difficulties due to visual dysfunction in early childhood that results from a wide range of developmental disorders and brain injuries (Zihl & Dutton, 2015). It is a disorder associated with heterogeneous visual dysfunctions arising from brain injury or abnormality (Philip & Dutton 2014). Sakki and colleagues (2018) have described CVI as heterogeneous visual dysfunctions of multiple pediatric etiologies that originate in the brain rather than in the ocular structures or anterior visual pathways. Furthermore, it is characterized by deficits of visual function and functional vision caused by neurologic damage or maldevelopment of the visual processing areas in the brain (Gordon et al., 2024).

CVI is considered a neurodevelopmental disorder and may be comorbid with other neurodevelopmental disorders (Chang, et al., 2024). A vast majority of CVI children have comorbid neurological disorders and deficits including neurodevelopmental disabilities, epilepsy/seizures, cerebral palsy, hydrocephalus, genetic changes and periventricular white matter disease (Philip & Dutton, 2014; Jimenez-Gomez, et al., 2022)

CVI represents a lifelong condition characterized by a complex amalgam of impairments in lower- and/or higher-order visual functions caused by congenital or acquired brain injury, malformation, or malfunctioning of the visual processing networks, rather than any potentially co-occurring impairment of the peripheral visual system. The visual impairments and/or dysfunctions are heterogeneous and complex and impact the ability to perform vision-related or visually guided activities. This, together with the often-co-occurring neurodevelopmental impairments, can seriously limit functioning, educational performance, daily activities, and participation. (Micai et al., In Press). Consequently, the visual difficulties in CVI may manifest as both visual lower-order and higher-order deficits, leading to characteristic behaviors in affected individuals. The lower-order visual deficits may include impaired visual acuity, reduced contrast sensitivity or visual field deficits, acuity, whilst the higher-order deficits may include impaired face and object recognition, difficulties with visual-spatial orientation or impaired visual attention (Monteiro, et al., 2025). Moreover, children with CVI may have distinct difficulties, such as the ability to integrate multiple visual elements of a scene to achieve visual overview (global visual selective attention deficit) (Hokken, et al., 2024). Global visual selective attention is essential for navigating crowded environments and recognizing objects or faces. In addition, CVI children may display difficulties in the ability to integrate many individual motion signals of a large visual area to understand the coherent movement of a whole object or scene, like seeing a flock of birds move as one (global motion perception deficit) (Pamir et al., 2021)., Global motion perception is essential for extracting meaningful motion from complex scenes and is also necessary for navigation and avoiding obstacles during navigation.

It is crucial to highlight that CVI deficits are prone to significant individual differences and can exist in varying combinations and severities. Accordingly, CVI should be considered a spectrum disorder, not a single diagnosis, where the specific type of visual deficit and its severity depend on the location and extent of brain damage affecting visual processing (Chokron & Dutton, 2023). Statistical analyses of children with suspected or diagnosed congenital CVI have revealed three subgroups (A1, A2, B), with discrete profiles and a continuous spectrum of severity including visual acuity reduction from Group A1 to B in direction of greater severity and with Group A2 as intermediate (Sakki et al., 2021), although the exact number of subgroups is still debated.

Auditory Processing Disorder (APD) on the other hand, is a deficit in the way sounds are analyzed by the brain (Dillon and Cameron, 2021). APD often leads to difficulties in the brain`s ability to organize sound processing and interpret auditory signals, even with normal hearing. It is characterized by poor perception of both speech and non-speech sounds (Moore et al., 2011). Specific deficits in auditory rhythm perception, that is problems in the perception of regularly timed sound sequences have also been reported in children with APD (Sidiras, et al., 2019). Besides, children with APD have difficulty making sense of sounds including speech sounds, leading to trouble following verbal instructions, especially in challenging listening situations. Auditory processing difficulties become more pronounced in noisy environments or when multiple people are talking simultaneously from different directions.

APD represents a constellation of inconsistent responses to sounds, with or without normal pure-tone hearing sensitivity (Tepe, et al., 2023). Relatedly, inconsistent responses to sounds and poor speech clarity are also reported in an Auditory Neuropathy Spectrum Disorder (ANSD), which involves problems of sending sound from the inner ear to the brain, due to specific damage to inner hair cells or the auditory nerve fibers (i.e., deficient transmission of auditory signals). On the contrary, APD is a listening problem where the brain struggles to interpret sounds, especially in overwhelming listening conditions, such as in background noise (i.e., deficits in the neural processing of auditory information). APD manifests as an impaired processing of auditory information leading to significant auditory comprehension challenges, especially evident in learning tasks (Gitto, et al., 2025).

APD has been described as a specific deficit in processing of auditory information along the central auditory nervous system, including bottom-up and top-down neural connectivity. (Sidiras, et al., 2019). Accordingly, auditory function does not rely solely on the integrity of the ascending auditory neural pathways (upward route) but also depends on the connectivity of the descending auditory neural pathways (downward route), which include the brain's cognitive centers. It has been hypothesized that deficits seen in children with impaired auditory processing might not only arise from deficits in the upward auditory pathway (bottom–up processes), but also from impaired downward auditory pathways (top–down processes) possibly also affecting the efferent central auditory system, such as structures that mediate auditory processing by attention and memory (Moore, 2012). Accordingly, the listening difficulties of children with APD are often not fully explained by disordered transduction in the cochlea or abnormal early processing along the auditory brainstem pathway, but most likely that listening challenges are associated with how auditory information is processed in the cortex (Ahmadi, et al., 2024).

One of the most common symptoms of APD is poor listening skills, which often leads to a listening difficulty. Poor listening skills are characterized by difficulty distinguishing speech from background noise, decreased attention to auditory information, need for excessive verbal repetitions, distracted in listening situations, restless during conversations, difficulty localizing the source of the speech signal and difficulty to discriminate among speech sounds (Vandergrift, 2004). When listening breaks down, children can miss key instructions, appear inattentive and distracted, and fall behind academically (Chermak, et al., 2002).

Listening is the process of hearing with intention and attention (Kiessling, et al., 2003), with an intent to extract information. Accordingly, listening involves a complex interplay between lower-order processing (i.e., hearing sound details, distinguishing similar sounds, determining the sequence or timing order of sounds,) and higher-order processing (i.e., interpreting sounds, auditory-based language processing, attention to sounds, remembering auditory sequences) (Khavarghazalani et al., 2024). Especially the allocation of auditory attentional resources and auditory working memory play a vital role in the higher order processing of listening (Mattsson, et. al., 2019). Hence, in overwhelming listening conditions, the degraded or ambiguous auditory signal places increased demands on the listener's auditory attention or auditory working memory to achieve accurate perception. While listening was initially examined as a singular ability, recent examinations have framed listening as a dynamic network of auditory, linguistic and cognitive processes that develop throughout childhood (Gurteen, et al., 2026; Obuchi, et al., 2026)

Furthermore, listening involves identifying the source of the sound (i.e., sound localization) and is influenced by the acoustic quality in the listening environment. Sound localization is how the brain figures out where a sound comes from in space, spatial processing. Sound localization involves the precise relative intensity and timing between the two ears (i.e., binaural cues), as well as neural encoding of sound locations, especially the processing of sound sources in the cortex (Tian, et. al., 2021). It involves several specialized and complementary mechanisms that go beyond the mere detection of sound sources, and it involves multilayered sound processing at both perceptual level and in higher level integrative functions, especially in the integration of auditory spatial cues (Alzaher, et al., 2026). Practically, sound localization is essential for safe navigation in the environment, and plays a central role in communication (Alzaher, et al., 2026).

Regarding, the acoustic quality in the listening environment (i.e., room acoustics) factors such as excessive reverberation or high background noise can mutually disrupt a child`s ability to listen effectively (Zhou, et al., 2025). Although several parameters can be used to characterize room acoustics, reverberation is the most dominant one. Findings highlight that poor room acoustics may intensify cognitive fatigue and listening difficulty (Breuer, et al., 2022). Furthermore, difficulties in listening vary significantly between indoor and outdoor environments due to differences in acoustics and types of background noise (Mercugliano, et., 2025). Hence, problems with sound localization and listening difficulties in poor acoustic environments represent debilitating symptoms of APD.

Children with APD often experience confusion and difficulty with everyday listening tasks. Adequate listening skills rely not only on auditory processing but may also depend on multiple other foundational skills such as hearing levels, cognitive function and language ability (Gudkar, et al., 2024). Children with difficulties in listening might therefore have difficulties with one or more of these foundational skills which can be caused by underlying deficits in multiple domains such as deficits in auditory processing, language, cognition and spatial processing (Dillon, & Cameron, 2021). Furthermore, some of these underlying deficits may be the cause of others, hence creating a cascading effect. For example, protracted or repeated middle ear infections during the first five years of life may have left a lasting spatial processing difficulty that affects the child's ability to understand speech in noisy environments, thereby slowing the rate of language acquisition. In turn, that deficit in language ability then makes it harder to fill in the gaps when listening to speech in noise (Dillon et al., 2025).

Current scientific understanding of APD is complex and has remained a controversial topic within audiology, with limited consensus and various approaches to the exact definition or diagnostic standards of APD (Wilson & Arnott, 2013). Therefore, an integral approach for understanding listening difficulties and their interconnected links to a range of audiological factors (e.g. hearing acuity and auditory processing) and non-audiological factors (e.g. attention and language abilities) are needed (O'Hara & Mealings, 2018; Seeto, et al., 2021; Gudkar, 2024). The current understanding of auditory processing is rooted in the theoretical framework of complex interactions between the peripheral and central auditory nervous systems and supports the idea that auditory processing is multidimensional and consists of distinct but connected skills (Shaikh, et al., 2026).

A high proportion of children with APD have comorbidities, thus, suggesting a complex connection between listening difficulties and cognitive or language deficits (Keith, et al., 2019). Attention deficits in children with APD appear to be centered around the auditory modality (Stavrinos, et al., 2018). Besides, listening difficulty linked to developmental language disorders has been characterized by an impaired processing of attended speech rather than a generalized auditory disengagement (Kojima et al., 2026).

Regarding APD and listening difficulties, the British Society of Audiology Position Statement and Practice Guidance on Auditory Processing Disorder (Moore et. al., 2018) has classified APD into three categories: 1) Developmental APD (cases presenting in childhood with listening difficulties, but with normal audiometric hearing and no other known etiology or potential risk factors), 2) Secondary APD (cases where listening difficulties occur in the presence, or as a result of either transient or permanent peripheral hearing loss) and 3) Acquired APD (cases where listening difficulties are associated with known medical causes, such as a brain lesion or abnormalities). Listening difficulties in acquired APD due to neurological etiologies have been reported in children with epilepsy (Beshr et al., 2025), children with identified brain lesions (Matos, et al.,

2018) and in young children with post-concussion (Bonacina, et al., 2024).

By and large, CVI is a problem with visual processing in the brain. Similarly, APD is a problem with auditory processing in the brain (i.e. listening difficulty). Brain based auditory and visual impairment (BAVI) may share similar characteristics with the different subgroups of CVI and the categories of APD. Like CVI and APD, BAVI involves a breakdown in the complex interplay between lower-order processing and higher-order processing due to brain-related issues, resulting in a collection of varied functional deficits.

Nevertheless, pediatric BAVI should be considered as a distinctive neurodevelopmental disorder that creates a functional impairment that is much more complicated than the combination of CVI and APD. Thus, BAVI is not merely the sum of separate visual and auditory processing disorders, but rather a distinct clinical disorder that diminishes the ability to process both visual and auditory information.

The profile of BAVI can have diverse manifestations and unique characteristics. Specifically, the processing problems of children due to pediatric BAVI may fall on a spectrum and co-occur in other neurodevelopmental disorders. It might be challenging, yet important, to differentiate BAVI from other neurological or neurodevelopmental disorders. Due to shared neurodevelopmental pathology, many children with BAVI may also experience comorbid motor, language, or cognitive difficulties.

BAVI may create difficulties for a person to simultaneously process auditory and visual information and can affect both children and adults.

3. Understanding BAVI as a clinical disorder

Wide range of etiologies or risk factors may contribute to peripheral vision and hearing problems and concomitant brain dysfunctions in the auditory and visual processing systems. Traumatic brain injuries (TBI), including concussion due to significant blast exposure may lead to central hearing and vision difficulties and cognitive dysfunctions simultaneously (Lew, et al., 2009). Frequently, these adult patients are informed that they do not have hearing and visual loss despite their perceived listening difficulties and visual perceptual deficits in their daily lives. The disorder of having typical/near normal visual and auditory acuity and yet experiencing visual and hearing difficulties in everyday life may often be misunderstood or mislabeled. Thus, it is necessary to understand acquired vision and hearing processing deficits in adult patients originating in central neural pathways or networks rather than in the peripheral eyes and ears. Generally, a clinical assessment that includes measures of peripheral hearing, peripheral vision, central auditory functions, visual processing functions and neuropsychological tests are essential in recognizing the relative effect of the two processing deficits in adults (Saunders & Echt, 2012).

Vision and hearing deficits are known outcomes of TBI and exposure to explosives may put veterans and military personnel at particular risk of developing visual and auditory processing disorders unrelated to ageing (Raza, et al., 2024). The effects of peripheral changes to ears and eyes and the deficits associated with auditory and visual processing in adults have been described in military war veterans because of combat blast exposures (Saunders & Echt, 2012; Brungart, et al., 2019) and in professional divers because of barotrauma or underwater explosions (Ergen et al., 2019). Furthermore, visual processing problems (i.e., misperceptions of object size, distance, and shape) and auditory processing problems (i.e., difficulties in perceiving where a sound is coming from/spatial problems; difficulties in the timing or order of sounds/temporal problems), have been described in space mission astronauts due to exposure to microgravity following several months in orbit (Clément et al., 2013; Navarro Morales et al., 2023; Avcı, 2024). A combination of other risk factors, such as reduced visual stimulation, elevated background noise, social isolation and prolonged confinement during spaceflight may act as environmental stressors, which in turn may impair perceptual and cognitive processing of visual-auditory stimuli (Taylor, et al., 2016).

Taking all this clinical evidence together, it can be suggested that the disorder of a combined auditory and visual processing impairment exists in adults due to various etiologies and risk factors. However, the profile of combined auditory and visual processing impairment in children can significantly differ from patterns or features described in adults.

The deficits seen in children with combined visual and auditory processing (pediatric BAVI) may be interconnected and can impact the child's auditory lower-order & higher-order functions and visual lower-order & higher-order functions at any time. Pediatric BAVI can stem from various causes like premature birth, low birth weight, neonatal hypoxia or ischemia, viral infections during infancy, traumatic brain injuries, brain tumors, strokes, seizure disorders, congenital hydrocephalus, congenital brain anomalies/maldevelopment and genetic predispositions/risk genes. Risk genes are typically expressed during cortical development (Willsey, 2013). Hence with reference to genetic neurodevelopmental disorders with neurological implications (i.e., CHARGE syndrome), it is necessary to consider the likelihood of pediatric BAVI secondary to associated brain abnormalities.

Overall, pediatric BAVI is about the complex disorder of auditory and visual processing deficits and subsequently how it interferes with some or many aspects of information processing. Particularly, children with BAVI may struggle to process visual and auditory impressions consistently, including difficulties with visual and auditory perception, visual and auditory attention, as well as navigating complex visual and sound environments. Besides, BAVI may often lead to difficulties in noticing or responding instantly/rapidly to visual targets in overwhelming visual scenes and to auditory targets in challenging listening situations.

In conditions of irrelevant sounds or distracting background noise (auditory clutter), the listening brain of a child with BAVI may struggle to separate background noise from meaningful sounds, which can often lead to increased auditory fatigue. Similarly, in conditions of overwhelming presence of visual elements within a given space (visual clutter), the brain of a child with BAVI may require more effort to integrate multiple visual elements of a scene or extract meaningful motion from complex scenes, which can often lead to increased visual fatigue.

The auditory and visual processing difficulties of children with BAVI can negatively impact learning, independence and several areas of life. Frequently a child with BAVI may not meet typical auditory and visual developmental milestones and this could often lead to marked developmental delays.

4. Possible underlying neural mechanisms of BAVI

Pediatric BAVI as a neurodevelopmental disorder may affect the auditory and visual processing neural structures, pathways and underlying mechanisms. It might thus be conjectured that the spectrum of visual and auditory deficits seen in pediatric BAVI could be attributed to underlying brain dysfunction that affects the development of visual and auditory processing pathways and systems. However, it should be emphasized that the underlying relationships in BAVI are more complex and currently we cannot pinpoint exactly the level of neurological specificity.

The human brain is phenomenally complex and consists of regions and networks that exhibit a balance between network integration and segregation of visual and auditory processing. The brain is characterized by highly complex interactive networks. Current evidence suggests that the brain`s central associative hubs links regions within networks and function as an efficient "small world" connector that supports large-scale information integration (Li, et al., 2026).

Visual processing is the visual system's ability to effectively transfer and analyze visual information, along the same lines auditory processing is the auditory system's ability to effectively transfer and analyze auditory information. Visual and auditory processing are associated with a complex array of sensory impressions which are encoded respectively by the ears and eyes and then processed by multiple functional areas or pathways in the brain. The auditory and visual processing in the human brain suggest that the properties of sound (e.g., pitch, amplitude, timbre, duration) and the properties of vision (e.g., color, depth, motion, form) are processed in separate areas of the cerebral cortex and are assumed to be organized in parallel processing pathways (Salo, et al., 2013). Thus, efficient perceptual and cognitive functioning requires the integration of separate, but interconnected cortical networks in the brain (Parks, et. al., 2013).

