Article

Project Prakash: Merging Basic Science and Societal Service in Vision Research

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Abstract

For nearly 20 years, Prakash has created a humanitarian-scientific synergy by treating congenitally blind children in rural India, then following their visual development to understand how the human brain learns to see. From solving a 300-year-old conundrum to deconstructing the "critical window" of neuroplasticity, Prakash has led to new ways of thinking about development. Unfortunately, many children suffering from treatable congenital blindness around the world remain untreated due to a persistent belief that improvements are not possible past a "critical age" of 5–7 years old. Here, a review of the data identifies an urgent need to engage with stakeholders across the global medical community to disseminate Prakash's findings and overturn these entrenched dogmas. Toward that end, recent partnerships with eye-health organizations expand the reach of this approach and cultivate a cohesive global network. Prakash exemplifies both evidence-based intervention and intervention-based scientific discovery.

Keywords

Project Prakash, visual learning and development, late sight onset, sight recovery, congenital cataracts, visual plasticity, vision science and policy

Key Points

1. Many children suffer from treatable blindness since birth, often due to cataracts.
2. Vision-health organizations believe that treatment for children past the critical age of development is ineffective because the brain cannot acquire new visual skills.
3. Project Prakash treats children with congenital blindness and studies their late-age visual learning.
4. Extensive research spanning nearly 20 years has shown that the visual brain retains plasticity into early adulthood, allowing for acquisition of many skills.
5. These studies offer insights into late-age visual learning mechanisms and inform evidence-driven interventions to facilitate vision usage.
6. However, treatment provision and rehabilitation programs need to improve.
7. A global network of eye-health professionals, educators, and researchers will scale local efforts and expand research findings to benefit the children directly.

Social Media

Prakash's research challenges critical period dogmas and reveals untapped potential for late visual development. However, many children remain untreated. Collaborative efforts aim to scale research, expand treatment, and design evidence-driven rehabilitation.

Introduction

Carl Sagan once wrote: "*We live in a society exquisitely dependent on science and technology, in which hardly anyone knows anything about science and technology. This is a clear prescription for disaster… How can we decide national policy if we don't understand the underlying issues*?" (Sagan, 1990, p. 263). Sagan's stark warning is more relevant today than ever. In a society driven by information, social media, and entrepreneurship, an engaged public has the potential to push change. But to realize this potential, it is not enough for science to merely enter public discourse—it must inspire as well.

Biomedical science distinguishes between basic and applied research. The two differ in the immediacy with which they engage with real-world problems. For the public, the basic research often appears to offer no immediate benefit to humanity's well-being, which in turn dampens

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society's enthusiasm for supporting it. The long-term health of society requires changing this perception.

Recent scientific endeavors have strived to integrate fundamental research with public outreach. Notable among them is Project Prakash (www.projectprakash.org). Founded in 2004, Prakash (meaning *light* in Sanskrit) was conceived when Massachusetts Institute of Technology (MIT) neuroscientist Pawan Sinha learned of the disproportionately large burden of childhood blindness in the developing world, much of which is treatable or even preventable. Sinha, who resolved to help these children gain sight, realized that doing so would provide a unique scientific opportunity to answer foundational questions about how the human brain learns to see. Thus, Prakash was created as a model with two complementary goals, one humanitarian and the other scientific. The former delivers life-altering treatment to blind children, while the latter enriches scientific knowledge by applying rigorous methodology to study the development of their newly acquired visual skills. This approach has ignited the public's interest in a way that a study confined to the lab never could and has had far-reaching implications for answering questions that are central to scientists, philosophers, and anyone gifted with curiosity.

