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REVIEW ARTICLE

Neuroeconomics and myopia prevention: A framework for public health intervention

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Abstract

Aims to outline the application of neuroeconomics in paediatric myopia prevention, offering a framework for designing public health interventions that target decision-making mechanisms such as intertemporal choice, social preferences and neurohormonal regulation. We synthesized theories and empirical evidence from neuroeconomics, psychology and neuroscience. Multimodal approaches—including behavioural tasks (e.g. delay discounting, Ultimatum Game), functional near-infrared spectroscopy (fNIRS), pupillometry and salivary assays—were used to evaluate how interventions influence neurocognitive processes. Neuroeconomic research reveals that myopia-related behaviours involve neural competition between impulsive and regulatory systems, temporal discounting of future rewards and modulation by social norms and neurohormones (e.g. dopamine, oxytocin). Intervention strategies incorporating immediate incentives, social normative feedback, environmental nudges and reduced cognitive effort show potential in promoting outdoor time and behaviour change. Neuroeconomics provides a novel framework for myopia prevention by targeting neural computation mechanisms. Future research should focus on cross-cultural and developmental validation while addressing ethical and implementation challenges to advance precise and equitable public health strategies.

KEYWORDS
myopia, neuroeconomics, prevention

1 | INTRODUCTION

The global surge in paediatric myopia has escalated into a critical public health challenge of the 21st century, particularly across East Asia where prevalence rates among teenagers frequently exceed 80% (Han et al., 2025; Holden et al., 2016; Morgan et al., 2018). This trend, increasingly observed in Europe and North America, portends a significant future burden of vision-threatening complications, including myopic macular degeneration, retinal detachment, glaucoma and cataracts, thereby elevating the risk of irreversible low vision and blindness in adulthood (Bullimore & Brennan, 2019; Haarman et al., 2020). While genetic predisposition plays a contributory role, the rapid temporal increase in myopia incidence is mainly attributed to environmental and behavioural factors (Biswas et al., 2024; Li et al., 2025). Paramount among these are prolonged engagement in near-work activities, encompassing tasks that require sustained ocular accommodation and convergence at short distances, such as reading, writing and the use of digital screens (e.g. smartphones, tablets, computers) (Huang et al., 2015; Sherwin et al., 2012). Moreover, extensive epidemiological and clinical research has consistently demonstrated that increased time outdoors, exceeding approximately 2 h per day, exerts a powerful protective effect against the onset and progression of myopia, a effect mediated in part by light-induced retinal dopamine release (Karouta et al., 2025; Martinez-Perez et al., 2025; Parssinen, 2025).

Consequently, the cornerstone of contemporary public health strategies for myopia prevention advocates for behavioural modification: promoting outdoor activity and managing near-work behaviours (Flitcroft et al., 2019; Pan et al., 2025). While certain optical interventions have also shown efficacy in delaying the onset of myopia in pre-myopic children in randomized trials (Wang et al., 2025), the primary public health focus remains on behaviour. However, the translation of this knowledge into effective, large-scale intervention has

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proven remarkably difficult. Traditional health communication campaigns, based on disseminating knowledge about long-term risks, have consistently yielded disappointing results in altering habitual behaviours (Janz & Becker, 1984; Webb & Sheeran, 2006). This failure underscores a fundamental paradox: Why do children and their caregivers, despite being aware of the potential future consequences, persistently engage in behaviours that jeopardize long-term visual health? The answer lies in the very nature of the decision-making processes involved. The benefits of compliance, forgoing immediate screen entertainment for outdoor play or maintaining correct reading posture, are distant and probabilistic, while the costs (perceived or real), such as loss of immediate gratification, social disconnection or effortful self-control, are immediate and salient (Claus et al., 2011; Scholten & Read, 2010). This tension represents a classic intertemporal choice conflict, where decisions are made between smaller-sooner rewards (screen time) and larger-later rewards (preserved eyesight) (Hayden, 2016).

This is where the emerging, transformative field of neuroeconomics offers a novel and powerful explanatory framework and toolkit. Neuroeconomics, an interdisciplinary fusion of economics, psychology and neuroscience, seeks to uncover the neurobiological mechanisms that underlie decision-making, particularly in situations involving risk, reward, uncertainty and strategic interaction (Hsu et al., 2008). It moves beyond the traditional economic model of the perfectly rational agent and instead provides a biologically grounded understanding of how cognitive and affective neural systems compete and integrate to produce actual choices (Rangel et al., 2008). The core premise of this review is that the challenges in paediatric myopia prevention are not merely educational or motivational in a general sense but are fundamentally rooted in the neurocomputational processes of valuation and choice. Therefore, overcoming these challenges requires interventions that are explicitly designed to engage with these deep-seated neural mechanisms.