According to the cortical processing of visual input, light or visual impressions from the environment are encoded by the retina which includes both the sensory neurons that respond to light and the intricate neural circuits that perform the first stages of image processing. The extracted aspects of the image are encoded as electrical messages, which travel through the optic nerve and optic chiasm. Signals are then transmitted along the thalamic neurons, conveyed through the optic chiasm before they reach the cerebral cortex for further feature identification and visual perception. The thalamus, specifically the lateral geniculate nucleus, actively relays visual information from the retina to the primary visual cortex in the occipital lobe for interpretation (Shipp, 2007). Visual areas beyond the primary visual cortex are called the extra striate visual cortex. The extra striate area V5/MT is crucial for processing the overall direction or coherent movement of a whole object or scene (Riecanský, 2004; Pamir et al., 2021). Furthermore, the neural regions of the extra striate cortex are considered part of either the ventral or dorsal stream (Milner, 2017). These pathways or networks are assumed to use visual object and visual spatial information differently (Salo, et al., 2013). The ventral network projects from the primary visual cortex to the inferior temporal cortex (i.e., occipitotemporal pathway). Generally, the ventral network (what" pathway), is associated with the encoding of basic geometric shapes, color discrimination and in the processing of foreground/background (level of depth) of visual stimuli. Information is then fed anteriorly to the inferotemporal cortex, where the fusiform face area resides, encoding facial features to enable efficient facial recognition (Prasad & Dinkin, 2019). In contrast, the dorsal network projects from the primary visual cortex to the posterior parietal cortex (i.e., occipitoparietal pathway). Largely, the dorsal network («where" pathway) is associated with motion processing and representations of object locations (Khader et. al., 2005). Besides, it is also responsible for processing the visual information needed for visually guided behavior (Norman, 2002). It is also crucial for visuospatial working memory, acting as the neural substrate for maintaining spatial information, location, and motion (Pisella, 2017). See figure 1.

According to the cortical processing of auditory input, sound or auditory impressions involve the collection of sound wave energy from the environment to the fluid vibrations within the cochlea. These sound vibrations or vibratory energy are then transformed into electric potentials by hair cells, and the activated neural impulses are transmitted via the auditory nerve. From the auditory nerve, auditory signals ascend along the central auditory pathways in which most critical sound attributes are processed. Signals are then transmitted along thalamic neurons before they reach the cerebral cortex. The thalamus, specifically the medial geniculate body, actively relays auditory information to the primary auditory cortex in the temporal lobe for interpretation (Lee, 2013). Auditory information enters the cortex through the primary auditory areas and then projects to secondary auditory areas. The primary auditory cortex is the first cortical region involved in acoustic processing, whereas the superior temporal gyrus encompasses the secondary auditory areas. The secondary auditory areas process more complex features, such as helps to organize sound information spatially (i.e. sound location) and interfaces with the lower-level auditory areas and higher-level structures contributing to language, music, and other forms of auditory processing (Ahmadi, et al., 2024).

Studies have demonstrated that non-auditory-related brain areas are critical for auditory processing (Schmithorst et al., 2013; Farah et al., 2014). For instance, the corpus callosum is involved in auditory processing because it is the main pathway for transferring auditory information between the brain's two hemispheres (Musiek, et al., 2011). Besides, the cerebellum, known to play an important role in motor functions, is also involved in a range of auditory processing functions such as coordinating timing and rhythm, processing temporal features of sound and in sound recognition through stored cerebellar memory templates (McLachlan & Wilson, 2017). Analogously to the visual "what-where" pathway model, two parallel processing streams (ventral/dorsal) have been identified in the auditory modality (Alain, et al., 2001). The ventral network projects from the primary auditory cortex ventrally along the temporal lobe to regions of the anterior temporal lobe, such as the anterior superior gyrus and Heschl's gyrus (Leavitt, et al., 2011). The ventral network ("what" pathway) is associated with processing the content, identity and meaning of sounds, and in the processing of short-timescale auditory patterns such as environmental and speech sounds (Ahveninen, et al., 2006). In contrast, the dorsal network projects from the primary auditory cortex dorsally to the regions of the parietal cortex, such as the planum temporal and posterior superior temporal gyrus (Leavitt, et al., 2011).

Largely, the dorsal network (where" pathway) is associated with the spatial processing of sound, locating sound sources, processing of rapidly changing auditory information (Ahveninen, et al., 2006), and in maintaining and integrating sound-based items (Poliva, 2016). See figure 1.

As described, extending findings demonstrate a diverse range of independent neural systems that are engaged in visual and auditory processing. However, there are other neural systems that connect brain regions and form an anatomical basis for an integrated processing of visual and auditory information. For instance, distinct brain areas (i.e., posterior superior temporal sulcus & intraparietal sulcus) contribute to the integration of visual and auditory contents (Grefkes, & Fink, 2005; Beauchamp, et al., 2004).

It should also be emphasized that the functions of the ventral and dorsal networks are very much integrated and less segregated. A more nuanced network-level understanding of information processing, points towards the existence of more intricate context-driven functional networks selective of "what" and "where" information rather than segregated streams of processing along ventral and dorsal brain regions (Ray et al., 2020). Besides, the ventral and dorsal networks have distinct circuits but collaborative roles on attentional subprocesses. Neither of the two networks control attentional processes in isolation. The flexible interaction between both systems enables the dynamic control of attention in relation to bottom-up sensory stimulation and top-down goals (Vossel, et al., 2014). See fig. 1.

Bottom-up attention is important for detecting salient events, whereas top-down attention is important for maintaining continuous tracking of visual or auditory information (i.e., top-down selective attention). Selective attention is characterized by the tracking of visual or auditory objects while filtering out distracting visual or auditory disturbances.

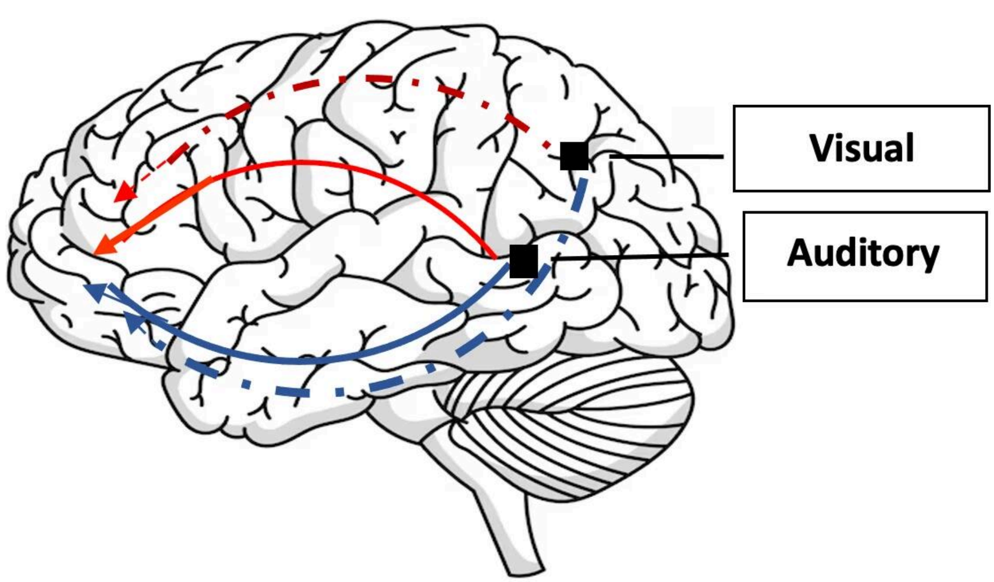

Figure1. Schematic illustration of the visual ventral network (- - -) and dorsal network (- - -) pathway projections,

alongside auditory ventral network (__) and dorsal network (__) projections. Although, the visual & auditory ventral and dorsal networks have distinct pathways, their functions are very much integrated and play collaborative roles on attentional subprocesses, such as visual and auditory selective attention.

In terms of impairment, dysfunction in the visual brain areas or pathways may result in specific visual processing deficits. For instance, dysfunctions in the thalamus may disrupt the flow of visual input and result in visual perceptual processing deficits (Sherman, 2007), whereas interference in the V5/MT area might lead to a motion-specific visual discrimination deficit (Blanke, et al., 2002). Dysfunctions involving the ventral network are associated with difficulties with visual recognition and visual memory of objects, faces and other visual stimuli, whilst dysfunctions involving the dorsal network are associated with difficulties with visual attention, visuospatial relations, and with the visual guidance of movement (Binkofski & Buxbaum, 2013). Besides, dorsal network disruptions may result in difficulties of actively maintaining visual information (i.e., shapes, colors) and spatial information (i.e., location, movement) in memory over short periods of time (i.e., visuospatial working memory) (Pisella, 2017).

Likewise, dysfunctions in auditory brain areas or pathways may result in specific auditory processing deficits. For instance, dysfunction in the cerebellum might lead to significant disruptions in the perception of temporal aspects of sound and in difficulties processing the timing of sounds (Akshoomoff et al., 1994), whereas dysfunction in the corpus callosum may disrupt the flow of auditory input and result in auditory perceptual deficits (Chermak, et. al, 2011). Particularly, maldevelopment of the corpus callosum may interrupt auditory interhemispheric transfer resulting in greater difficulty localizing sound and understanding speech in noise (Bamiou, et al., 2007). Dysfunctions involving the ventral network are associated with difficulties in auditory object recognition, such as problems in identifying or recognizing sounds or vocal communications and problems in organizing sounds or speech into meaningful components, whilst dysfunctions involving the dorsal network are associated with difficulties with the spatial processing of sounds and difficulties in processing rapid auditory changes such as those in a conversation or in musical piece. Besides, dorsal network disruptions may result in difficulties temporarily storing and manipulating sound-based information and with difficulties of actively maintaining sounds in memory over short periods of time (i.e., auditory working memory) (Leavitt, et al., 2011; Poliva, 2016).

In general, dysfunctions of BAVI should be considered as breakdown in the whole brain's ability to process both auditory and visual information efficiently. Accordingly, one or more neural areas involved in auditory lower & higher order processes and visual lower order & higher order processes may be compromised or constrained in Brain based Visual and Auditory Impairment (BAVI). However, we lack evidence for the level of neural specificity of BAVI.

It is crucial to highlight that when exploring the dysfunctions of BAVI, neuroimaging can provide some valuable anatomical insights into the etiologies of BAVI. Neuroimaging techniques have significantly advanced our understanding of brain function and provided essential insights into neurological disorders (Yen, et al., 2023). For instance, a Magnetic Resonance Imaging (MRI) assessment would facilitate in revealing brain structures or brain networks and may aid in systematically understanding the underlying neural mechanisms associated with BAVI. However, it must be emphasized that BAVI may be present in a child, but cerebral damage or dysfunction per se may not always be detected by means of standard brain imaging methods. Importantly, auditory and visual processing problems may be linked to functional disruptions in specific auditory and visual pathways without demonstrability of structural brain changes. Thus, it is important to keep in mind that some children with BAVI may display functional deficits due to BAVI even when causative brain injury cannot be corroborated through structural brain imaging methods. This would suggest that, while structural brain abnormalities play a role in the etiology of BAVI, standard neuroimaging assessments (i.e., MRI) may be limited in their capability to correlate visual and auditory functional deficits with neuroanatomical changes. Whether the source of BAVI can or cannot be revealed by standard neuroimaging assessments or whether the impairment is mild or severe, the underlying source of BAVI is neurological, resulting from brain malfunctions or disruptions in brain functioning.

5. BAVI = BAD + BVD: a conceptual framework

In this conceptual framework the three different levels and aspects that encompass impairment, dysfunction, and deficit in a BAVI context are presented. "Impairment" is referred as the functional loss of a mental process, "dysfunction" as the disruption or failure to function or perform properly during a task or everyday activities, while "deficit" is described as a measurable shortfall or absence of a distinct ability compared to what is expected.

According to the conceptual framework, BAVI as an impairment could be conceptualized as a complex disorder associated with the dysfunctions of both brain based visual processing dysfunction (BVD) and brain based auditory processing dysfunction (BAD). Furthermore, the behavioural manifestations of BVD and BAD are respectively accompanied with visual lower-order & higher-order functional deficits and auditory lower-order & higher-order functional deficits in a coherent way. The conceptual framework illustrates dynamic relationships across the key domains of impairment, dysfunctions and deficits. See figure 3 for the conceptual framework of BAVI.

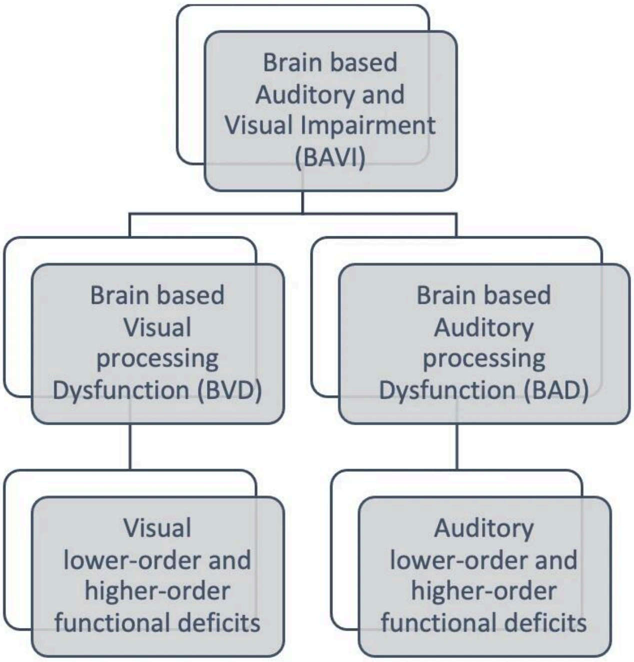

Figure 2: The BAVI conceptual framework: BAVI as an impairment can be conceptualized as a complex disorder associated with the dysfunctions of both brain based visual processing dysfunction (BVD), and brain based auditory processing dysfunction (BAD). Furthermore, behavioural manifestations of BVD and BAD are respectively accompanied with visual lower-order & higher-order functional deficits and lower-order & higher-order functional deficits in a coherent way.

6. The development of the P-BAVI

At the outset, the goal was to identify items that could be able to adequately sample behavioural manifestations of the domains of brain based visual processing dysfunction (BVD), and brain based auditory processing dysfunction (BAD) in a comparative manner. The individual checklist items are behavioural indicators of visual and auditory processing difficulties, and not direct measures of underlying neurological deficits.

The main objective was to design an observational checklist to identify behavioural characteristics that can describe visual lower-order and higher-order & auditory lower-order and higher-order functional deficits. The project set out to explore the daily visual and auditory processing difficulties of children "at risk for BAVI" and identify the functional deficits that best captured the impact of BAVI on auditory and visual processing in the child`s day-to-day functioning. Particularly, as pediatric BAVI is a newly defined issue and its phenomenology is complex, the evaluation framework model strives to be well grounded in clinical observations and in the experiences of parents and teachers of the child.

The items of the P-BAVI were formulated based on the BAVI conceptual framework (figure 3), by applying established clinical practices and expert consensus. Initial development involved reviewing current peer-reviewed empirical studies and reviews/guidelines from the different scientific disciplines on auditory and visual processing and its disorders (i.e., neuroscience, educational science, neurology, neuropsychology), as well as existing CVI and APD checklists to identify key indicators.

To start with, several clinical cases of children exhibiting behavioural characteristics of BAVI ("suspected BAVI") were discussed and analyzed by the three authors (JN, CS, AS). This process allowed us to identify and specify items that described the behavioural characteristics that underlie visual lower-order & higher-order functional deficits and auditory lower-order & higher-order functional deficits in a comparative manner. Furthermore, this judgement ensured that all items were assigned to the relevant domain and functional deficits.

Initially 56 items were identified based on the conceptual framework of understanding BAVI as a malfunction between the seeing-hearing mechanisms and the neural processes involved in visual and auditory processing. Six out of the 56 items were deleted because they could not be clarified without significantly altering the underlying meaning. Furthermore, a systematic evaluation process that aided allocating the item content balance between the domains of BVD and BAD was implemented. The item content balance was achieved by ensuring that both domains were adequately represented in terms of number of items, item quality and conceptual relevance.

Out of the 50 items, 21 items were able to identify behavioural characteristics that underpin visual lower-order and higher-order difficulties, whilst another 21 were able to identify behavioural characteristics that underpin auditory lower-order and higher-order difficulties. Besides, 4 items that identified characteristics of visual preferences and 4 items that identified characteristics of auditory preferences were included. As a core objective, each of the 50 items were able to align with a specific visual lower-order and higher-order functional deficit or auditory lower-order and higher-order functional deficit.

As a first trail, the 50 items P-BAVI checklist was used as a starting point for a small-scale preliminary study in clinical practice (n=4). This study resulted in giving several illustrative examples for each item in the checklist for the purpose of adding clarity.