Prakash currently consists of a team of MIT researchers who work closely with outreach and medical personnel in India, through which 43,000 individuals have been screened; non-surgical treatment was provided for 1,500 and surgical treatment for over 500 children and young adults. This effort is achieved through a collaborative and integrated effort of the three "arms" of the foundation. A team of field workers and eye care specialists organize outreach camps in the most rural and overlooked areas of N. India. In each camp, hundreds of children are screened for any existing eye-health issues and, if need be, provided with refractive correction, eye drops, or referral for further care. In these camps, the team also identifies children with treatable blindness who are candidates for participation in the research program (following the iron rule that no child is refused treatment regardless of whether they or their caretaker wishes to participate in research). Children with treatable blindness are then brought back to the Shroff Charitable Eye Hospital in Delhi along with their families for further assessment and surgical treatment. Throughout this process, the research team works closely with both the outreach and medical teams to clearly identify and assess the visual status of children who are a good fit for research, which broadly speaking means treatable bilateral blindness since birth.

Project Prakash: Research

In 1689, British philosopher John Locke publicly wrestled with a fundamental question posed by the famed scientist William Molyneux: Would a man who was born blind and learned to distinguish a cube and globe by touch be able to name these objects by sight if his vision was restored (Locke, 1836)? Over the centuries, many speculations were offered, but in 2003, the Molyneux problem was finally tested empirically with the help of the Prakash children who had received sight-providing surgery after years of congenital blindness. In a simple "match-to-sample" experiment performed right after surgery, children who could effectively distinguish between two objects by either vision or touch alone were unable to distinguish between the objects with the other sense. This was the first ever direct answer to Molyneux's question. Even more surprising, while such cross-modal mappings were not available immediately after sight onset, the children did develop them rapidly (Chen et al., 2016; Held et al., 2011). Thus, one of the first Prakash studies paved a new way of thinking about development: despite the longstanding belief that there is a "critical period" beyond which visual learning is impossible (Wiesel et al., 1965), profound neural plasticity actually persists well into development. This study captivated the public's interest and was featured prominently in several media outlets, including the *New York Times* (Bakalar, 2011).

This deconstruction of the "developmental window" of neural plasticity spurred an in-depth research program to further test visual development after prolonged blindness, which in turn afforded more infrastructure for providing sight-restoring treatment to many more children. Scientifically, Project Prakash has been invaluable in identifying discrete constituents that make up neural processes we call *vision*. For example, the Prakash children taught us that while the developmental trajectory always unfolds the same after late sight onset, the rate of visual learning is individual to each child. Also, it turns out that not all aspects of vision are equally plastic: whereas low-level vision such as acuity and contrast sensitivity appear permanently limited by extended visual deprivation (Ganesh et al., 2014; Kalia et al., 2014a), high-order visual functions can still be largely acquired (Gandhi et al., 2015; Ostrovsky et al., 2006). The impact of these data is wide reaching: from immediate implications for treating blindness, to a changed understanding of learning processes, to the design of artificial intelligence. Throughout, the public and scientific communities have embraced the Prakash mission by offering funding, infrastructure, and expertise, which have sustained the scientific endeavor and inspired the formation of similar research models in China, Ethiopia, and Pakistan. This paper reviews some of the most significant research born out of Prakash and similar lab models on late sight onset, with the specific focus on the role of motion in acquiring visual skill late in life. The goal is to review the findings and their implications in a way that is accessible to stakeholders, including clinicians, community outreach organizations, funding mechanisms, and the public. Finally, next steps necessary to scale the efforts will be outlined—both in treatment provision and evidence-driven rehabilitation for the newly sighted.

Low-Level Aspects of Vision Remain Only Partially Plastic

A newborn begins her visual experience with extremely low visual acuity, below 20/600 (Courage & Adams, 1990; Dobson & Teller, 1978; Sokol, 1978) and well beyond the criterion for legal blindness. Over the first few months of development, the infant will achieve a stereotyped pattern of acuity improvement (Daw, 2014) until she reaches adult-like acuity around the age of 2 years old. The dogmatic view has been that low-level aspects of vision such as acuity consolidate during the critical early months and years of life, and visual plasticity (the ability to acquire new visual skill) peaks during these early sensitive periods of normal visual development. In other words, a long-held belief viewed visual learning as subject to putative critical periods, suggesting that if the brain does not receive appropriate visual input early in life, then past this period the brain would be unable to make use of the information. Indeed, studies in animals and humans have provided converging evidence that gains in visual function are minimal and deficits are most severe when visual deprivation persists beyond this early period of development (Riesen, 1950).