Neuroeconomics provides key concepts that are directly applicable to the myopia prevention dilemma (Table 1). The dual-system theory of decision-making, for instance, posits that choices arise from the interaction between an impulsive, affective system (associated with limbic and striatal regions like the amygdala and ventral striatum) that prioritizes immediate rewards, and a reflective, cognitive control system (associated with the prefrontal cortex, particularly the dorsolateral and ventromedial regions) that supports long-term planning and self-regulation (Hare et al., 2009; McClure et al., 2004). In the context of myopia, sedentary near-work activities often provide potent, immediate stimulation to the impulsive system, while the reflective system, which is still developing throughout childhood and adolescence, may be too weak or under too much cognitive load to consistently override these impulses (Casey & Caudle, 2013). Furthermore, concepts like time discounting—the devaluation of future rewards relative to immediate ones—explain why the abstract future benefit of healthy vision is often outweighed by the concrete present benefit of a video game (Kable & Glimcher, 2007). Social preferences, such as inequity aversion and conformity, mediated by brain regions like the insula and anterior cingulate cortex, help explain how peer pressure and social norms can powerfully influence a child's decision to play indoors or outdoors (Fehr & Camerer, 2007; Sanfey et al., 2003). Finally, research on neurohormones like oxytocin (linked to trust and social bonding) and dopamine (central to reward prediction and reinforcement learning) offers insights into how social interventions and incentive structures could be biologically optimized to encourage protective behaviours (Schultz, 2002; Zak et al., 2005).

The objective of this review is to systematically bridge this theoretical gap. We propose a novel framework for applying neuroeconomic principles to the design of public health interventions aimed at curbing the paediatric myopia epidemic. While this review proposes a theoretical framework and direct evidence for its efficacy in myopia prevention is still emerging, it is grounded in robust empirical findings from behavioural economics showing that targeted incentives can modify health behaviours (Volpp et al., 2011), and from ophthalmology confirming the protective role of outdoor time against myopia onset and progression (He et al., 2015). We will argue that effective interventions must move beyond simply providing information and instead be strategically engineered to recalibrate the neurocomputational value signals that guide behaviour. This involves designing incentives that make healthy choices more immediately salient and

TABLE 1 Summary of neuroeconomics-informed intervention strategies for myopia prevention.

Intervention strategy	Neuroeconomic target	Example application	Measurable outcome (Behavioural/Neural)
Immediate Incentives (Kable & Glimcher, 2007)	Temporal discounting; dopamine	Token economy for outdoor time (e.g. points redeemable for rewards)	↑ Outdoor time (GPS data); ↑ VS activation (fNIRS)
Social group challenges (Falk & Bassett, 2017; Fehr & Camerer, 2007)	Social preferences; oxytocin	School-wide competition with public leaderboards	↑ Collective outdoor time; ↑ self-reported enjoyment
Default Nudges (Schultz et al., 1997; Zak et al., 2005)	Cognitive load; LPFC function	Automated router shut-off during evening hours	↓ Screen time (device logs); ↓ Pupillary stress response
Personalized Feedback (Hare et al., 2009; McClure et al., 2004)	Prefrontal cortex activation	App-based feedback comparing behaviour to age-based norms	↑ Awareness; ↑ PFC engagement during decision-making

Note: All examples are supported by key references from the neuroeconomics literature.

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rewarding, leveraging social norms and reputational concerns to align behaviour with health goals, and mitigating the cognitive effort required for self-control. By integrating findings from neural measurements—such as functional magnetic resonance imaging (fMRI) studies of intertemporal choice and social preference, and psychophysiological measures like pupillometry and skin conductance response—we can gain unprecedented insight into the mechanisms of intervention efficacy and failure (Falk et al., 2012). This review will explore these applications, discuss methodological and ethical considerations for researching neuroeconomics-informed interventions in paediatric populations and outline a future research agenda. Ultimately, we posit that harnessing the power of neuroeconomics is not merely an academic exercise but a necessary step toward developing the next generation of effective, biologically informed and scalable strategies to safeguard the visual health of children and adolescents worldwide.