Furthermore, some items of the P-BAVI checklist with examples were reviewed by professionals in deafblindness (n=21) at a workshop organized by the Royal Kentalis in October 2025 and at a workshop for special education teachers (n=10) at the school for deafblind children, Kentalis Rafael in March 2026, both in the Netherlands. To ensure consensus the professionals were asked to rate each item on two response choices (yes or no), after watching a short video sequence of a child exhibiting BAVI behaviours/characteristics. The results showed that most of the professionals were able to identify the behavioural manifestations of BVD and BAD on the selected P-BAVI items. However, the findings revealed a mixed profile, with some visual and auditory domain items demonstrating similar patterns of difficulty, while other items could not be fully compared. For instance, similar BVD and BAD domain items were scored in a comparative manner that allocated item content balance (i.e., rated as yes and demonstrating similar patterns of difficulty on the BVD and BAD domain items), whilst some items were not (i.e., rated as yes or no and not demonstrating similar patterns of difficulty on BVD an BAD domain items). This mixed profile may suggest that the P-BAVI was able to capture different levels of BVD and BAD issues or the difficulties of assessing BVD and BAD items between the two domains.

A similar consensus process was done at the Consortium Centre Jules-Léger (CCJL) in January 2026. CCJL is a specialized francophone educational institution in Ontario, Canada and supports students aged 4 to 21 who are deafblind, deaf or hard of hearing, blind, or have low vision. Four deafblind resource consultants reviewed the 50 items of the P-BAVI checklist with actual students from their caseloads. These students were individuals who have been identified with CVI and ADP or with characteristics associated with CVI and ADP, across different ages and developmental profiles.

Overall, there was consensus among the consultants that they could answer yes or no to most of the items. They also began noticing possible clusters and similarities between some of the BVD and BAD characteristics. At the same time, some items, particularly within the BAD domain, were more difficult to answer definitively depending on the student's age and developmental level and required more analysis. Besides, using the checklist helped the consultants to pinpoint similarities and interactions between vision and hearing.

The finalized form of the P-BAVI contains 50 items and two domains. The P-BAVI items are typically clustered in accordance with the two domains of BVD and BAD; 25 BVD items that include visual lower-order & higher-order functional deficits) and 25 BAD items that are auditory (low-order & higher-order functional deficits) in coherent and comparative manner.

7. P-BAVI materials and scoring procedures

The P-BAVI materials consist of the P-BAVI form and the Scoring form.

The cover page of the P-BAVI form includes instructions for completing the form. The page contains an area for recording the date of evaluation, general information about the person (name, age, gender), specific information about the child`s history of risk factors, whether diagnosed with a genetic disorder, whether assessed with an electroencephalogram (EEG), neuroimaging assessment (i.e., MRI, CT) or with a neurological or neuropsychological test. Furthermore, specific information about the person's sensory functions (vision, hearing, tactile), motor functions (gross and fine motor functions), and balance and coordination are included.

The remaining -- pages of the form are followed by the 50 P-BAVI items in which the two domains of BVD items (visual lower-order & higher-order functional deficits; n=25) and BAD items (auditory lower-order & higher-order functional deficits; n=25) are described in coherent and comparative manner. However, it is important to consider that certain functional descriptions of the lower-order and higher-order items may overlap. An overview of the visual and auditory behaviors of the functional difficulties along with visual & auditory preferences, and visual & auditory fatigue are presented in Table 1.

Brain based Visual Deficit (BVD) items: visual lower-order and higher-order functional deficits.	**Brain based Auditory Deficit (BAD) items: auditory lower-order and higher-order functional deficits**
Irregular visual blink reflex	Irregular startle reaction
Varying visual behaviours	Varying auditory behaviours
Stares intently/avoids certain light sources	Overly focuses/avoids certain sound sources
Difficulty looking & using hearing simultaneously	Difficulty using hearing & looking simultaneously
Difficulty looking & tactile exploring simultaneously	Difficulty using hearing & tactile exploring simultaneously
Difficulty responding within specific visual fields	Difficulty responding within specific auditory fields
Preference for visual familiarity	Preference for auditory familiarity
Preference for visual simplicity	Preference for auditory simplicity

Preference for certain colour elements	Preference for certain sound patterns
Preference for certain motion patterns	Preference for certain rhythmic patterns
Difficulty engaging with unfamiliar visual items	Difficulty engaging with unfamiliar auditory items
Difficulty engaging with complex visual items	Difficulty engaging with complex auditory items
Difficulty attending visually to the face	Difficulty attending to certain intonations or sound/words
Difficulty distinctly judging visual targets	Difficulty distinctly judging auditory targets
Difficulty noticing targets in visual clutter	Difficulty noticing targets in auditory clutter
Difficulty perceiving a person in crowded places	Difficulty perceiving less clear/synthetic voices
Difficulty tracking fast-changing visual targets	Difficulty tracking fast-changing acoustic targets
Difficulty perceiving spatial properties of items	Difficulty perceiving spatial properties of items/ indoors
Difficulty finding routes in different surroundings	Difficulty perceiving spatial properties of items/outdoors
Difficulty navigating through different surfaces	Difficulty navigating through different sound environments
Difficulty responding to visual materials instantly	Difficulty responding to auditory materials instantly
Difficulty being attentive in visual environments	Difficulty being attentive in auditory environments
Difficulty in mentally retaining visual information	Difficulty in mentally retaining auditory information
Difficulty in recollecting past visual information	Difficulty in recollecting past auditory information
Displays visual fatigue	Displays auditory fatigue

Table 1: 50 P-BAVI items in which auditory lower-order & higher-order functional deficits (25 BAD items) and visual lower-order & higher-order functional deficits (25 BVD items) are described in comparative manner.

Several illustrative examples are given for each item in the P-BAVI checklist to add clarity. The given examples are illustrative and not exhaustive. See P- BAVI checklist.

In the P-BAVI checklist form, the items are followed by boxes marked by two response options. The rating of items on the P-BAVI consists of the following response choices, YES or NO. Besides, if the response choice is YES, you can further elaborate it as clearly (c) or partially (p), whilst if the response choice is NO, you can further elaborate it as cannot observe (co) or cannot assess (ca). Although it may be difficult under certain circumstances, it may be still possible to differentiate between the type of scoring descriptions for the YES; clearly (c) or partially (p) and NO; cannot observe (co) or cannot assess (ca) response choices.

Especially, for the NO response choices, there is a subtle difference between cannot observe (co) and cannot assess (ca). Cannot Observe (co) means that the item behavior cannot be seen or the inability to perceive the item behavior; *"I cannot see/notice it"*, whereas Cannot Assess (ca) refers to the inability to make a judgment or determine the value of the item behavior, based on the available observational data; *" I cannot determine since the item does not apply to this specific child".* The response choice of Cannot Assess (ca) is most likely possible to be scored when certain P-BAVI items may appear too complex for the specific child, for instance either because of child`s young age or level of functioning. Table 2.

Response choices	**Observation Descriptions**
Yes	**Clearly (c),** "I clearly see the behaviors/behavioural examples" **Partially (p),** "I partially see the behaviors/behavioural examples"
No	**Cannot observe (co),** "I cannot see/notice the behaviors/ behavioural examples" **Currently cannot assess (ca),** "I cannot determine since the item does not apply to this specific child"

Table 2: the observation descriptions for the YES response choices clearly; (c) or partially (p) and for the NO response choices; cannot observe (co) or cannot assess (ca) response choices.

A binary scoring evaluation that uses a dichotomous scoring method is used in the P-BAVI, typically the score of 1 represents the outcome Yes, *clearly (c), "I clearly see the behaviors/behavioural examples"* or *partially (p),"I partially see the behaviors/behavioural examples"* and the score of 0 represent the outcome No, *cannot observe (co), "I cannot see/notice the behaviors/behavioural examples"* or *currently cannot assess (ca), "I cannot determine since the item does not apply to this specific child").* Table 3.

Response choices	**Descriptions**	**Binary scoring**
Yes	**Clearly (c**), "I clearly see the behaviors/behavioural examples" **Partially (p), "**I partially see the behaviors/behavioural examples"	1

No	**Cannot observe (co),** "I cannot see/notice the behaviors/ behavioural examples" **Currently cannot assess (ca),** "I cannot determine since the item does not apply to this specific child"	0

Table 3 shows scoring of the response choices (Yes or No) and the binary scoring (1 or 0) in the scoring form.

However, it should be emphasized that if there are too many NO: Cannot Assess (ca) scores recorded, one needs to consider whether the evaluation results are interpretable and perhaps conclude that the behavioural results of evaluation are difficult to obtain or inconclusive. Inconclusive P-BAVI test results for a child may indicate that the findings are not clear to either rule in or rule out a BAVI disorder. Thus, requiring a follow-up or repeat evaluation.

During the P-BAVI evaluation, it may be less difficult to observe behavioural examples of visual BVD items than the auditory BAD items. For instance, the behaviors of visual responses or reactions may be easier to observe (for instance, by following the child`s eye movements, fixation patterns or visual scanning) than the behaviors that reveal auditory responses or reactions.

Furthermore, it may be less difficult to observe behavioural examples of visual and auditory lower-order functional deficits (for example, items 1.1, 1.2, 2.1, 3.1, 3.2, 4.1) than some of the behavioural examples of visual and auditory higher-order functional deficits (for example, 6.1, 6.2, 6.3, 7.2, 7.1, 7.3, 8.1, 8.2, 8.3, 9.1, 10.1 11.1, 11.2). Higher-order visual or auditory functions (e.g., sustained/ selective attention, working memory) can be difficult to observe during the P-BAVI evaluation because they are complex, context-dependent, and it may be harder to isolate the specific item behavior being observed. It is important to note when lower-order visual and auditory deficits are profound, higher-order visual and auditory dysfunctions may be difficult to detect and confirm.

Besides, certain P-BAVI items may represent subtle differences, which may make it difficult to observe the behavioural nuances. For instance, there may be a subtle difference between item 5.1 (familiar/well known) and 6.1 (unfamiliar/unknown) or between item 5.1 (familiar/well known) and 6.2 (complex/not simple). The difficulties in observing the behavioural nuances described in these items may be apparent and may require close attention to detect, especially in certain populations (i.e., toddlers, children with DB-BAVI, children with limited language proficiency or children with a global developmental delay).

This suggests that the evaluator should be aware of these evaluation challenges and understand how these challenges may influence their evaluation of the items and the selection of response choices. However, some of these evaluation challenges can be reduced when using video-based observations over a longer period and ensuring the inclusion of two observers when analyzing the video data or when scoring the P-BAVI response choices. Video analysis can improve the accuracy of item evaluations by capturing subtle nuances in the child's BAVI behaviors. Besides, the two observer-based consensus may aid in discussions about the meaning/description of a P-BAVI item and determine whether the behavioural example for each item is sufficient to be scored as "YES" (*clearly (c) or partially (p)*) or "NO" (*cannot observe (co) or cannot assess (ca)*).

It is worth pointing out that formal training in the use of the P-BAVI is essential. A trained professional would be more skilled in observing the item behaviors and rating the response choices appropriately.

When scoring the P-BAVI, a total BVD score (min. 0 - max. 25) and a total BAD score (min. 0 - max. 25) can be obtained by respectively scoring each of the 25 BVD items and 25 BAD items. A total BAVI (min. 0 - max. 50) is obtained by summing the total BVD and total BAD scores. See table 4.

Items no.	**BVD items**	1 or 0	(c)/(p) or (co)/(ca)	**BAD items**	1 or 0	(c)/(p) or (co)/(ca)
1.1	Irregular visual blink reflex			Irregular startle reaction		
1.2	Varying visual behaviours			Varying auditory behaviours		
2.1	Stares intently/avoids certain light sources			Overly focuses/avoids certain sound sources		
3.1	Difficulty looking & using hearing simultaneously			Difficulty using hearing & looking simultaneously		
3.2	Difficulty looking & tactile exploring simultaneously			Difficulty using hearing & tactile exploring simultaneously		
4.1	Difficulty responding within specific visual fields			Difficulty responding within specific auditory fields		
5.1	Preference for visual familiarity			Preference for auditory familiarity		
5.2	Preference for visual simplicity			Preference for auditory simplicity		
5.3	Preference for certain colour elements			Preference for certain sound patterns		
5.4	Preference for certain motion patterns			Preference for certain rhythmic patterns		
6.1	Difficulty engaging with unfamiliar visual items			Difficulty engaging with unfamiliar auditory items		
6.2	Difficulty engaging with complex visual items			Difficulty engaging with complex auditory items		

6.3	Difficulty attending visually to the face			Difficulty attending to certain intonations or sound/words		
6.4	Difficulty distinctly judging visual targets			Difficulty distinctly judging auditory targets		
7.1	Difficulty noticing targets in visual clutter			Difficulty noticing targets in auditory clutter		
7.2	Difficulty perceiving a person in crowded places			Difficulty perceiving less clear or muffled voices		
7.3	Difficulty tracking fast-changing visual targets			Difficulty tracking fast-changing acoustic targets		
8.1	Difficulty perceiving spatial properties of items			Difficulty perceiving spatial properties of items/ indoors		
8.2	Difficulty finding routes in different surroundings			Difficulty perceiving spatial properties of items/outdoors		
8.3	Difficulty navigating through different surfaces			Difficulty navigating through different sound environments		
9.1	Difficulty responding to visual materials instantly			Difficulty responding to auditory materials instantly		
10.1	Difficulty being attentive in visual environments			Difficulty being attentive in auditory environments		
11.1	Difficulty in mentally retaining visual information			Difficulty in mentally retaining auditory information		
11.2	Difficulty in recollecting past visual information			Difficulty in recollecting past auditory information		
12.1	Displays visual fatigue			Displays auditory fatigue		
	Total BVD score	/25				
	Total BAD scores				/25	

	Total BAVI score (BVD+BAD scores)	/50		

Table 4. The P-BAVI scoring scale. Binary scoring (1or 0) and recording clearly (c)/ partially (p) observe or cannot observe (co) /currently cannot assess (ca). A total BVD and a total BAD score can be obtained by respectively scoring each 25 BVD items and 25 BAD items. A total BAVI is obtained by summing the total BVD and total BAD scores.

The 50 items of P-BAVI are not linked to cut scores. However, a rubric scoring guide can aid to define the total BVD scores and the total BAD scores to overall BAVI scores by using a simple scoring description. In this way, providing a holistic score interpretation of visual lower-order & higher-order functional deficits (BVD) and auditory lower-order & higher-order functional deficits (BAD) in a comparative manner.

The P-BAVI scoring scale can be used when scoring the total BVD, total BAD and the total BAVI. For a scoring example see table 5.

	Total BVD score	**21/25**		
	Total BAD score			**15/25**
	Total BAVI score (BVD+BAD scores)	**36/50**		

Table 5. Total score on BVD, BAD, and the total score on BAVI.

In this example: a child exhibiting BAVI behavioural characteristics obtains a total score of 21 on BVD, a total score of 15 on BAD, and a total score of 36 on overall BAVI. The BVD, BAD and the overall BAVI percentage scores are calculated based on the following formula:

The total BVD item score of the child: (i.e., 21 out of 25). Score:21

The total BAD score of the child: (i.e., 15 out of 25). Score: 15

The total BAVI score of the child (BVD+BAD scores): 21+15=36

*BVD percentage: (21/25) * 100 = 84%*

*BAD percentage:(15/25) * 100 = 60%*

*Overall, BAVI percentage: (36/50) * 100 = 72%*

The results of a higher overall BAVI percentage greater than or equal to 50 (≥ 50%) would suggest that the child may be at "risk for BAVI", but this would need to be clarified with a professional who understands BAVI.

It is also important that the P-BAVI results should be considered together with past medical history records and interviews with parents and other professionals to provide a comprehensive understanding of BAVI (see case illustrations). Furthermore, the total observational results would need to be interpreted by a professional who understands BAVI to clarify the complex disorder of auditory and visual processing problems. In other words, to discover whether the child is displaying behaviours reflecting a disruption in the interplay between visual lower-order and higher-order functions (BVD) & auditory lower-order and higher-order functions (BAD).

The ≥50% cut-off is a useful threshold, but at present it is unvalidated and untested and requires further investigation. It is also important to emphasize that a high BAVI percentage (≥50%) can occur due to other causes. For instance, in DB-BAVI the child's peripheral vision and hearing loss might result in a high BAVI percentage. In this instance, it may be challenging to differentiate whether the BAVI dysfunction is due to peripheral loss, central processing issues, or both. However, there is a strong likelihood that central auditory and visual processing can apply their interpretative influence, especially if there are signs indicating central nervous system disturbances or neurological etiologies.

When identifying a childwho may be at risk for a BAVI disorder, one must consider the P-BAVI results together with the child`s history of risk factors, the visual, auditory and neurological information and how the child uses his/her senses in real-world situations.

8. Applying the P-BAVI: case-based reviews with administering, scoring, and interpretation

Case illustration 1: Thomas

Purpose of the evaluation:

The purpose of this evaluation using the Pediatric Brain based Auditory and Visual Impairment (P-BAVI) checklist was to identify Thomas's combined auditory and visual processing difficulties. Brain based Auditory and Visual Impairment (BAVI) is about how the brain causes auditory and visual processing deficits.

Thomas was previously diagnosed with cerebral visual impairment (CVI) and has a unilateral hearing loss. He has a single-sided cochlear implant on his left ear. Despite seemingly normal hearing functions with his CI, his communication is described as very limited. He does not use any oral expressions, and it is unclear what he understands from spoken language.

The parents of Thomas were concerned about his development. There were specific questions on how he processes visual and auditory input and questions about how to support Thomas in his overall development.

Case history:

Thomas is a 4-year-old boy. He was diagnosed with congenital cytomegalovirus (cCMV;1st trimester). He has cerebral palsy (spastic bilateral palsy) and microcephaly.