However, research from the authors and other labs with late-sighted children suggest a more nuanced view of early critical periods, even with respect to the low-level visual measures that are often used by clinicians as the gold-standard assessment of visual status. In fact, it turns out that children who experienced 8–17 years of visual deprivation since birth improved significantly in both contrast sensitivity (Kalia et al., 2014b; Ye et al., 2021) and visual acuity (Ganesh et al., 2014) following treatment. Counter to common belief, these visual skills developed independently of age of treatment, a proxy for years of visual deprivation (though a recent meta-analysis suggests that final post-treatment visual acuity may partially depend on the duration of visual deprivation [May et al., 2022]). Importantly, despite these impressive improvements in spatial vision, the visual acuity outcomes of late-sighted children never reach perfect 20/20 Snellen acuity levels, consistent with the idea of a critical period for high acuity vision (Maurer, 2017). Overall, nearly 20 years of care and research show that significant vision can emerge even after the putative critical period of 5–6 years old, though the degree of improvement remains variable across individuals and acuity never reaches its full potential.

These seemingly rudimentary findings have far-reaching implications. First, acuity and contrast sensitivity are the two most consistently used measures of visual status by vision-health clinicians, who often still believe that children born blind should not be treated because their improvements are likely to be hindered by putative critical periods. Second, these rudimentary aspects of vision are the building blocks of functional vision, and even partial acquisition of these processes can have far-reaching implications for facilitating the acquisition of higher-order and functional vision.

Another important aspect of processing low-level image properties is the ability to estimate the brightness of different image regions. It turns out that newly sighted children are susceptible to the classic "simultaneous brightness illusion" immediately after the onset of vision (Crucilla et al., 2016): when simultaneously presented with two identical gray dots, but such that one is placed on a dark background and the other on a light background, the children (erroneously) perceive the two dots as having different brightness. The late-sighted children's susceptibility to this illusion immediately after sight onset strongly points to innate circuitry that need not be learned through visual experience. The implication is that the critical computations underlying this percept can be useful in bootstrapping and driving downstream visual development and recognition, regardless of age of treatment, and highlights how to design effective rehabilitation strategies using visual cues that are interpretable right at the onset of visual learning. Additionally, the finding with the Prakash children led the researchers to make testable hypotheses about typical visual development: by studying normally sighted individuals using binocular displays that provide separate input to each eye, researchers discovered that eye of origin had a profound influence on the eventual brightness percept, suggesting that the mechanisms underlying these brightness percepts occur at an early processing stage that precedes the fusion of information between the two eyes. In this way, studies in newly-sighted children and studies in typically-sighted ones can prove complementary—with data from one cohort driving specific questions about the other.

While other low-level cues, such as color discrimination (McKyton et al., n.d.; Pitchaimuthu et al., 2019) and size constancy (McKyton et al., n.d.) may not be available immediately after treatment, children with late sight onset acquire these skills within months of treatment, pointing to experience-expectant processes. In other words, the neural mechanisms that support these processes are not susceptible to early visual deprivation and can remain dormant (expectant) until patterned visual input (experience) becomes available, at which point they are activated, but not fully formed until sufficient visual experience is gained. This idea is consistent with the finding that typically developing infants are born with the rudimentary circuitry that supports the development of low-level vision (Brown, 1990; Skelton et al., 2022).

Overall, convergent studies of low-level visual cues from various labs provide a nuanced picture of some circuits remaining robustly plastic despite the lack of early visual input, yet still requiring some visual experience to develop and consolidate. While dramatic improvements are possible, some mechanisms, such as visual acuity, never reach their full potential and thus do in fact appear to be tethered to critical periods. Ongoing research is investigating why, despite treatment allowing the high-resolution information to enter the eyes, the brain still seems to receive or process the information as low resolution.