Thomas has unilateral hearing loss, with a CI on his left ear since the age of two years and one month. Due to his inconsistent auditory responses, it was difficult to assess his hearing functions. However, based on a Brainstem Evoked Response Audiometry (BERA) assessment, his right ear showed normal hearing. Furthermore, a CT-scan showed normal middle and inner ear structures. CT mastoid showed no technical objections against CI implantation.

Thomas has been diagnosed with Cerebral Visual Impairment (CVI) as a neurodevelopmental consequence of symptomatic cCMV infection. Thomas was first ophthalmologically assessed at the age of 7 months, because there were doubts about his visual functioning. He was assessed with low vision (0.08). The ophthalmologist found no indications for opticus pathology based on the VEP assessment. The Optical Coherence Tomography (OCT) showed no abnormalities either. The assessment team assumed that the low vision was caused by cerebral visual impairment, also based on the MRI results, and as a result of cCMV.

In a follow-up visual functioning assessment, his visual acuity was measured at 0.15. The orthoptist concluded that the abnormal visual behavior and his inconsistent visual alertness were more prominent than his reduced visual acuity and visual field. Thomas shows inconsequent and delayed visual reactions. Often, he does not seem to use his vision at all. His parents describe him as functioning as a blind child.

His gross motor functions, balance and coordination are described as poor. Thomas can move around while sliding on his knees and hands. He often chooses the 5-point position or lies down on his back.

It was difficult to say how the cerebral palsy influenced his tactile functioning. In daily practice, Thomas has been observed to be using his tactile sense increasingly.

Thomas has been attending an early intervention group for children with deafblindness since the age of two years and 6 months. His parents and support staff use spoken language and tactile signs and gestures in communication with Thomas, supported by tangible objects used in the situation. Besides this, a consistent daily routine and structure are used to provide an overview of Thomas's day.

The P-BAVI observational checklist:

The P-BAVI observational checklist has a total number of 50 items that describe the behavioral manifestations on the domains of brain based auditory processing deficits (BAD), and brain based visual processing deficits (BVD) in a coherent and comparative manner. 25 items describe auditory lower-order & higher-order functional issues associated with Brain based Auditory Deficits (BAD), whilst 25 items describe visual lower-order & higher-order functional issues associated with Brain based Visual Deficits (BVD). The deficits typically associated with BAVI may illustrate a disorder that comprises of behavioral characteristics that are linked to both brain based auditory processing deficits (BAD), and brain based visual processing deficits (BVD) with onset in early childhood.

Obtaining information for formulating a case history:

Past medical history records were obtained (e.g., medical, neurological, audiology/ophthalmology reports, functional vision and hearing assessments).

Interviews with parents and the speech and language therapist were also conducted. The interviews with the parents and the speech and language therapist were designed to collect as much information as possible about the sensory functioning of Thomas, especially vision and hearing. The case history was formulated based on this information.

Furthermore, the findings on the Magnetic Resonance Imaging (MRI) assessment revealed structural brain abnormalities. The neuroimaging results highlighted extensive subependymal calcifications, especially around the temporal and occipital horns and a dilation of the ventricular system, with the temporal horns, particularly affected. Besides, the image showed white matter diffusely abnormal (myelination abnormality) in the cerebrum, however with normal myelination of the corpus callosum.

Observations using the P-BAVI checklist:

Both direct observations and video-based observations were used to capture behaviors relevant to visual and auditory processing deficits. In addition, interviews with parents and involved professionals were carried out to obtain the necessary information that was observed by them in Thomas`s everyday life.

The video-based observations were conducted in various situations, particularly during interactions with the parents, with other familiar professionals or with the evaluator interacting with Thomas. The latter was necessary for the evaluator to see how Thomas was using his vision and hearing during interaction. Besides, this was crucial to create distinct situations to capture processing behaviors related to certain items of the P-BAVI checklist. The P-BAVI evaluation took place in a familiar place (at home and in the early intervention group) and in unfamiliar surroundings (unknown room).

In the P-BAVI checklist form, the items are followed by boxes marked by two response options. The rating of items on the P-BAVI consists of the following response choices, YES or NO. Besides, if the response choice is YES, you can further elaborate it as clearly (c) or partially (p), whilst if the response choice is NO, you can further elaborate it as cannot observe (co) or cannot assess (ca). Although it could be difficult under certain circumstances, it may be still possible to differentiate between the type of scoring descriptions for the YES; clearly (c) or partially (p) and NO; cannot observe (co) or cannot assess (ca) response choices. See table 2 in the manual.

A binary scoring evaluation that uses a dichotomous scoring method is used in the P-BAVI, typically the score of 1 represents the outcome Yes, clearly (c), "I clearly see the behaviors/behavioural examples" or partially (p),"I partially see the behaviors/behavioural examples" and the score of 0 represent the outcome No, cannot observe (co), "I cannot see/notice the behaviors/behavioural examples" or currently cannot assess (ca), "I cannot determine since the item does not apply to this specific child").

The observation data was evaluated and scored using the P-BAVI observational checklist form. The video recordings were analyzed in detail by two professionals with several years of experience in assessing children with combined visual and hearing loss/deafblindness.

Results from the P-BAVI observational checklist:

The P-BAVI scoring scale was used to record Thomas`s behaviours that were relevant to each item. When scoring the P-BAVI, a total BVD score (min. 0 - max. 25) and a total BAD score (min. 0 - max. 25) can be obtained by respectively scoring each of the 25 BVD items and 25 BAD items. A total BAVI (min. 0 - max. 50) is obtained by summing the total BVD and total BAD scores. Table 6 provides the P-BAVI scoring profile for Thomas. See below.

Items no.	**BVD items**	1 or 0	(c)/(p) or (co)/(ca)	**BAD items**	1 or 0	(c)/(p) or (co)/(ca)
1.1	Irregular visual blink reflex	1	C	Irregular startle reaction	1	c
1.2	Varying visual behaviours	1	C	Varying auditory behaviours	1	c
2.1	Stares intently/avoids certain light sources	1	C	Overly focuses/avoids certain sound sources	0	co
3.1	Difficulty looking & using hearing simultaneously	1	C	Difficulty using hearing & looking simultaneously	1	c
3.2	Difficulty looking & tactile exploring simultaneously	1	C	Difficulty using hearing & tactile exploring simultaneously	1	c
4.1	Difficulty responding within specific visual fields	1	C	Difficulty responding within specific auditory fields	0	ca
5.1	Preference for visual familiarity	0	Co	Preference for auditory familiarity	1	c
5.2	Preference for visual simplicity	0	Co	Preference for auditory simplicity	1	c
5.3	Preference for certain colour elements	0	co	Preference for certain sound patterns	1	c
5.4	Preference for certain motion patterns	0	co	Preference for certain rhythmic patterns	1	c
6.1	Difficulty engaging with unfamiliar visual items	1	C	Difficulty engaging with unfamiliar auditory items	1	c
6.2	Difficulty engaging with complex visual items	1	C	Difficulty engaging with complex auditory items	1	c
6.3	Difficulty attending visually to the face	1	C	Difficulty attending to certain intonations or sound/words	0	ca

6.4	Difficulty distinctly judging visual targets	1	C	Difficulty distinctly judging auditory targets	0	ca
7.1	Difficulty noticing targets in visual clutter	1	C	Difficulty noticing targets in auditory clutter	1	c
7.2	Difficulty perceiving a person in crowded places	1	C	Difficulty perceiving less clear or muffled voices	1	c
7.3	Difficulty tracking fast-changing visual targets	1	C	Difficulty tracking fast-changing acoustic targets	1	c
8.1	Difficulty perceiving spatial properties of items	1	C	Difficulty perceiving spatial properties of items/ indoors	1	c
8.2	Difficulty finding routes in different surroundings	1	C	Difficulty perceiving spatial properties of items/outdoors	1	c
8.3	Difficulty navigating through different surfaces	1	C	Difficulty navigating through different sound environments	1	c
9.1	Difficulty responding to visual materials instantly	1	C	Difficulty responding to auditory materials instantly	1	c
10.1	Difficulty being attentive in visual environments	1	C	Difficulty being attentive in auditory environments	1	c
11.1	Difficulty in mentally retaining visual information	1	C	Difficulty in mentally retaining auditory information	0	ca
11.2	Difficulty in recollecting past visual information	1	C	Difficulty in recollecting past auditory information	0	ca
12.1	Displays visual fatigue	1	C	Displays auditory fatigue	1	c
	Total BVD score	21/25				
	Total BAD scores				19/25	
	Total BAVI score (BVD+BAD scores)	40/50				

Table 6. The P-BAVI scoring profile for Thomas

The 50 items of P-BAVI are not linked to cut scores. However, a rubric scoring guide can aid to define the total BVD scores and the total BAD scores to overall BAVI scores by using a simple scoring description. In this way, providing a holistic score interpretation of visual lower-order & higher-order functional deficits (BVD) and auditory lower-order & higher-order functional deficits (BAD) in a comparative manner.

The BVD, BAD and the overall BAVI percentage scores of Thomas are calculated based on the following formula:

The total BVD score of Thomas: (i.e., 21 out of 25). Score: 21

The total BAD score of Thomas: (i.e., 19 out of 25). Score: 19

The total BAVI score of Thomas (BVD+BAD scores): 21+19=40. Score of 40

BVD percentage: (21/25) * 100 = 84 %

BAD percentage:(19/25) * 100 = 76 %

Overall, BAVI percentage: (40/50) * 100 = 80 %

There are several "currently cannot assess (ca)" scores on the P-BAVI scoring scale, especially on some BAD items. Besides that, there are "currently cannot observe (co)" scores on the BVD items, especially on all items of visual preferences (5.1; 5.2; 5.3; 5.4). The "currently cannot observe (co)" scores on these items reflect that Thomas does not seem to look at all, not even for specific visual preferences.

Although 0 scores (currently cannot assess or currently cannot observe) are evident in the P-BAVI profile, the BAD and the BVD percentage scores are high, respectively 76 % and 84%, suggesting that the evaluation results may be considered as interpretable. Besides, the P-BAVI profile showed a slight difference between the BVD and BAD percentages. This seems to be because in this child, the BAD items were more difficult to evaluate than the BVD items.

Thomas obtained an overall high BAVI percentage (80%). In a child exhibiting BAVI behaviours/characteristics, a higher overall BAVI percentage greater than or equal to 50 (≥ 50%) may suggest a child "at risk for BAVI". It is important to mention that the ≥50% cut-off is a useful threshold, but at present it is unvalidated and untested, thus caution is required.

The P-BAVI results were considered together with past medical history records and interviews with parents and other professionals to provide a comprehensive understanding of BAVI. The total observational results were interpreted by professionals who understood BAVI to clarify the complex disorder of auditory and visual processing problems. Overall, it can be proposed that Thomas was displaying behaviours that reflected a disruption in the interplay between visual lower-order and higher-order functions (BVD) & auditory lower-order and higher-order functions (BAD).

Thomas has both vision and hearing loss. Thus, it is important to emphasize that in a child with both vision and hearing loss, a higher BAVI percentage (≥50%) can be due to problems related to the child's peripheral vision and hearing loss. Besides, it is challenging to differentiate whether the BAVI dysfunction is due to peripheral loss, central processing issues, or both. However, there is a strong likelihood that central auditory and visual processing can apply their interpretative influence, especially if there are signs indicating central nervous system disturbances or neurological etiologies, such as in the case of Thomas.

The findings on the Magnetic Resonance Imaging (MRI) assessment revealed structural brain abnormalities. Thus, implying a possibility that the visual lower-order and higher-order functions & auditory lower-order and higher-order functions deficits identified in the overall P-BAVI profile of Thomas could be considered as a breakdown in the whole brain's ability to process both auditory and visual information efficiently.

The P-BAVI item analysis:

Although some behavioral characteristics of Brain based Auditory Deficits (BAD), and Brain based Visual Deficits (BVD) were difficult to identify, many other behavioral characteristics associated with BAD and BVD were partially or clearly recognizable. Generally, the P-BAVI findings revealed that most items were scored in a comparative manner that allocated domain item balance (i.e., similar BVD and BAD items were rated as yes), whilst some items were not (similar BVD and BAD items were rated as yes and no). The latter was primarily the case in items that were not assessable in this child.

Thomas shows irregular reactions to both visual and auditory stimuli (1.1) and varying visual and auditory behaviors and (1.2). The items show irregular reactions to simple items (1.1, 1.2) as well as complex items (6.1, 6.2, 6.3, 6.4), both for visual and auditory stimuli. Thomas 1shows both difficulties in attending to visual and auditory stimuli, especially visual stimuli. He can be more attentive to specific auditory stimuli like singing, when in a quiet setting, in a comfortable position.

The scoring scale shows processing problems related to the time aspect in both visual and auditory processing. Furthermore, the scoring scale shows difficulties responding to both visual and auditory stimuli instantly (9.1). It takes several seconds for Thomas to react. When he is tired or distressed, this processing time increases. This is particularly clear for auditory input, as he shows very little reaction to visual stimuli in general.

Visual as well as auditory fatigue (12.1) are clearly present. Thomas can get very upset when he is overstimulated. He can remove his CI or put a finger in his 'good' ear.

The MRI findings may aid in explaining some of the difficulties Thomas has regarding time-based processing (processing speed) and fatigue (visual fatigue; auditory fatigue). Due to myelination abnormalities the brain's speed of processing visual and auditory information can be disrupted, thus, making simple tasks feel overwhelmingly exhausting. See chapter 4, pg.

Thomas seems to have difficulty with both visual and auditory clutter (7.1). He easily gets upset or becomes withdrawn, when visual or auditory information is overwhelming to him. He finds it very difficult to focus on sound when there is more than one sound in the room.

Thomas shows difficulties in hearing and looking at the same time. He also has difficulties in looking and using hearing at the same time (item 3.1). He turns away his head from the source when listening. The scoring scale also shows difficulties in simultaneously tactile exploring and either hearing or looking (item 3.2). When there are sounds in his environment, Thomas barely uses his touch simultaneously. He can 'follow' hand under hand gestures while the interaction partner is singing. Only after processing time, can he continue the interaction by humming and tactile gestures. This underlines the presence of a simultaneous sensory processing issue. The P-BAVI evaluation was very important in providing this detailed information regarding Thomas' sensory functioning.

Some higher-order functions were difficult to assess due to his developmental characteristics or milestones. However, some difficulties with both lower-order and higher-order auditory and visual functions are observed.

Conclusion:

The P-BAVI profile of Thomas with overall high total BAVI percentage (80%), demonstrates a child exhibiting BAVI behaviors/characteristics and may suggest a clinical disorder of BAVI. The profile also revealed difficulties with lower-order auditory & visual functions and higher-order auditory & visual functions, which could be considered as consequence of BAVI. The high scores on the BVD items clearly link to the CVI diagnosis that was given earlier.

Although some of his visual and auditory processing problems may be caused by his low vision and unilateral deafness, both brain based visual deficits (BVD), and brain based auditory deficits (BAD) can apply their interpretative influence.

There is a likelihood that BAVI can cause developmental delays because it may impact how the brain processes auditory and visual information. Due to BAVI, Thomas may not meet typical auditory and visual developmental milestones, often leading to challenges in social interaction and communication, motor skills (i.e., reaching, walking) and cognition (i.e., learning, understanding).

The overall results of the P-BAVI checklist confirm the observations and concerns that Thomas`s parents and other involved professionals shared with the evaluators initially. The results also provide directions for recommended interventions for his visual and auditory processing functions.

Based on the current results, it was recommended that Thomas is observed again with the P-BAVI observational checklist (repeat evaluation) in about three years' time. Furthermore, an assessment of Thomas`s tactile functioning was also recommended.

Thomas will require individualized tailored support designed to meet his specific needs. This support should be based around basic management of BAVI and through specific targeted interventions. See chapter 9.

Thomas will require individualized and highly tailored support designed to meet his specific needs. This support must provide meaningful interventions and be based around basic management of BAVI and through specific targeted interventions. See chapter 9.

Chapter 9 provides an overview of interventions to support children with BAVI. This chapter describes basic management strategies and specific management strategies regarding Thomas.

Case illustration 2: Xavyer

Purpose of the evaluation:

The purpose of this evaluation using the Pediatric Brain based Auditory and Visual Impairment (P-BAVI) checklist was to identify Xavyer's combined auditory and visual processing difficulties. Brain based Auditory and Visual Impairment (BAVI) is about how the brain causes auditory and visual processing deficits.

Xavyer was previously diagnosed with Cerebral visual impairment (CVI). Although there is no documented hearing loss, his auditory functioning appears atypical. For example, he is highly attentive to music but may not respond consistently to other environmental sounds or speech. Questions remain regarding how he processes speech and auditory information.

His communication is described as very limited. He does not use oral speech but communicates through vocalizations and responds using a total communication approach. The evaluators hope to gain a better understanding of how Xavyer processes visual and auditory information in order to support his communication, learning, and overall development.

Case history

Xavyer is a 6-year-old boy. He was diagnosed with Dup15q syndrome. Dup15q syndrome is a rare, lifelong neurodevelopmental disorder caused by an extra copy of a specific region on chromosome 15 and is associated with global developmental delays, hypotonia, autism spectrum disorder, and a high prevalence of seizures. Children with Dup15q often present with significant communication, sensory processing, and feeding challenges. Although developmental progress is expected, it generally occurs at a much slower pace and requires highly individualized support.

The evaluators did not have access to the audiological report; however, the parents confirmed that no hearing abnormalities were identified during hearing assessments at birth. Both the parents and school staff reported that Xavyer demonstrates an interest in favourite songs and appears to recognize and respond to familiar key words. They also noted that he does not tolerate noisy environments well and may become overwhelmed or disengaged in the presence of excessive auditory stimulation.

Xavyer is nonverbal and primarily communicates through vocalizations and changes in affect. For example, he will cry when he is in pain or not feeling well. His responses to auditory information are inconsistent. He does not respond to his name being called; however, he may orient or respond more consistently when addressed by familiar individuals with whom he has established relationships. Given these observations, questions remain regarding the nature and extent of his functional auditory abilities and how he processes and assigns meaning to speech and other auditory information in his environment.

Xavyer has a diagnosis of Cerebral Visual Impairment (CVI) made by an ophthalmologist, as documented in a report, prior to his first birthday. The parents report that his visual processing differs from that of typically developing children. Patterns and lights provide strong visual stimulation but can also be distracting. His best visual comprehension is achieved using bright, solid colours, particularly red, purple, and yellow, presented against a plain black or white background. Movement may also attract and sustain his visual attention.

At about three years old, Xavyer was assessed using the Roman CVI Range. The CVI Range Assessment is a functional vision assessment designed to investigate the visual and behavioral characteristics associated with CVI (Roman, 2007). The CVI range results suggested that he was beginning to recognize and engage with familiar visual targets; however, he was not consistently decoding or assigning meaning to what he was seeing.

Xavyer shows significant gross motor delays and reduced functional mobility, consistent with the hypotonia associated with Dup15q syndrome. He is non-ambulatory and relies on a wheelchair for mobility. Due to decreased trunk control and postural stability, he requires additional positioning support, including a butterfly harness, to maintain an upright and secure sitting position in his wheelchair.

Although Xavyer can move his upper and lower limbs, these movements are not consistently purposeful or functionally integrated for independent mobility or object manipulation. He can use his hands to activate a switch and to explore or touch preferred objects. Tactile information appears to play an important role in his learning and exploration. He also uses his mouth, lips, and tongue to gather information about objects in his environment, suggesting that oral-tactile exploration is an important sensory strategy for understanding and decoding items presented to him.

Xavyer attends a specialized classroom for students who are functionally deafblind, as this educational setting was deemed to be the most appropriate to meet his complex sensory and developmental needs. He is supported by a multidisciplinary team, including a teacher, educational assistants, and a deafblind teacher consultant, and communicates using a total communication approach.

Within his classroom environment, Xavyer has access to specialized sensory spaces, including a Snoezelen room and a dark room used to provide individualized visual and auditory stimulation. Xavyer is described by both his family and school team as a happy and engaging child. However, questions remain regarding his level of functioning, particularly his functional auditory abilities and how he processes auditory information within his environment. Both his parents and educational team expressed a desire to better understand his sensory processing profile.

The P-BAVI observational checklist:

The P-BAVI observational checklist has a total number of 50 items that describe the behavioral manifestations on the domains of brain based auditory processing deficits (BAD), and brain based visual processing deficits (BVD) in a coherent and comparative manner. 25 items describe auditory lower-order & higher-order functional issues associated with Brain based Auditory Deficits (BAD), whilst 25 items describe visual lower-order & higher-order functional issues associated with Brain based Visual Deficits (BVD). The deficits typically associated with BAVI may illustrate a disorder that comprises behavioral characteristics that are linked to both brain based auditory processing deficits (BAD), and brain based visual processing deficits (BVD) with onset in early childhood.

Obtaining information for formulating a case history:

Information for this evaluation was gathered from multiple sources, including a review of medical reports, school records, and documents provided by the family. A meeting was held with Xavyer's mother at school, and additional information regarding his sensory functioning was obtained through discussions with his teacher, educational staff, and deafblind resource consultants who had been involved with his case for several years. The records reviewed documented diagnoses and concerns including Dup15q syndrome, epilepsy, cerebral visual impairment (CVI), autism spectrum disorder (ASD), reported hearing abnormalities, and abnormal eye movements. Collecting information from multiple informants allowed for a comprehensive understanding of Xavyer's developmental and sensory profile.

Observations using the P-BAVI checklist:

Both direct observations and video-based observations were used to capture behaviors relevant to visual and auditory processing deficits. In addition, interviews with parents and involved professionals were carried out to obtain the necessary information that was observed by them in Xavyer`s everyday life.

In-person observations were conducted in various situations at school, particularly during interactions with familiar professionals or with the evaluator interacting with Xavyer. The latter was necessary for the evaluator to see how Xavyer was using his vision and hearing during interaction. Besides, this was crucial to create distinct situations to capture processing behaviors related to certain items of the P-BAVI checklist. The P-BAVI evaluation took place both in a familiar place (in his classroom) and in unfamiliar surroundings (unknown rooms in the school).

In the P-BAVI observational checklist form, the items are followed by boxes marked by two response options. The rating of items on the P-BAVI consists of the following response choices, Yes or No. Besides, if the response choice is Yes, you can further elaborate it as clearly (c) or partially (p), whilst if the response choice is No, you can further elaborate it as cannot observe (co) or cannot assess (ca). Although it could be difficult under certain circumstances, it may be still possible to differentiate between the type of scoring descriptions for the YES; clearly (c) or partially (p) and NO; cannot observe (co) or cannot assess (ca) response choices. See table 2 in the manual.

A binary scoring evaluation that uses a dichotomous scoring method is used in the P-BAVI, typically the score of 1 represents the outcome Yes, clearly (c) or partially (p); "I clearly or partially see it" and the score of 0 represent the outcome No, cannot observe (co) or currently cannot assess (ca); "I cannot see/notice it, or "I cannot determine since the item does not apply to this specific child"). See table 3 in the manual.

The observation data was evaluated and scored using the P-BAVI checklist form. The video recordings were analyzed in detail by two professionals with several years of experience in assessing children with combined visual and hearing loss/deafblindness.

Results from the P-BAVI observational checklist:

The P-BAVI scoring scale was used to record Xavyer's behaviors that were relevant to each item. When scoring the P-BAVI, a total BVD score (min. 0 - max. 25) and a total BAD score (min. 0 - max. 25) can be obtained by respectively scoring each of the 25 BVD items and 25 BAD items. A total BAVI (min. 0 - max. 50) is obtained by summing the total BVD and total BAD scores. Table 7 provides the P-BAVI scoring profile for Xavyer. See below.

Items no.	**BVD items**	1 or 0	(c)/(p) or (co)/(ca)	**BAD items**	1 or 0	(c)/(p) or (co)/(ca)
1.1	Irregular visual blink reflex	0	C	Irregular startle reaction	0	c
1.2	Varying visual behaviours	1	C	Varying auditory behaviours	1	c
2.1	Stares intently/avoids certain light sources	1	C	Overly focuses/avoids certain sound sources	1	c
3.1	Difficulty looking & using hearing simultaneously	1	C	Difficulty using hearing & looking simultaneously	1	c
3.2	Difficulty looking & tactile exploring simultaneously	1	C	Difficulty using hearing & tactile exploring simultaneously	1	c
4.1	Difficulty responding within specific visual fields	1	C	Difficulty responding within specific auditory fields	1	c
5.1	Preference for visual familiarity	1	C	Preference for auditory familiarity	1	c
5.2	Preference for visual simplicity	1	C	Preference for auditory simplicity	1	c
5.3	Preference for certain colour elements	1	C	Preference for certain sound patterns	1	c
5.4	Preference for certain motion patterns	1	C	Preference for certain rhythmic patterns	1	c
6.1	Difficulty engaging with unfamiliar visual items	1	C	Difficulty engaging with unfamiliar auditory items	1	c

6.2	Difficulty engaging with complex visual items	1	C	Difficulty engaging with complex auditory items	1	c
6.3	Difficulty attending visually to the face	1	C	Difficulty attending to certain intonations or sound/words	1	p
6.4	Difficulty distinctly judging visual targets	1	C	Difficulty distinctly judging auditory targets	1	p
7.1	Difficulty noticing targets in visual clutter	1	C	Difficulty noticing targets in auditory clutter	1	c
7.2	Difficulty perceiving a person in crowded places	1	C	Difficulty perceiving less clear or muffled voices	0	co
7.3	Difficulty tracking fast-changing visual targets	0	Ca	Difficulty tracking fast-changing acoustic targets	1	p
8.1	Difficulty perceiving spatial properties of items	1	C	Difficulty perceiving spatial properties of items/ indoors	0	co
8.2	Difficulty finding routes in different surroundings	0	Ca	Difficulty perceiving spatial properties of items/outdoors	0	co
8.3	Difficulty navigating through different surfaces	0	Ca	Difficulty navigating through different sound environments	1	p
9.1	Difficulty responding to visual materials instantly	1	C	Difficulty responding to auditory materials instantly	1	c
10.1	Difficulty being attentive in visual environments	1	C	Difficulty being attentive in auditory environments	1	p
11.1	Difficulty in mentally retaining visual information	1	P	Difficulty in mentally retaining auditory information	1	p
11.2	Difficulty in recollecting past visual information	0	Ca	Difficulty in recollecting past auditory information	0	ca
12.1	Displays visual fatigue	1	C	Displays auditory fatigue	1	c
	Total BVD score	20/25				

	Total BAD scores			20/25
	Total BAVI score (BVD+BAD scores)	40/50		

Table 7. The P-BAVI scoring profile for Xavyer

The 50 items of P-BAVI are not linked to cut scores. However, a rubric scoring guide can aid to define the total BVD scores and the total BAD scores to overall BAVI scores by using a simple scoring description. In this way, providing a holistic score interpretation of visual lower-order & higher-order functional deficits (BVD) and auditory lower-order & higher-order functional deficits (BAD) in a comparative manner.

The BVD, BAD and the overall BAVI percentage scores of Xavyer are calculated based on the following formula:

The total BVD score of Xavyer: (i.e., 20 out of 25). Score: 20

The total BAD score of Xavyer: (i.e., 19 out of 25). Score: 20

The total BAVI score of Xavyer (BVD+BAD scores): 20+20=40. Score of 40

BVD percentage: (20/25) * 100 = 80 %

BAD percentage:(20/25) * 100 = 80 %

Overall, BAVI percentage: (40/50) * 100 = 80 %

There are several "currently cannot assess (ca)" scores on the P-BAVI scoring scale or also '0' scores both in BVD and BAD items that lowered the total BAVI score. However, the BAD and the BVD percentage scores are high (80 % and 80%), suggesting that the evaluation results may be considered as interpretable.

Xavyer obtained an overall high BAVI percentage (80%). In a child exhibiting BAVI behaviors/characteristics, a higher overall BAVI percentage greater than or equal to 50 (≥ 50%) may suggest a child "at risk for BAVI". It is important to mention that the ≥50% cut-off is a useful threshold, but at present it is unvalidated and untested, thus caution is required.

The P-BAVI results were considered together with past medical history records and interviews with parents and other professionals to provide a comprehensive understanding of BAVI. The total observational results were interpreted by professionals who understood BAVI to clarify the complex disorder of auditory and visual processing problems. Overall, it can be proposed that Xavyer was displaying behaviours that reflected a disruption in the interplay between visual lower-order and higher-order functions (BVD) & auditory lower-order and higher-order functions (BAD).

Unlike children with documented peripheral vision and hearing loss, Xavyer does not have confirmed hearing impairment, and available medical information regarding his vision is primarily limited to a diagnosis of Cerebral Visual Impairment (CVI) and reports of abnormal eye movements. Despite the absence of significant peripheral sensory findings, both his family and educational team describe functional difficulties of processing and responding to visual and auditory information in everyday environments. This discrepancy between medical findings and observed functioning raises important questions regarding the contribution of brain based auditory and visual processing deficits. Xavyer has Dup15q syndrome with comorbid neurodevelopmental disabilities and epilepsy/seizures. Epilepsy and BAVI are frequently connected brain-based disorders, often co-occurring in children with neurological, genetic, or complex developmental disorders. Thus, there is a strong likelihood that central nervous system dysfunction may influence how Xavyer interprets and responds to sensory information across environments.

The P-BAVI item analysis:

Although several behavioral characteristics of Brain-based Auditory Deficits (BAD) and Brain-based Visual Deficits (BVD) were difficult to evaluate due to Xavyer's developmental level, non-ambulatory status, and communication profile, many other characteristics associated with BAD and BVD were partially or clearly recognizable. The P-BAVI findings revealed a mixed profile, with some visual and auditory items being rated as yes and demonstrated similar patterns of difficulty, while other items were rated as yes or no and did not demonstrate similar patterns of difficulty on the BVD and BAD domain items. These results suggest that Xavyer displays different levels of difficulties on the BVD and BAD items.

Xavyer demonstrates varying visual and auditory behaviors, with responses that fluctuate depending on the complexity of the environment, familiarity of the stimuli, and his level of engagement. He appears to rely heavily on familiar sensory information, including preferred songs, familiar voices, and visually preferred characteristics such as bright colours, movement, and backlit stimuli. In contrast, his responses to novel, competing, or rapidly changing sensory information are less consistent.

The scoring profile highlighted difficulties with auditory complexity and clutter (7.1, 7.3, 8.3). Xavyer demonstrates reduced auditory attention in noisy environments and appears to become overwhelmed when multiple sounds are present simultaneously, such as in the gymnasium or when a television and music are playing concurrently. In these situations, he may disengage, have difficulty attending to speech, and show signs of wanting to leave the environment. Excessive auditory stimulation also appears to negatively affect his ability to visually attend to and understand his surroundings.

The P-BAVI findings further suggest challenges with simultaneous sensory processing (3.1, 3.2). Xavyer often appears to process sensory information more effectively when input is simplified and presented through a single modality or within familiar contexts. Tactile information plays an important role in his learning and exploration, and he frequently uses his hands, mouth, lips, and tongue to gather information about objects in his environment.

Several higher-order functions, including route finding, navigation, spatial orientation, and aspects of visual and auditory memory (8.1, 8.2, 8.3, 11.2), were difficult to assess due to his significant motor limitations and developmental characteristics. Although there is evidence of partial recognition of familiar songs, voices, objects, and routines, it remains difficult to determine the extent to which Xavyer can recall, recognize, and meaningfully interpret previously encountered auditory and visual information.

Overall, the P-BAVI evaluation suggests that Xavyer's sensory functioning is influenced not only by his diagnoses of Cerebral Visual Impairment (CVI), Dup15q syndrome, autism spectrum disorder, and epilepsy, but also by brain-based differences in how auditory and visual information is processed, integrated, and used within everyday environments. The P-BAVI was valuable in identifying specific sensory processing vulnerabilities and in providing a better understanding of the conditions that support his engagement, communication, participation and learning.

Conclusion:

The P-BAVI profile of Xavyer, with an elevated total BAVI percentage, demonstrates a child exhibiting numerous BAVI behaviors and characteristics and may suggest a clinical disorder of Brain-based Auditory and Visual Impairment (BAVI). The profile revealed difficulties affecting both lower-order and higher-order auditory and visual functions, although some higher-order items could not be fully evaluated due to his developmental level, communication profile, and non-ambulatory status. The outcomes on the BVD scale are consistent with his previous diagnosis of Cerebral Visual Impairment (CVI) and support observations of atypical visual processing.

Although no peripheral hearing loss has been documented and only limited ophthalmological findings beyond CVI and abnormal eye movements have been reported, both Brain-based Visual Deficits (BVD) and Brain-based Auditory Deficits (BAD) appear to exert an interpretative influence on how Xavyer processes, integrates, and responds to sensory information. The discrepancy between relatively limited peripheral findings and the significant functional difficulties observed by his family and educational team further supports the need to consider brain-based auditory and visual processing deficits.

There is a likelihood that BAVI can cause developmental delays because it may impact how the brain processes auditory and visual information. Due to BAVI, Xavyer may not reach typical auditory and visual developmental milestones, often leading to challenges in communication, sensory regulation, orientation, participation and learning.

The overall results of the P-BAVI checklist confirm the observations and concerns that Xavyer`s parents and other involved professionals shared with the evaluators initially. The results also provide directions for recommended interventions for his visual and auditory processing functions.

Based on the current results, it was recommended that Xavyer is observed again with the P-BAVI observational checklist (repeat evaluation) in approximately three years, or sooner if significant developmental changes occur.

Xavyer will require individualized and highly tailored support designed to meet his specific needs. This support must provide meaningful interventions and be based around basic management of BAVI and through specific targeted interventions. See chapter 9.

Chapter 9 provides an overview of interventions to support children with BAVI. This chapter describes basic management strategies and specific management strategies regarding Xavyer.

9. Intervention strategies to support children with BAVI

1. Basic and specific management of BAVI

Appropriate management of BAVI begins with particularly identifying the child's visual and auditory processing deficits. Furthermore, it is essential to have a comprehensive understanding of each child's individual needs to provide effective support. The goals of any basic management plan may cover everything that makes life easier for the child with BAVI and should include supporting the child to attain his/her optimum level of vision and hearing functioning, fostering the child`s autonomy or sense of agency, reducing the child`s emotional or psychosocial challenges and inclusion of multisensory learning, despite the child`s limits in simultaneous multisensory input. Besides, it must include a greater emphasis on relationship building and on highly individualized interventions that address the development of communication strategies with ample opportunities for social interaction.