Motion Processing: Integrating Spatial and Temporal Cues—Available and Essential for Early Visual Learning

Motion processing is a fundamental aspect of visual perception that plays a crucial role in organizing and understanding complex visual information in the real world. Real-world images consist of numerous regions with varying colors and luminance levels, challenging the visual system to effectively process and interpret these components. The previous section discussed how individuals who acquire sight late in life can learn to "see" and differentiate these different components, though to a sub-optimal level. Here, the question is how humans acquire coherence for meaningful percepts, given that our sensorium is inherently a "blooming, buzzing confusion," as the philosopher and psychologist William James (James, 1890) put it.

Typically developing and experienced human visual systems entail mechanisms that efficiently integrate subsets of regions into meaningful entities. These heuristics for binding different image regions together seem to emerge during early development and lead to effective parsing of meaningful information from the visual scene. Indeed, typically developing infants *segment* visual information from motion cues at least two months prior to doing so from static cues (Arterberry & Yonas, 2000; Johnson, 2003) and their *visual binding* (the ability to link spatially separated parts of a partially occluded object) is strongly driven by the common motion of those parts (Johnson et al., 2002; Kellman & Spelke, 1983). The perception of motion, or the integration of spatial and temporal changes, is therefore critical for early visual learning and serves as a bootstrapping mechanism, enabling the binding of visual elements into coherent object representations.

But what happens when the visual system is deprived of pattern information early in the developmental journey, during the period when these foundational heuristics typically develop? Investigations into the effects of early visual deprivation have shed light on the role of visual experience in temporal processing, a critical component of motion perception. Previous studies have shown that brief durations of visual deprivation followed by extended periods of visual experience result in near-normal temporal perception (Ellemberg et al., 1999). Notably, even Prakash children, whose visual deprivation extends years beyond the assumed critical periods, show remarkable improvements in temporal contrast sensitivity right at the onset of vision, and reach stability after only two months of visual experience (Ye et al., 2021). This differs from spatial contrast sensitivity, which requires extensive periods of visual experience to improve. These findings are consistent with studies in typically sighted infants, which show that temporal contrast sensitivity is quite mature early in the developmental timeline, whereas spatial contrast sensitivity is still quite poor (Braddick & Atkinson, 2009). Overall, despite visual deprivation, the circuitry supporting accurate temporal processing is mature early in development and does not require meaningful visual input to fine tune in the same way that the processing of spatial information does. In other words, unlike spatial processing, temporal processing is not experience-expectant, and the two processes do not develop in parallel.

To understand how these two cues are integrated to form coherent visual percepts, we must first better understand the acquisition of motion perception. Tests of motion coherence provide a measure of how well the visual system can detect different parts of an object or pattern as moving together, when presented within an otherwise incoherent noise pattern. It is this ability that then drives binding of object parts together into a coherent whole, and their parsing from background information (i.e., figure-ground segmentation). Previous studies found that children born with bilateral cataracts but treated within the first few months of life exhibit profound deficits in performing motion coherence tasks, despite being tested many years after treatment (Ellemberg et al., 2002; Hadad et al., 2012). In fact, both behavioral and imaging studies with individuals suffering from extended visual deprivation found poorer than typical performance on visual but not auditory motion recognition tasks when tested years after surgery (Bottari et al., 2018; Huber et al., 2019). In contrast, children who had clear vision during early infancy but then developed cataracts performed normally on these tasks, suggesting that the development of global motion mechanisms requires only short periods of visual input, but that this input must be received in early infancy. Notably, all these studies tested children only years after treatment, comparing their performance to their typically sighted peers. It is still unclear, however, how well these children do with detecting global motion right at the outset of vision, and how this ability changes, if at all, with the acquisition of visual experience. In other words, might the children in the above studies have acquired some level of global motion perception but just not reached their full potential? In recent longitudinal studies, we found that children that are unable to detect any motion coherence prior to treatment show stark improvements right at the onset of vision (i.e., with little to no visual experience), but quickly stop improving such that their final performance still falls short of their typically sighted peers (Raja et al., 2019). What these data suggest is that the onset of vision immediately makes the binding of visual information from motion available, which in turn may incentivize the system to favor the use of motion cues early in the visual journey, when visual experience is not yet available. However, the detection of motion cues does not continue to fine tune and improve as visual experience is gained, and so may not prove as useful for later more nuanced recognition that is acquired through more extensive visual experience. The exact interplay between motion and higher-level visual experience remains an open area of investigation, though a recent study showed that within a year of treatment, children with late sight onset can learn to differentiate between two shapes when viewing them through a small window that moves across the pattern (Orlov et al., 2021)—a task that specifically requires the perception of shape from temporal integration in order to recover the global spatial structure of the viewed object.