Children with BAVI can display varied visual and auditory functional deficits and may require specific interventions to support their learning. Thus, it is important to provide actionable strategies to parents and teachers to reduce the impact of the child's visual and auditory processing difficulties in daily life. Regarding the specific management of BAVI, the intervention will always require it to be tailored to the unique needs of each child. Since BAVI may share similar characteristics with both CVI and APD, the specific management strategies of BAVI could consider some intervention strategies implemented for children with CVI or APD. This is for the purpose of minimizing the adverse effects of visual and auditory processing deficits on the child`s day-to-day functioning.

The management of CVI in children necessitates a multifaceted approach that addresses early identification to assess visual impairment and aim for the minimization of visual impairment to enhance wellbeing. CVI interventions may involve both bottom-up and top-down approaches to improve the visual-spatial ability of children with CVI. Table 8 provides some suggestions for bottom-up and top-down management strategies for CVI.

Management strategies of CVI	**Examples**
Optimizing residual vision	maximizing remaining sight through environmental adaptations and optical devices
Implementing early visual stimulation	using high-contrast, slow-moving, brightly coloured, or illuminated objects to capture attention

Improving basic visual skills	targeted visual training; providing visual activities that enhance visual scanning, eye-hand coordination, visual discrimination or visual spatial relations
Applying task adaptations	waiting patiently for the child to process what they see; providing sufficient time for visual processing; using coloured, three-dimensional (3D) images/forms rather than two-dimensional (2D) representations
Providing structured routines	employing consistent, repetitive activities to help in the identification and recognition of visual targets
Accommodating environmental modifications	reducing visual complexity, using consistent lighting to decrease sensory overload; reducing visual clutter and visual fatigue; implementing orientation and mobility training
Enhancing complex visual skills	improving visual tracking skills by supporting the child to focus and follow a fast-moving object
Focusing on building compensatory skills (top-down strategies)	teaching the child to talk to themselves through what they are looking at (verbal mediation); encouraging the child to use the environment to predict what an object is. If they see a blurry shape on the kitchen counter next to the sink, top-down logic tells them it is likely a soap bottle or a cup, not a toy car (contextual clues)

Table 8. Some bottom-up and top-down management strategies of CVI with examples

Along the same lines, managing APD in children compromises a multifaceted approach to treating difficulties with listening and their interconnected links to a range of audiological factors (e.g. hearing acuity and auditory processing) and non-audiological factors (e.g. attention, working memory, and language abilities). APD interventions may involve both bottom-up and top-down approaches to improve the listening ability of children with APD (Almarjawi, et al., 2026). Table 9 provides some suggestions for bottom-up and top-down management strategies for APD.

Management strategies of APD	**Examples**
Optimizing residual hearing	maximizing remaining hearing through environmental adaptations and hearing devices

Applying task adaptations	waiting patiently for the child to process what they hear; providing sufficient time for auditory processing; reducing the rate of speech; providing short phrases and clear key words; simplify speech
Providing structured routines	placing the child closer to the speaker; preferential seating in the classroom
Accommodating environmental modifications	utilization of personal FM systems or noise-canceling headphones for acoustic amplification; reducing background noise or auditory information; reducing auditory clutter and auditory fatigue; reverberation management to increase the signal-to-noise ratio (e.g., sound-absorbing panels/materials)
Enhancing auditory skills	targeted auditory training by providing structured exercises to refine active listening skills; distinguishing and recognizing subtle differences between environmental or speech sounds/auditory discrimination training; playing sound-matching games/active listening exercises; drawing attention to the source and direction of a sound/sound localization training
Improving auditory processing skills in combination with music	targeted and strategic musical training for boosting auditory processing abilities over time; playing musical pattern games to develop timing and rhythm perception; providing dance or dance movement therapy
Improving phonological awareness (metalinguistic strategies)	focusing on the overall meaning or main idea of a message rather than trying to process every single individual phoneme or sound; helping the child to be aware of environmental sound cues or voices and to respond to them accurately; rhyming or identifying words with similar ending sounds; manipulating individual sounds by clapping syllables or words in a sentence; training the child to use surrounding context, body language, and situational cues to "fill in the blanks" for missed words
Focus on using higher-order cognitive skills (metacognitive strategies)	teaching the child to monitor their own attention and recognize when they have stopped understanding; using visualization, mind mapping, or repeating information back in chunks to strengthen working memory

Table 9. Some bottom-up and top-down management strategies of APD with examples

Children with BAVI may need a combination of these CVI and APD strategies. It is important to emphasize that the CVI and APD strategies need to be intertwined rather than considered separately. For example, reducing visual complexity may be an appropriate CVI strategy, but that alone may not be sufficient if the child is still trying to function in a complex auditory environment. We may also need to reduce background noise or auditory information, simplify speech, provide additional processing time, avoid asking the child to look and listen simultaneously, and consider whether information should be presented multisensorial or through one sensory channel at a time. The visual and auditory processing strategies need to interact or work together, and the implementation approach will differ from child to child. In other words, their relevance will always depend on the individual characteristics, developmental profile, sensory functioning, needs and responses of the child.

However, we should be more cautious about some of the CVI and APD interventions that are mentioned in tables 8 & 9, particularly the top-down strategies. Some of the CVI and APD interventions may be useful, but they are not established BAVI interventions. The evidence base for BAVI interventions is still developing.

Furthermore, it is essential to consider that some of these intervention strategies implemented for a child with CVI or APD may be difficult to apply or are less effective for certain children with BAVI, for instance, for a toddler with global developmental delay or for a child with DB-BAVI. A child with DB-BAVI may display a different developmental path with restricted access to sensory input and limited processing skills for visual and auditory information, thus impacting how they learn, communicate, and interact with the world. While some adaptations or accommodations can be made on the above-mentioned management strategies of CVI or APD, compensation for a brain based auditory and visual impairment (BAVI) is much more complex and will require specialized, individualized and multidisciplinary approaches.

For individuals with BAVI, compensatory strategies based on the sense of touch, such as providing individualized tactile-based strategies could be helpful. Teaching compensatory tactile strategies have been suggested in the integrated rehabilitation approach of military war veterans with deficits associated with both auditory and visual processing (Saunders & Echt, 2012). Besides, tactile-based rehabilitation instructions could assist individuals with dual sensory loss to enhance their awareness of touch and to refine their touch cues/tactile skills to effectively supplement or replace vision and hearing (Martinello, 2025).

However, in children with BAVI more emphasis must be given to tactile sensory and tactile perception interventions, such as using targeted touch, pressure, and textured activities to help the brain process and respond to skin or bodily sensations. Touch is not necessarily an automatically accessible compensatory sense. Tactile information needs to be meaningful and interpretable for the individual child rather than simply added as another sensory input.

Providing individualized tactile-based strategies may enable a child with BAVI to develop adequate learning strategies and further influence the child`s life-long learning and communication development. The utilization of touch within early childhood instruction and throughout learning experiences will often be beneficial to support access to learning (Luckner et al., 2016). In this regard, tactile-based learning strategies that focus on tactile sensory perception and tactile cognition may influence the learner`s motivation and attention as well as in the selection and processing of information (Nicholas, et al., 2025).

2. Case-specific management of BAVI

Case illustration 1: Thomas

Before considering suggestions to strengthen outcomes for parents and teachers, it is helpful to describe the complex BAVI challenges of Thomas. Parents and teachers should understand the impact of BAVI on Thomas`s daily life. Fundamentally, the child with BAVI is a child who happens to have a distinct clinical disorder that diminishes the ability to process both visual and auditory information. The evaluation using the P-BAVI has identified Thomas`s difficulties due to BAVI. Table 6 provides the P-BAVI scoring profile for Thomas.

Basic strategies of BAVI should include supporting Thomas to attain his optimum level of visual and hearing functioning, encouraging his participation, reducing his emotional challenges, and improving his ability to effectively communicate. Specific strategies of BAVI should include actionable strategies to reduce the impact of Thomas's visual and auditory processing difficulties in his daily life. Difficulties specific to Thomas have been identified through the P-BAVI evaluation. Specific strategies may include:

-Build learning through familiarity and predictability. *Familiar songs, objects, routines and people should be used as entry points for introducing new activities and concepts. Consistent routines and predictable environments are likely to reduce processing demands and thus increase his engagement, understanding, and participation.*

- Present information using one sensory modality at a time. *Thomas appears to process information most effectively when sensory demands are less complex or simplified. Whenever possible, visual, auditory, and tactile information should be presented sequentially rather than simultaneously. Activities should avoid requiring him to look, listen, and manipulate objects at the same time, as simultaneous sensory input may reduce his ability to attend and participate.*

- Allow Thomas to take 'sensory breaks', as looking and listening are demanding for him. *Short breaks or pauses during an activity may stop him from getting too tired and help him focus better on the next task.*

-Provide a quiet learning environment which is necessary for Thomas to learn and develop. *Especially, auditory clutter is very disturbing for Thomas. Interaction and communication should occur in quieter environments whenever possible. Background music, televisions, multiple conversations, and other competing sounds should be minimized, particularly during learning activities. Reduced auditory complexity is likely to improve his attention and ability to process meaningful information.*

- Allow Thomas sufficient time to process visual and auditory information. *Thomas may need extended time to notice, process and respond to sensory information, particularly when materials are unfamiliar or during demanding or increasing environmental conditions. Thomas should be allowed sufficient wait time, and rapidly changing activities should be avoided.*

- Simplify visual and sound environments simultaneously. *Thomas sometimes seems not to respond to very bright light in a dark room. By presenting individual visual objects one at a time in a simple, non-visual clutter environment and in a quiet, non-auditory clutter surrounding may foster his visual attention.*

- Monitor and respond to Thomas`s signs of sensory overload or feeling overwhelmed*. When he is overstimulated and feels stressed or upset, it is important to reduce the amount of spoken information, long phrases and the rate of speech. Humming and holding him tight (deep pressure) may help him calm down. Besides, reducing environmental visual and auditory clutter could be effective.*

- Provide music and rhythms for boosting communication and processing abilities*. Singing is one of Thomas's strongest motivators and appears to facilitate attention, engagement, and participation. Preferred songs, rhythmic activities, and musical routines should be incorporated into his daily life and may benefit to support transitions, anticipation, and communication opportunities. 'Songs of reference' are already being used by his parents at home for communicating activities to him.*

- Use the bodily-tactile modality for contact, communication, exploration and orientation. *Tactile and oral-tactile experiences appear to be important avenues through which Thomas gathers information about his environment. Opportunities for safe exploration of real objects should be provided, and tactile experiences should be paired with language, routines, and meaningful activities to support understanding and concept development.*

- Implement tactile signs and gestures which seem to be more appropriate compared to visual signs or only spoken language. *Thomas is very open to a hand-under-hand approach, which is a way of interacting and communicating using touch. Attention should be given to his whole-body during interaction, since he also uses his feet to communicate his needs.*

The P-BAVI was not only helpful to identify BAVI characteristics, but it also provided a stronger foundation for deciding what to change in Thomas's sensory environment and in his social interaction patterns so that he can function and learn more successfully. Table 10 gives an overview of how Thomas learns and responds to his environment.

OBSERVED STRENGTHS		
Familiarity • Recognizes familiar songs ('songs of reference') • Recognizes familiar voices • Recognizes familiar objects implicitly	**Motivation** • Strong response to singing songs • Greater involvement in tactile interaction • Interest in tactile exploration	**Functional Memory** Quickly learns new songs with tactile gestures Anticipates in certain songs with tactile gestures Recognizes meaningful objects

OBSERVED CHALLENGES		
Sensory complexity • Difficulty with background noise • Multiple simultaneous sounds can be overwhelming (he 'freezes')	**Dual-task Processing** • Difficulty listening and tactile exploring at the same time • Difficulty looking in almost all circumstances • One sense often takes priority over others (usually auditory or tactile)	**Variability** • Responses change depending on fatigue • Responses change depending on the envionment • Responses change depending on interest
KEY SUPPORTS FOR SUCCESS		
To support listening abilities • Quiet environment • Familiar voices • Use intonation and singing voice • Clear key words	**To support tactile development** • One sense at a time • Hand under hand interaction • Make visual and auditory experiences tactile as well	**To support participation** • Predictable routines • Processing time • Sensory breaks • Strategic use of music
KEY MESSAGE		
• When the environment and the approach for interaction are adapted to his sensory needs, Thomas demonstrates increased understanding, engagement and participation **Tactile input + simplicity + motivation + calm = greater success**		

Table 10: An overview on Thomas`s observed strengths and challenge with key supports for success.

Case illustration 2: Xavyer

Before considering suggestions to strengthen outcomes for parents and teachers, it is helpful to describe the impact of the complex BAVI challenge on Xavyer`s daily life. Fundamentally, the child with BAVI is a child who happens to have a distinct clinical disorder that diminishes the ability to process both visual and auditory information. The evaluation using the P-BAVI has identified Xavyer`s difficulties due to BAVI. Table 7 provides the P-BAVI scoring profile for Xavyer.

Basic strategies of BAVI should include supporting Xavyer to attain his optimum level of visual and hearing functioning, encouraging his participation, reducing his emotional challenges, and improving his ability to effectively communicate. Specific strategies of BAVI should include actionable strategies to reduce the impact of Xavyer's visual and auditory processing difficulties in his daily life. Specific strategies may include:

- Present *information with one sensory modality at a time;* Xavyer appears to process information most effectively when sensory demands are simplified. Whenever possible, visual, auditory, and tactile information should be presented sequentially rather than simultaneously. Activities should avoid requiring him to look, listen, and manipulate objects at the same time, as simultaneous sensory input may reduce his ability to attend and participate.

- *Build learning through familiarity and predictability;* Familiar songs, objects, routines, picture cues, and people should be used as entry points for introducing new activities and concepts. Consistent routines and predictable environments are likely to reduce processing demands and increase his engagement, understanding, and participation.

- *Reduce auditory clutter and competing sounds;* Instruction and communication should occur in quieter environments whenever possible. Background music, televisions, multiple conversations, and other competing sounds should be minimized, particularly during learning activities. Reduced auditory complexity is likely to improve his attention and ability to process meaningful information.

- *Simplify visual environments;* Visual information should be presented in a structured and uncluttered manner. Presenting one object or picture at a time, using plain backgrounds, and reducing the number of competing visual elements may increase his ability to visually attend, recognize, and respond to information.

- *Use visually salient materials;* Xavyer demonstrates increased visual attention to bright colours, illuminated objects, and movement. Educational materials should incorporate high contrast colours, movement, and visual features that are meaningful and motivating to him. Whenever possible, objects should be presented within his preferred right central visual field.

- *Allow additional processing time;* Xavyer may require extended time to notice, process, and respond to sensory information, particularly when materials are unfamiliar or when environmental demands are increased. Adults should allow sufficient waiting time and avoid rapidly changing activities or repeating instructions too quickly.

- *Incorporate music and rhythm into programming;* Music is one of Xavyer's strongest motivators and appears to facilitate attention, engagement, and participation. Preferred songs, rhythmic activities, and musical routines should be incorporated into daily programming and used to support transitions, anticipation, and communication opportunities.

- *Monitor and respond to signs of sensory overload;* Xavyer demonstrates signs of sensory overload in highly stimulating env1ironments, including disengagement, turning away, mouthing objects, and seeking to leave the environment. Staff should monitor for these behaviours and provide opportunities for regulation, reduced sensory input, and access to quieter spaces when needed.

- *Maintain highly structured and predictable environments;* Xavyer appears to function most successfully in familiar, organized, and predictable environments. Maintaining consistency in routines, material placement, and environmental organization is likely to support orientation, participation, and emotional regulation while reducing cognitive and sensory demands.

- *Support tactile and oral-tactile exploration;* Tactile and oral-tactile experiences appear to be important avenues through which Xavyer gathers information about his environment. Opportunities for safe exploration of real objects should be provided, and tactile experiences should be paired with language, routines, and meaningful activities to support understanding and concept development.

The P-BAVI was not only helpful to identify BAVI characteristics, but it also provided a stronger foundation for deciding what to change in Xavyer 's environment, programming and interactions so that he can function and learn more successfully. Table 11 gives an overview of how Xavyer learns and responds to his environment.

OBSERVED STRENGTHS		
Familiarity • Recognizes preferred objects • Recognizes familiar songs • Recognizes certain familiar voices • Navigates familiar environments	**Motivation** • Strong response to music • Interest in lights and movement • Greater engagement with preferred activities	**Functional Memory** • Remembers familiar routines • Recognizes meaningful symbols • Anticipates certain sounds or activities
OBSERVED CHALLENGES		

Sensory complexity • Difficulty with visually cluttered environments • Difficulty with background noise • Multiple simultaneous sounds can be overwhelming	**Dual-task Porcessing** • Difficulty looking and listening at the same time • Difficulty listening while manipulating objects • One sense often takes priority over others	**Variability** • Responses change depending on fatigue • Responses change depending on interest • Responses change depending on the environment
KEY SUPPORTS FOR SUCCESS		
To support visual abilities • simple materials • reduced visual distraction • familiar objects • optimal positioning	**To support listening abilities** • quiet environment • familiar voice • short phrases • clear key words	**To support participation** • predictable routines • processing time • sensory breaks • strategic use of • music • support tactile and oral-tactile exploration
KEY MESSAGE		
When the environment is adapted to his sensory profile, the student demonstrates increased understanding, engagement, and participation. **Familiarity + simplicity + motivation + calm = greater success**		

Table 11: An overview on Xavyer`s observed strengths and challenge with key supports for success.