The significance of motion processing extends beyond its role in early visual learning and bootstrapping. Motion provides a foundation for acquiring higher-level object and face recognition processes. In fact, the profound significance of dynamic information processing as a building block for other visual skills explains some of the earliest observations with the Prakash children. When tested within the first month of sight, children struggled with detecting overlapping shapes or contours embedded in noise: they perceive all closed loops and regions of uniform luminance as distinct objects, leading to consistent errors of over-fragmentation (Ostrovsky et al., 2009). For instance, when viewing two overlapping squares, the visually inexperienced children consistently parsed them into three distinct objects. These difficulties have important real-life implications. For example, when three-dimensional shapes, such as cubes or pyramids, are presented with surfaces of varying luminance consistent with lighting and shadows, visually inexperienced individuals report perceiving distinct objects, one corresponding to each facet, rather than integrating the facets into the percept of a single three-dimensional object. However, incorporating motion cues into the stimuli, such as having an overlapping square and triangle move in opposite directions while maintaining some overlap, leads to instant improvements in the children's ability to perform the parsing tasks, indicating that motion provides a particularly robust cue for enabling these children to link together parts of an object into a meaningful whole. Even more interesting, when tested on the static parsing task 10–18 months following treatment, the late-sighted children performed well even without the introduction of motion cues. This indicates that during the early stages of visual learning, motion cues are instrumental for scaffolding robust representations of the visual world that later become useful for recognition even when motion cues are no longer available. Overall, these findings contribute to our understanding of how the human brain meaningfully parses natural imagery and provide valuable insights for the development of computational models of complex visual learning (Sinha et al., 2009). Importantly, by isolating cues that support visual learning at different points in the developmental timeline, we can build better assessments for predicting the longitudinal outcomes of these children, and developing cue-specific rehabilitation programs designed to capitalize on the type of information that is most beneficial at different points in visual development.

High-Level Vision for Social Functioning Is Particularly Robust for Motion-Driven Cues

As discussed in the previous section, the studies conducted by Project Prakash and similar lab models have shown that motion cues that are available at the outset of vision can play an important role for parsing visual information and establishing robust mechanisms for shape discovery. Next, consider more downstream, socially relevant aspects of high-level vision, namely, face recognition and the perception of biological motion.

Face perception is crucial for social functioning and learning, but its development occurs gradually and can be affected by visual deprivation during critical periods (Bayet & Nelson, 2020). Remarkably, even short periods of deprivation during the first few months of life have detrimental effects on face recognition abilities (Le Grand et al., 2001). Even so, certain aspects of face classification can be acquired. For example, while children with late sight onset cannot distinguish face from non-face patterns immediately, they do begin to learn this skill over the course of months after treatment (Gandhi et al., 2017), suggesting that basic face categorization can be acquired with sufficient visual experience. Interestingly, this learning is initially bottom-up and graded, meaning that patterns resembling faces to a greater degree are more likely to be identified as faces. However, given sufficient visual experience, the children transition to a more stereotypical step function, whereby they consistently reject non-faces, regardless of how face-like the pattern is. These improvements in face classification are associated with structural changes in the brain, including increased integrity of late visual pathways known to support face processing (Pedersini et al., 2023). Overall, these findings have implications for the innateness of sensitivity to faces (it seems to be experience-expectant), theories of plasticity and critical periods (some skills can be acquired even at a late age, though acquisition is protracted), and specific cues that are used for early categorization (graded to step function).