10. Conclusion

The Pediatric Brain based Auditory and Visual Impairment (P-BAVI) checklist can be used as a preliminary step in the evaluation of a brain based visual and auditory impairment (BAVI), as a way of determining if further, more comprehensive assessment is necessary. Currently the P-BAVI should be considered as an observational checklist rather than a diagnostic instrument. Establishing it as a diagnostic instrument would require considerably more systematic work. For instance, the ≥50% cut-off of the P-BAVI is a useful threshold, but at present it is unvalidated and untested and requires further investigation. The reliability, validity, diagnostic accuracy and normative data of the P-BAVI have not yet been established, and these are areas we hope to investigate as the tool develops.

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Pediatric BAVI Checklist (P-BAVI)

Instructions

On the following pages is a list of fifty items with behavioral examples that that describe Brain based Auditory and Visual Impairment (BAVI) in children. Several illustrative examples are given for each item in the checklist to add clarity. The given examples are illustrative and not exhaustive.

The Pediatric BAVI Checklist (P-BAVI) is developed to identify behavioral characteristics that describe difficulties in perceiving and interpreting both visual and auditory impressions/information. The checklist includes items that describe auditory lower-order and higher-order functional deficits & visual lower-order and higher-order functional deficits. Besides, the checklist also includes items that consider the auditory and visual preferences of a child with BAVI.

P-BAVI has a total number of 50 items, in which 25 items describe Brain based Visual Deficit (BVD), whilst 25 items describe Brain based Auditory Deficit (BAD) in a comparative manner to determine the Brain based Auditory and Visual Impairment (BAVI) in a child.

The items within the checklist can be rated through direct or video observations. The P-BAVI should be administered by an examiner who has good observational skills and a knowledge of the child's repertoire of behaviors. The most valid BAVI results are obtained if the child is observed in multiple environments and during various times of the day.

The items in the P-BAVI checklist are followed by boxes marked by two response options: Yes or No. Besides, if the response choice is Yes, you can further elaborate it as clearly (c) or partially (p), whilst if the response choice is No, you can further elaborate it as cannot observe (co) or cannot assess (ca). *Please see the P-BAVI manual for further details.*

Yes	*when you can clearly (c) see or partially (p) see the behaviors/behavioral examples relevant to the item: "I clearly or partially see it"*
No	*when you cannot observe (co) or cannot assess (ca) the behaviors/behavioral examples relevant to the item: "I cannot see/notice or "I cannot determine since the item does not apply to this specific child".*

Read each item and the illustrative examples and carefully tick Yes; *(c) or (p)* or No; *(co) or (ca)* in one of the boxes of the response options that you think best corresponds to the item behaviors and examples, i.e., do you see the item behavior occurring in everyday situations?

It is important that you complete the whole checklist for the purpose of obtaining an accurate picture of the child's brain based auditory and visual impairment.

Before you begin rating the items, please fill in the information below.

- Date of assessment: ______________________
- Name: _______________________________
- Age: _________________________________
- Gender: ________________________________

Does the child have a history of one or more of the following risk factors? Please tick the appropriate Yes or No box.

- Prematurity
  ☐ Yes ☐ No
- Low birth weight
  ☐ Yes ☐ No
- Neonatal Hypoxia Ischemia
  ☐ Yes ☐ No
- Hydrocephalus
  ☐ Yes ☐ No
- Infections (i.e., CMV, toxoplasmosis)
  ☐ Yes ☐ No
- Inflammation (i.e., meningitis)
  ☐ Yes ☐ No
- Congenital brain anomalies
  ☐ Yes ☐ No
- Cerebral Palsy
  ☐ Yes ☐ No
- Seizure disorders
  ☐ Yes ☐ No
- Head trauma/Traumatic Brain Injury
  ☐ Yes ☐ No
- Stroke/ Brain tumour
  ☐ Yes ☐ No
- Others: _____________________

Has the child been diagnosed with a genetic disorder?
☐ Yes ☐ No
If yes, which genetic syndrome: ______________________________________

Did the child get an electroencephalogram (EEG) or neuroimaging assessment (i.e., MRI, CT)?

☐ Yes ☐ No

If yes, what were the results from the EEG or brain scan: ______________

Other, neurological/neuropsychological assessments?

☐ Yes ☐ No

Vision:

Has the child been formally assessed?

☐ Yes ☐ No

Visual loss:

☐ None ☐ Mild ☐ Moderate ☐ Severe

Visual aid/optical devices/other: ______________________

Hearing:

Has the child been formally assessed?

☐ Yes ☐ No

Hearing loss:

☐ None ☐ Mild ☐ Moderate ☐ Severe

Hearing aid/cochlear implant/other: ____________________

How do you rate the following functions?

- Sensory functions of touch
  ☐ Good ☐ Average ☐ Poor
  (The ability to register and respond to the feeling of being touched by others or touching various textures; using hands/body within active exploration)

- Gross motor functions
  ☐ Good ☐ Average ☐ Poor
  (Gross motor skills coordinate larger movements of the body: lying, rolling, sitting, crawling, standing, walking, running or jumping)

- Fine motor functions
  ☐ Good ☐ Average ☐ Poor
  (Fine motor skills coordinate precise, small movements of the body: holding small items, buttoning clothing, turning pages, eating or cutting with scissors)

- Balance and coordination
  ☐ Good ☐ Average ☐ Poor
  (Maintaining a controlled body position during tasks/activities: sitting at a table, retrieving an object from the floor or changing from a standing position to sitting)

<table>
<tr><th>Brain based Visual Deficit (BVD) items: visual lower-order and higher-order functional deficits</th><th colspan="2">Rating</th></tr>
<tr><td colspan="3">1. Does the child show atypical visual reflex responses or varying visual behaviours that aren`t caused by the eyes themselves?</td></tr>
<tr><td>1.1 Visual blink reflex is irregular.

(i.e., lack or fail to blink when an object comes too close to the eyes or when object touches the bridge of the nose; delayed eye-blinks or protective blink response; struggles to detect a rapidly approaching visual item and may become easily frightened, for instance of a person walking quickly through their environment)</td><td>Yes
(c) or (p)</td><td>No
(co) or
(ca)</td></tr>
<tr><td>1.2 Shows varying visual behaviours throughout the entire day.

(i.e., varying degrees of establishing and maintaining eye-to-object contact; varying levels of visual curiosity; difficulties in fixation and shifting eye gaze; inconsistent visual responses in a predictable context, such as sometimes notices strong visual items and sometimes not; shows normal/near-to- normal levels of visual acuity/sharpness of vision through formal/standard assessments, but the functional vision performance does not correspond to visual test results; varying degrees of visual efficiency in spite of having normal/near-to-normal acuity)</td><td>Yes
(c) or (p)</td><td>No
(co) or
(ca)</td></tr>
<tr><td colspan="3">2. Does the child display atypical gaze patterns?</td></tr>
<tr><td>2.1 Gazes/stares intently at certain light sources/visual targets and/or avoids certain light sources in the environment.
(i.e., involuntarily drawn to natural/artificial light sources, such as, light from windows, glare on surface areas, ceiling lights, lamps or TV monitors/computer screens/smart phones; captivated by brightly illuminated objects or objects that cause glare; wiggles/flicks fingers in front of the light source; actively avoids looking at certain light sources; demonstrates increased light sensitivity/visual discomfort to intrusive visual items, such as flashing/flickering lights or zig-zag patterns)</td><td>Yes
(c) or (p)</td><td>No
(co) or
(ca)</td></tr>
<tr><td colspan="3">3. Does the child have problems using vision while attending to auditory or tactile inputs?</td></tr>
<tr><td>3.1 Difficulty when looking and actively using hearing simultaneously.

(i.e., problems looking at an object and engaging with the auditory information simultaneously; finds it hard looking at a visual target and being aware of a sound at the same time; struggles looking at the person's face and listening to the voice at the same time during a face-to-face interaction/conversation; looks away from people when listening to them; trouble seeing and listening to a simultaneously occurring sound; struggles to read and listen simultaneously)</td><td>Yes
(c) or (p)</td><td>No
(co) or
(ca)</td></tr>
</table>

3.2 Difficulty when looking and tactually exploring simultaneously. (i.e., problems looking and doing something with hands at the same time; problems coordinating vision with movement, such as difficulty with visually guided reaching; looks away from a visual target when touching/reaching occurs)	**Yes (c) or (p)**	**No (co) or (ca)**
4. Does the child show behaviours around visual field deficits?		
4.1 Difficulty responding to visual items within a specific visual field/fields. (i.e., difficulty detecting or acting upon visual stimuli in a specific area of their vision; problem responding to items within a particular visual field; limited visual field abilities when out in the real world such as bumping into objects or tripping; shortens the viewing distance while playing with toys; positions eyes to a particular side when viewing; tilt head to a particular side to view objects from their accessible visual field of view; moves whole head to scan the visual target; postural skews when drawing/writing)	**Yes (c) or (p)**	**No (co) or (ca)**
5. Does the child show preferences for viewing targets in a particular visual element, such as familiarity, simplicity, colour elements, and motion patterns?		
5.1 Preference for visual familiarity. (i.e., visually interested in familiar/ known objects; visually alert or gives attention when an activity becomes more familiar; identifies common objects quickly when they are familiar and accompanied by known contextual details in a distraction-free environment; needs less time or reaction time to notice and respond to a repeatedly occurring familiar visual item)	**Yes (c) or (p)**	**No (co) or (ca)**
5.2 Preference for visual simplicity. (i.e., visually interested in simplistic or non-complex images/materials; finds it easier to attend to an object when there are few of them, for instance, can spot an apple but will have difficulty when the apple is in a basket filled with other apples; finds it easier to identify items when presented in an organized row or with increased spacing between each item; finds it easier to match or tell the difference between shape/size details presented on a simple backdrop; needs less time or reaction time to notice and respond to a repeatedly occurring non-complex visual target item)	**Yes (c) or (p)**	**No (co) or (ca)**
5.3 Preference for certain colour elements. (i.e., visually attracted towards visual targets of a certain colour; consistently looks and chooses objects with colour intensity; draws attention to familiar landmarks with certain bright colours; finds it easier to identify people based on the colour of hair or clothing; visually alert or gives attention to objects with just one colour compared to multi-coloured ones; finds it easier to identify three-dimensional (3D) coloured images/forms compared to two-dimensional representations (2D)	**Yes (c) or (p)**	**No (co) or (ca)**

5.4 Preference for certain motion patterns. (i.e., visually attracted towards visual targets in a certain motion, such as a slow moving ball or slow drifting clouds; prefers an environment with predictable or methodical motion; drawn towards objects that move/spin compared to stationary/still targets; may not notice a person until they start moving; visually alert when using movement, for instance moves or spins objects to establish visual attention; visually alert when using self-motion, for instance visually orients better while in movement; prefers watching films/animation with slow presentations and limited movement)	**Yes (c) or (p)**	**No (co) or (ca)**
6. Does the child have perceptual difficulties in identifying or discriminating certain visual targets?		
6.1 Difficulty engaging with unfamiliar visual items. (i.e., is less visually alert when a visual target is unfamiliar; shows little visual keenness for new/novel objects or to unfamiliar versions of a well-known object; difficulties in visual search arise when visually exploring an unfamiliar target object; finds it hard to identify an unknown visual target in the absence of contextual details; misinterprets the meaning of unfamiliar visual information; hesitates to proceed in exploring a visual object in an unexpected setting)	**Yes (c) or (p)**	**No (co) or (ca)**
6.2 Difficulty engaging with visually complex items. (i.e., is less visually alert when an object has complex outlines and forms; shows little visual keenness for highly patterned images or richly illustrated drawings; problems identifying abstract drawings compared to real objects; struggles identifying two-dimensional (2D) materials compared to three-dimensional (3D) representations in a picture book; finds it challenging to tell the difference between visual aspects of shape and size when it's upside down or at a different angle or orientation; misinterprets the meaning of complex visual information; problems in distinguishing letters or numbers; problems decoding letters or numbers when they are combined to form a word or number grouping)	**Yes (c) or (p)**	**No (co) or (ca)**
6.3 Difficulty attending visually to the face. (i.e., problems looking at or keeping a gaze to faces, such as, may not "look into" a person`s eyes or may appear looking "through;" trouble identifying the faces of familiar persons outside the usual context; struggles interpreting facial cues or facial expressions of others; problems integrating facial features which may lead to misinterpreting social cues)	**Yes (c) or (p)**	**No (co) or (ca)**

6.4 Difficulty distinctly judging or comprehending visual targets of objects or items. (i.e., easily mixes up similar looking visual items at expected distances; trouble with tasks requiring precise visual gauging, like pouring liquids; trouble identifying an object when only parts of it are visible or when it is partially obscured, for instance, trying to locate a specific book on a cluttered shelf where only the spines are partially visible, or finding a lost item under a pile of clothes where only a small part of it is showing)	**Yes (c) or (p)**	**No (co) or (ca)**
7. Does the child have difficulties in perceiving visual targets in overwhelming visual conditions?		
7.1 Difficulty noticing visual targets in conditions with excessive presence of visual elements (visual clutter). (i.e., trouble finding an item when items are on a crowded shelf or are scattered on a surface/floor; trouble finding an item when items are spaced too closely or are in a tightly packed space; problems finding/sorting a familiar object within a complex array of other objects, such as a special toy among a lot of toys, a specific piece of clothing among pile of clothes or a specific item on a messy table top; struggles identifying or distinguishing an object from other objects in highly patterned backgrounds that do not clearly separate the figure from the background; difficulties in rearranging visual layers, especially when patterns, textures and overlapping objects increase in visual-perceptual load; trouble counting the number of letters/numbers if they are close together; problems reading pages/sheet music when there is too much visual clutter on the page)	**Yes (c) or (p)**	**No (co) or (ca)**
7.2 Difficulty perceiving a familiar person in a crowded environment. (i.e., trouble finding a family member or known person in a crowded place, such, as school yards, swimming pools, supermarkets, shopping malls or sports stadiums; problems finding a familiar person in a setting with increasing crowds of people; mistakes others for a family member, for example, someone with similar hair or height)	**Yes (c) or (p)**	**No (co) or (ca)**
7.3 Difficulty visually tracking fast-changing visual targets or surveying visual scenes that change rapidly. (i.e., problems following or recognizing fast-moving visual targets, such as fast-moving cars or rapidly bouncing tennis balls; trouble detecting an object when movement of visual target is random; difficulty detecting distinct direction changes in a fast-moving visual target; misses important visual details in a situation of rapid visual scene transitions, such as in fast-changing animation sequences or movie scenes; avoids fast moving films)	**Yes (c) or (p)**	**No (co) or (ca)**
8. Does the child have difficulties with localization of visual items or navigating environments?		

8.1 Difficulty perceiving spatial properties of visual items. (i.e., trouble locating visual items when presented in a random formation; problems determining the spatial placement of an object in relative to another, such as trouble putting a block onto the tower when stacking it up; problems in correctly judging the relative position of objects; such as trouble figuring out whether the book is in front of, behind, or next to the cup; misjudges location and reaches/grabs next to objects, for instance when grabbing food; difficulty judging the distance between oneself and a visual target; confusion over directions like left versus right & up versus down)	**Yes (c) or (p)**	**No (co) or (ca)**
8.2 Difficulty with route finding and directions in different surroundings. (i.e., gets easily lost in a busy/crowded place; trouble with navigation in an unfamiliar/novel environment; gets easily disoriented in new spaces or in an environment with high volumes of movement; hesitates to explore an open field or an unknown surrounding; trouble following an unpredictable route; finds it difficult to evaluate distance as they move through larger spaces; problems avoiding obstacles when moving towards a visual target)	**Yes (c) or (p)**	**No (co) or (ca)**
8.3 Difficulty when navigating through different surfaces. (i.e., problems walking on uneven terrains or levels; difficulty walking on different types of staircases; difficulty walking downstairs; difficulty going up or down the pavement; difficulty in perceiving or estimating subtle or not-so-subtle changes in depth when navigating steps, sidewalks, or patterned surfaces)	**Yes (c) or (p)**	**No (co) or (ca)**
9. Does the child have difficulties in time-based processing of a particular visual information?		
9.1) Difficulty responding to certain visual materials instantly (visual response latency). (i.e., length of time/reaction time to notice and respond to an unfamiliar or complex visual target is long, especially in overwhelming visual conditions; needs much time for visual searching and responding to an abstract visual target, such as a highly patterned image or richly illustrated drawing)	**Yes (c) or (p)**	**No (co) or (ca)**
10. Does the child have difficulties paying attention in a particular visual situation?		

10.1 Difficulty being attentive in an environment with varying visual details or visual disturbances (visual sustained/selective attention). fluctuations in focused attention when attending to visual details over time; difficulty sustaining concentration and maintaining overview over visual details during continuous visual activities/games, such as when solving jigsaw puzzles, building sets or playing card games; demonstrates poor attentional behaviours during continuous visual activities, for instance, may look around or away; becomes easily captivated by irrelevant visual elements and struggles to redirect/disengage visual attention to relevant elements; gets easily distracted by competing visual elements in the environment and struggles to stay on task; problems integrating multiple visual features which results in misinterpreting a visual information)	**Yes (c) or (p)**	**No (co) or (ca)**
11. Does the child have difficulties remembering distinct visual information?		
11.1 Difficulty mentally retaining visual information (visual working memory). (i.e., struggles retaining a small set of visual items, up to five items, and instantly know how many there are without counting; easily forgets various visual information, in spite of several visual cues/reminders; struggles to retain visual information that can be mentally taxing, especially when the visual task load or demand increases; struggles to retain symbols, numbers or letters in spite of several repetitions; finds it difficult to copy visual items from a book or from the board; trouble copying visual spatial figures/items; difficulty in applying learned visual skills to novel circumstances)	**Yes (c) or (p)**	**No (co) or (ca)**
11.2 Difficulty recollecting past visual information (visual memory). (i.e., struggles to recall visual traits of a form/object that has been seen several times before; struggles to recall how to solve a visual task that has been done numerous times before; finds it challenging to recall visual sequences that has been seen and shared in the past, such as in recollecting a sequence of objects in the correct order or following a multi-step plan/instruction in the correct order; problems recalling numbers, letters, words or visual signs that they have seen or learned before; problems reproducing distinct visual items at a later time, such as drawing a figure after a delay)	**Yes (c) or (p)**	**No (co) or (ca)**
12. Does the child lose energy and show signs of fatigue when engaging in visual activities?		