The finding that face classification is experience-expectant and can be acquired despite early visual deprivation re-opened the debate on the potential plasticity of more downstream face processes. Previous studies have found that even brief periods of visual deprivation results in compromised (less than normal) performance on a battery of face perception tasks even years after treatment (Geldart et al., 2002), with deficits persisting even into adulthood (Maurer et al., 2005). As a result, the general consensus was that early experience with faces is critical to the development of cortical regions that will support face processing throughout life (Bayet & Nelson, 2020). While it seems likely that early visual deprivation does lead to differences in the circuitry supporting face perception, ongoing longitudinal efforts try to address why some aspects of face perception may be more susceptible to early visual deprivation compared to others. For example, the finding that early visual deprivation has an unequal impact on the acquisition of different face-related tasks has led to a possible explanation for why facial identification, but not face/non-face classification, is particularly vulnerable to early visual deprivation. Rather than the period of deprivation per se, it may be the unusual visual acuity trajectory that these children experience once they gain sight that is responsible for their specific difficulties with identifying faces (Vogelsang et al., 2018). When children are treated for congenital cataracts, they experience sudden acuity improvements, such that they begin their visual journey with higher visual acuity than a typical newborn. This altered visual acuity trajectory may lead to the development of smaller windows of spatial integration, resulting in difficulties with tasks that require the integration of information over large spatial windows, such as the global processing that typically supports efficient face identification, but not face/non-face categorization. In other words, there may be clear downsides to beginning one's visual journey with higher than normal visual acuity. Consistent with this idea is data from children who experienced extremely brief periods of visual deprivation struggling with global, but not local, face recognition tasks even years after treatment (Maurer et al., 2002; Maurer & Mondloch, 2011), as well as more recent findings that early visual deprivation leads to persistent impairments in face—but not object—identification (Gilad-Gutnick et al., 2023), supposedly because objects can be individuated using local information, whereas face individuation relies on intact holistic processing. In addition to explaining the differential impairments in high-level processing that children with late sight onset exhibit, a domain-general account that explains persistent impairments in terms of acuity trajectory rather than putative critical periods also provide a foundation for possible interventions to address the observed impairments (e.g., training children with low resolution images early in the developmental trajectory may force their visual system to develop larger windows of spatial integration).

Beyond considering if and how face perception emerges following treatment for blindness since birth, ongoing work also investigates how motion cues may support high-level visual skill acquisition, particularly for skills that support social functioning. As reviewed in the previous section, motion information plays a vital role in early learning and facilitates generalization of recognition even when motion is no longer available. For example, head motion is an effective cue for gaze following in referential communication. The Prakash children, who had early visual deprivation, showed a transfer effect from appreciating the referential intent of head motion during intervention trials to interpreting static face orientation in post-intervention trials (Rubio-Fernandez et al., 2022). Motion cues also strongly facilitate basic expression recognition in children with early visual deprivation, but this facilitation only emerges months to years following sight onset, pointing to an experience-expectant process (Gilad-Gutnick et al., 2019). In contrast, recent studies have shown that the perception of biological motion, such as human movements from point-light displays, seems to be largely intact in children treated for early visual deprivation (Ben-Ami et al., 2022; Bottari et al., 2015; Rajendran et al., 2020), suggesting that the neural systems for biological motion processing may not critically depend on visual experience.