12.1 Displays signs of visual overstimulation/overload and looking-related fatigue (visual fatigue). (i.e., tires easily after looking at disturbing light levels for a prolonged period; excessively rubs, pokes or squints eyes, especially when engaging in lengthy visual activities; shows signs of visual exhaustion by displaying visual stimming/stereotypic behaviours, such as, rapidly blinking/rolling the eyes flickering fingers in front of the eyes, making repetitive flapping/twisting hand movements or repeatedly waving objects in front of the face; demonstrates observable behaviours of visual strain, such as, touches eyes, glasses or around them, rests head in hands, puts head down or pushes all items out of view; fatigue significantly impairs concentration and visual functions, especially in visual cluttered environments)	**Yes (c) or (p)**	**No (co) or (ca)**
Brain based Auditory Deficit (BAD) items: auditory lower-order and higher-order functional deficits	**Rating**	
1. Does the child show atypical auditory responses or varying auditory behaviours that can`t be explained by hearing functions?		
1.1 Startle reaction to a sudden unexpected sound is irregular. (i.e., absent, or delayed startle reflex/reflexive response to a loud noise; brief, involuntary muscle contractions/head jerks in response to unexpected or loud short sounds; struggles to detect a rapidly approaching auditory item and may become easily frightened, for instance of the sound of a person's footsteps approaching rapidly)	**Yes (c) or (p)**	**No (co) or (ca)**
1.2 Shows varying auditory behaviours throughout the entire day. (i.e., inconsistent auditory responses to sounds, such as may not react to a door squeaking sound but will react to it at the time a parent is due home; inconsistent auditory responses to messages, such as sometimes hears a clear message and sometimes not, depending on the context; varying levels of hearing curiosity; fluctuation in the use of hearing throughout the day, such as sometimes turns toward a sound source and sometimes not; may show normal levels of hearing threshold through formal/standard assessments, but the functional hearing performance does not correspond to hearing test results)	**Yes (c) or (p)**	**No (co) or (ca)**
2. Does the child display atypical listening patterns?		

2.1 Overly focuses on certain sounds and/or avoids certain sounds sources in the environment. (i.e., intense focus or preoccupation with certain sounds or certain parts of a song; easily overwhelmed by mild environmental sounds, such as rustling leaves, gentle rainfall, distant traffic, or the quiet hum of a refrigerator; appears distressed or experiences discomfort to environmental sounds, by covering ears with palms, inserting fingers into ears or actively avoiding certain sound sources; demonstrates increased sensitivity to sound in an intrusive sound background, such as a dripping tap or the humming of an air conditioner)	**Yes (c) or (p)**	**No (co) or (ca)**
3. Does the child have problems using hearing while attending to visual or tactile inputs?		
3.1 Difficulty when actively using hearing and looking simultaneously. (i.e., struggles to use hearing effectively when visually scanning a target; finds it hard engaging with an auditory information and looking at a visual item at the same time; problems listening to the voice on the phone and visually orienting to the environment simultaneously)	**Yes (c) or (p)**	**No (co) or (ca)**
3.2 Difficulty when actively using hearing and tactually exploring simultaneously. (i.e., problems listening to verbal instructions and doing something with hands at the same time; struggles to listen and play a music instrument simultaneously, for instance a keyboard)	**Yes (c) or (p)**	**No (co) or (ca)**
4. Does the child show behaviours around auditory field deficits?		
4.1 Difficulty responding to an auditory target within a specific auditory field/ auditory fields. (i.e., difficulty detecting or acting upon a specific set of sound frequencies, for instance low-frequency sounds; struggles perceiving and responding to a sequence of alternating high and low tones; trouble hearing sounds like a kettle boiling)	**Yes (c) or (p)**	**No (co) or (ca)**
5. Does the child show preferences for listening to auditory targets in a particular auditory element, such as familiarity, simplicity, sound patterns, and rhythmic patterns?		
5.1 Preference for auditory familiarity. (i.e., shows interest and identifies sounds or words that are familiar; takes the time to listen more carefully to a known voice, familiar accent, or favourite song/melody; identifies auditory targets quickly when they are familiar and accompanied by known contextual details for instance, calling of own name, own voice from recorder, music from the radio or footsteps in a room; needs less time or reaction time to notice and respond to familiar sounds or words)	**Yes (c) or (p)**	**No (co) or (ca)**

5.2 Preference for auditory simplicity. (i.e., shows interest to simple auditory targets, such as a sound that always sounds the same, such as low-tone sounds; shows clear preferences for instructions with less words or with shorter sentences; takes the time to listen more carefully to a speaker when spoken to in a slower speed/slowed speech pattern; responds to emphasised words/key words; needs less time or reaction time to notice and respond to simple and short messages)	**Yes (c) or (p)**	**No (co) or (ca)**
5.3 Preference for certain sound patterns. (i.e., consistent auditory responses to sounds of laughter, gentle sounds that evoke feelings or meaning-bearing sounds, like a dog bark, cat meow or door knock; takes the time to listen to environmental sounds in quieter places; takes the time to listen more carefully to a speaker when intonation is used, such as falling intonation in a question during a conversation; takes the time to listen more carefully to slower and clearer speech sounds)	**Yes (c) or (p)**	**No (co) or (ca)**
5.4 Preference for certain rhythmic patterns. (i.e., follows the right musical flow when humming, drumming, or clapping with others; drawn towards certain tapping sounds, lullabies, rhythmic music, or a particular part of a song; takes the time to attend carefully to slow rhythmic music or slowed-down sounds)	**Yes (c) or (p)**	**No (co) or (ca)**
6. Does the child have perceptual difficulties in identifying or discriminating certain auditory targets?		
6.1 Difficulty engaging with unfamiliar auditory items. (i.e., is less acoustic alert when a sound target is unfamiliar compared to a familiar one; shows little keenness to an unfamiliar version of a well-known sound; problems following an unfamiliar voice during social interactions/conversations; misinterprets/misunderstands the meaning of unfamiliar auditory information)	**Yes (c) or (p)**	**No (co) or (ca)**
6.2 Difficulty engaging with complex auditory items. (i.e., is less acoustic alert when a sound target is complex compared to a simple tone/non-complex sound; struggles figuring out sounds created with synthesizers: responds to single words but not when used in a long sentence; misinterprets the meaning of complex auditory information; picks up the first part of a complex verbal instruction and starts to act immediately; picks up a word but does not understand the whole sentence; often says "what" or "eh" during longer conversations or story telling; trouble grasping/comprehending longer words/information of increasing linguistic complexity)	**Yes (c) or (p)**	**No (co) or (ca)**

6.3 Difficulty attending to certain intonations or sound/words. (i.e., struggles to understand how the voice rises and falls in speech during social interactions/conversations; problem understanding speech when there is a rapid change in the intonation in the speaker's voice; trouble grasping or recognizing patterns in sound, such as rhythmic beat tracking; problems putting words and sounds together; problems understanding nuances in speech sounds during social interactions/conversations; problems putting words and sounds together; trouble noticing minor differences between words; difficulty translating a word from print to speech; trouble pronouncing a word in a different way; difficulty in comprehending multisyllabic words)	**Yes (c) or (p)**	**No (co) or (ca)**
6.4 Difficulty distinctly judging or comprehending auditory targets of sounds or words. (i.e., easily mixes up sounds that are acoustically similar; struggles figuring out a sound object until it is brought closer; trouble identifying a complete word or phrase when some parts are missing or unclear; confuses words that sound similar; skips, misses, or jumbles some of the words in a sentence)	**Yes (c) or (p)**	**No (co) or (ca)**
7. Does the child have difficulties in perceiving auditory targets in overwhelming listening conditions?		
7.1 Difficulty noticing auditory targets in conditions with excessive presence of irrelevant sounds or distracting background noise (auditory clutter). (i.e., problems focussing or separating desired sound amidst background noise; problems listening to and understanding speakers in noisy environments, such as in a busy classroom, room with loud conversations or a busy street with traffic noise; trouble listening to and understanding what other people are saying in places with reverberation or echoing noise, such as in gyms, cafeterias and auditoriums with loudspeaker echo; problems following a particular speaker`s voice/speech and filtering out others, especially in crowded scenarios with multiple speakers; struggles to follow casual conversations which hinders effective communication, especially in a crowded place brimming with multiple conversations; finds it hard to follow/comprehend what is being said which leads to communication breakdown, especially in the presence of distracting sounds)	**Yes (c) or (p)**	**No (co) or (ca)**
7.2 Difficulty perceiving less clear or muffled voices. (i.e., trouble understanding a speaker who talks less clearly, indistinctly or with a mumbled speech; problem picking up on sound cues to understand what is being said; problem understanding partially obstructed voices, such as listening to a voice through a heavy scarf or mask; problem understanding computer-generated audio input that resembles human speech; hesitates to use a synthetic voice on an electronic communication device or in a video game)	**Yes (c) or (p)**	**No (co) or (ca)**

7.3 Difficulty tracking fast-changing acoustic targets or in auditory scenes that change rapidly. (i.e., trouble detecting alterations in sound characteristics during an ongoing social interaction/conversation; problems following fast-changing auditory targets, such as sounds that change rapidly in tempo, pitch or timbre; trouble understanding rapid speech; misses important sound details in a situation of rapid auditory scene transition, such as when there is an abrupt change in the surrounding soundscape, when a new instrument/melody begins to dominate a musical piece or when hastily transitioning from a quiet to louder/noisier place or vice versa)	**Yes (c) or (p)**	**No (co) or (ca)**
8. Does the child have difficulties in sound localization in varying surroundings?		
8.1 Difficulty perceiving spatial properties of auditory items in indoor situations. (i.e., trouble locating the sound source in an indoor place, such as such as the kettle boiling, the microwave beeping, a tap running, a door closing or a loud knock on the door; problems in locating where the voice is coming from when spoken to from behind in a quiet room; problems determining/mapping the location of a sound/music source, during an indoor game or activity; difficulty judging the distance between oneself themselves and the sound target in an indoor situation)	**Yes (c) or (p)**	**No (co) or (ca)**
8.2 Difficulty perceiving spatial properties of auditory items in outdoor situations. (i.e., problems locating the sound source in an outdoor place, such as car horn honking, ambulance or police sirens, aeroplanes flying overhead, dogs barking or thunder rumbling; problems determining/mapping the location of a sound source in nature, during an outdoor activity; difficulty judging the distance between oneself themselves and the sound target in an outdoor/open air situation)	**Yes (c) or (p)**	**No (co) or (ca)**
8.3 Difficulty when navigating through different sound environments. (i.e., problems finding one`s way in a noisy environment, characterized by loud background noise; trouble decoding sounds that could help in navigation, such as sound of car or beeping at traffic light signals)	**Yes (c) or (p)**	**No (co) or (ca)**
9. Does the child have difficulties in time-based processing of a particular auditory information?		
9.1 Difficulty responding to certain auditory materials instantly (auditory response latency). (i.e., length of time/reaction time to notice and respond to an unfamiliar or complex rhythm/sequence of sounds is long, especially in overwhelming listening conditions; needs much time or reaction time to perceive and comprehend longer words/ sentences or complex verbal instructions)	**Yes (c) or (p)**	**No (co) or (ca)**
10. Does the child have difficulties paying attention in a particular auditory situation?		

10.1 Difficulty being attentive in an environment with varying auditory details/disturbances (auditory sustained/ selective attention). (i.e., fluctuations in focused attention when attending to sound details over time , for instance will react to a loud sound only after consequently encountering it for the 3rd or 4th time; difficulty sustaining concentration and maintaining overview over auditory details during continuous listening activities/games, such as during a rhyming word pair game, or story-telling; demonstrates poor attentional behaviours during continuous auditory activities, for instance, may look around or away; becomes easily captivated by irrelevant auditory elements and is unable to redirect/disengage auditory attention to relevant elements; gets easily distracted by competing auditory elements in the environment and struggles to stay on task; problems integrating multiple auditory features resulting in misinterpreting an auditory information)	**Yes (c) or (p)**	**No (co) or (ca)**
11. Does the child have difficulties remembering distinct auditory information?		
11.1 Difficulty mentally retaining auditory information (auditory working memory). (i.e., difficulty distinguishing between similar sounds or sequences of sounds, in spite of several repetitions; struggles to hold auditory information in mind and fails to immediately associate which sounds go with which words; struggles to hold auditory information in mind while simultaneously relating it to prior knowledge; trouble following verbal instructions despite repeated instructions; easily forgets various auditory information, in spite of several auditory cues/reminders; struggles to retain various auditory information that can be mentally taxing, especially when the auditory task load or demand increases; difficulty in applying learned auditory skills to novel circumstances)	**Yes (c) or (p)**	**No (co) or (ca)**
11.2 Difficulty recollecting past auditory information (auditory memory). (i.e., finds it challenging to remember multi-step auditory sequences that has been heard and shared in the past, for instance, remembering a learned task that requires a series of directions; difficulty recalling auditory information at a later time, for instance, will only pick up parts of what is being said during a lesson/conversation and will have trouble recalling this information; struggles to recollect new/novelty auditory targets in the absence of contextual details; problems reproducing distinct auditory items at a later time, such as recalling rhymes/lyrics or stories/narratives in the correct order, after a delay)	**Yes (c) or (p)**	**No (co) or (ca)**
12. Does the child lose energy and show signs of fatigue when engaging in auditory activities?		

12.1 Displays signs of auditory overstimulation/overload and listening-related fatigue (auditory fatigue). (i.e., tires easily after listening to various sound materials for a prolonged period; shows signs of auditory exhaustion by displaying auditory stimming/stereotypic behaviours, such as clicking fingers, tapping on ears, random humming, repetitive vocalisations or repeating certain phrases/words; fatigue significantly impairs concentration and auditory functions, especially in auditory cluttered environments)	**Yes (c) or (p)**	**No (co) or (ca)**

P-BAVI scoring sheet

Yes	when you can clearly (c) see or partially (p) see the behaviors/behavioral examples relevant to the item: "I clearly or partially see it"	1
No	when you cannot observe (co) or cannot assess (ca) the behaviors/behavioral examples relevant to the item: "I cannot see/notice it, or I cannot determine what it means"	0

Items no.	**BVD items**	Yes=1 No= 0	(c)/(p) or (co)/(ca)	**BAD items**	Yes=1 No= 0	(c)/(p) or (co)/(ca)
1.1	Irregular visual blink reflex			Irregular startle reaction		
1.2	Varying visual behaviours			Varying auditory behaviours		
2.1	Stares intently/avoids certain light sources			Overly focuses/avoids certain sound sources		
3.1	Difficulty looking & using hearing simultaneously			Difficulty using hearing & looking simultaneously		
3.2	Difficulty looking & tactile exploring simultaneously			Difficulty using hearing & tactile exploring simultaneously		
4.1	Difficulty responding within specific visual fields			Difficulty responding within specific auditory fields		
5.1	Preference for visual familiarity			Preference for auditory familiarity		
5.2	Preference for visual simplicity			Preference for auditory simplicity		
5.3	Preference for certain colour elements			Preference for certain sound patterns		
5.4	Preference for certain motion patterns			Preference for certain rhythmic patterns		
6.1	Difficulty engaging with unfamiliar visual items			Difficulty engaging with unfamiliar auditory items		

6.2	Difficulty engaging with complex visual items			Difficulty engaging with complex auditory items		
6.3	Difficulty attending visually to the face			Difficulty attending to certain intonations or sound/words.		
6.4	Difficulty distinctly judging visual targets			Difficulty distinctly judging auditory targets		
7.1	Difficulty noticing targets in visual clutter			Difficulty noticing targets in auditory clutter		
7.2	Difficulty perceiving a person in crowded places			Difficulty perceiving less clear or muffled voices		
7.3	Difficulty tracking fast-changing visual targets			Difficulty tracking fast-changing acoustic targets		
8.1	Difficulty perceiving spatial properties of items			Difficulty perceiving spatial properties of items/ indoors		
8.2	Difficulty finding routes in different surroundings			Difficulty perceiving spatial properties of items/outdoors		
8.3	Difficulty navigating through different surfaces			Difficulty navigating through different sound environments		
9.1	Difficulty responding to visual materials instantly			Difficulty responding to auditory materials instantly		
10.1	Difficulty being attentive in visual environments			Difficulty being attentive in auditory environments		
11.1	Difficulty in mentally retaining visual information			Difficulty in mentally retaining auditory information		
11.2	Difficulty in recollecting past visual information			Difficulty in recollecting past auditory information		
12.1	Displays visual fatigue			Displays auditory fatigue		
	Total BVD score		/25			

	Total BAD scores			/25
	Total BAVI score (BVD+BAD scores)	/50		