Overall, the research summarized here paints a picture of a visually inexperienced, partially plastic brain that has evolved to integrate low-level motion cues to extract high-level form perception, even from the outset of vision. Extended visual deprivation does not seem to interfere significantly with these mechanisms. Children who have experienced prolonged blindness can acquire complex visual skills, including object recognition, cross-modal matching, and visually guided social perception, within months of gaining sight. Although the mechanisms supporting visual skill acquisition may differ from typically developing peers, some aspects of low-level vision can be partially acquired even at a late age. The availability of motion cues plays a crucial role in driving the significant improvements observed in these children and can aid in their quality of life and educational potential. The mechanistic findings from these studies can inform the development of evidence-based visual and educational rehabilitation programs that directly benefit children with early visual deprivation.

Policy Implications: Extending Influence and Reach

Pediatric ophthalmologists working on the front lines of the global effort to eradicate treatable childhood blindness often ask, "What benefit is there in treating the blindness of children over 5 years old? Aren't they well past the critical period for vision?" The persistence of this question is at the heart of the continued gap between the norms driving ocular treatments provided by clinicians, and what the last 20 years of research have shown about the positive impact of ocular treatment on quality of life regardless of age (Kalia et al., 2017). Reimagining a synergic service/research model globally would allow researchers to become an integral player in the global effort to eradicate treatable childhood blindness, a key goal of VISION2020 (Gilbert & Foster, 2001) and a critical component of the United Nations' Sustainable Development Goals (Sharma, 2021).

Overcoming Limitations

In addition to scaling up the research, a global network needs to support outreach, treatment, and follow-up rehabilitation for children of all ages. Several limitations currently hinder such an endeavor, but none are unsolvable, including the following:

1. Delayed translation between research and medical treatment: The gap in communicating and translating research findings into ocular outreach and treatment provision causes delays in reaching clinicians and ophthalmologists, hindering timely intervention.

Basic scientific findings are rarely disseminated in public health forums, and despite good intentions, basic science researchers rarely have the resources or training to translate their lab-findings into concrete evidence-based rehabilitation. Improved communication and collaboration between researchers and medical professionals are vital to bridge this gap, including opportunities to attend joint conferences and publish jointly in impactful journals.

2. Lack of comprehensive field studies and follow-ups: Accurate statistics on eligible children, successful treatments and long-term outcomes are essential for improving strategies and rehabilitation programs. Gathering and analyzing these data will provide valuable insights, but this effort must be undertaken jointly by the public health experts and the vision scientists who have the foresight to assess potential limitations and prospects of studying basic visual mechanisms.
3. Fragmented efforts: Fragmentation among organizations involved in childhood visual impairment research and treatment provision hampers progress. Opportunities for collaboration, partnerships, and information exchange are necessary to effectively work toward common goals.
4. Lack of a shared database: The absence of a centralized database hinders communication, data collection, insight dissemination, and collaboration among researchers, medical professionals, and educators. Establishing a common open-source database would facilitate dynamic cooperation and training across organizations and sites and enhance the translation of research into practical solutions.
5. Limited research supporting evidence-based programs: The lack of research supporting evidence-based learning and rehabilitation programs constrains comprehensive support for visually impaired children. Investing in research initiatives would improve treatment outcomes and quality of life.
6. Limited public engagement and funding: Insufficient public engagement and funding impede efforts to address childhood visual impairments. Raising awareness among field workers directly serving underprivileged communities, engaging and recruiting young trainees across a range of fields (e.g., undergraduates in the school of science, medical school students and volunteers from the local communities) and securing adequate funding to support temporary training and outreach efforts are all crucial for driving meaningful progress.
7. Limited training opportunities for treatment providers and educators: Investing in training programs, mentorship, and educational resources is crucial to ensure a new generation of qualified professionals and sustained advancements in the field. Specifically, building a program that brings together the different expertise to build a full-circle model for research-to-treatment-to-intervention-to-research is an enormous but necessary undertaking for facilitating the rapid and practical translation of research to solution provision.

Each of these challenges can be met with appropriate resourcing, good will, and strong outreach between researchers, clinicians, and educators. By fostering better collaboration, investing in research and training, promoting public engagement, and investing in tools for sharing data across both countries and expertise, better evidence-based interventions can develop to maximize treatment outcomes and provide a brighter future for one of the most vulnerable populations in the world.

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