2 | THEORETICAL FOUNDATIONS

The application of neuroeconomics to public health interventions, such as myopia prevention, is predicated on a suite of well-established theoretical constructs that elucidate the neural underpinnings of decision-making, as summarized in Figure 1. Central to this framework is the concept of intertemporal choice, which describes how individuals make trade-offs between costs and benefits that occur at different points in time. The tendency to disproportionately devalue future rewards in favour of immediate gratification is termed temporal discounting (Hayden, 2016). From a neuroeconomic perspective, this is not merely a cognitive miscalculation but a reflection of a neural competition. Neuroimaging studies have robustly demonstrated that choices for immediate rewards are associated with heightened activity in the limbic system and the ventral striatum—brain regions heavily innervated by dopamine and implicated in reward processing, incentive salience and impulsive motivation (Kable & Glimcher, 2007; McClure et al., 2004). By contrast, choices that favour delayed, larger rewards engage the lateral prefrontal cortex (LPFC) and the posterior parietal cortex, areas critical for executive functions such as cognitive control, future planning and the suppression of impulsive responses (Figner et al., 2010; Hare et al., 2009). In the specific context of myopia prevention, a child's choice to engage in screen time represents a canonical example of this neural competition. The impulsive system rapidly attributes high value to the immediate entertainment and social connectivity offered by digital devices. Concurrently, the reflective system, which is responsible for valuing the abstract and delayed benefit of 'preventing myopia in adulthood', is both developmentally immature and often cognitively depleted by other demands. Consequently, the salient, immediate reward signal often overwhelms the weaker, future-oriented one, leading to a behavioural preference for near-work over outdoor activities. The decision to engage in prolonged near-work (e.g. using a smartphone) for instant entertainment, thereby discounting the future risk of myopia, can be directly modelled as an outcome where the valuation signals in the impulsive system overwhelm the regulatory capacity of the deliberative system. This dual-system model provides a neural explanation for the limited efficacy of interventions that solely appeal to long-term health consequences; they primarily engage the reflective system without mitigating the hyperactive response of the impulsive system to immediate alternatives (Hofmann et al., 2009).

Furthermore, myopia-related behaviours are profoundly social in nature, making social preference theory another critical pillar. Children's and adolescents' choices are powerfully shaped by social norms, peer influence and concerns for fairness and reciprocity—factors that are deeply embedded in neural circuitry. For instance, the ultimatum game, a canonical experimental paradigm, has shown that people often reject unfair monetary offers at a personal cost, a behaviour associated with activation in the anterior insula (linked to negative emotional states like disgust and anger) and the dorsal anterior cingulate cortex (dACC, involved in conflict monitoring) (Civai et al., 2012; Sanfey et al., 2003). This neural response to inequity suggests that a child might reject a 'fair' health behaviour (e.g. going outdoor alone) if it is perceived within their social context as an unfair deviation from the group's norms (e.g. all friends

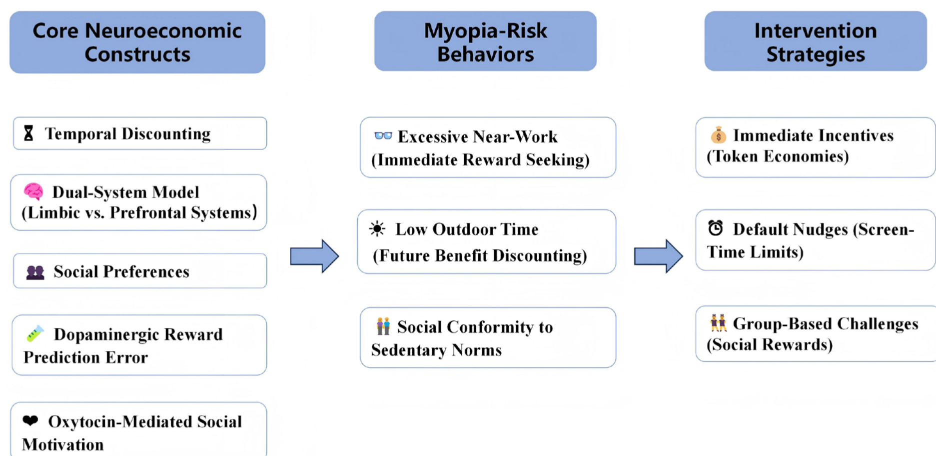

FIGURE 1 Theoretical framework: Linking neuroeconomic constructs to myogenic behaviour and intervention targets.

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are indoors gaming). Conversely, cooperative and prosocial behaviours are reinforced by the brain's reward system. Acts that align with social norms or elicit trust activate the ventral striatum and the septal area, generating a intrinsic reward signal that reinforces the behaviour (Fehr & Camerer, 2007; Rilling & Sanfey, 2011). Therefore, an intervention that successfully frames outdoor time as a socially cohesive, normative and fair activity within a peer group can tap into these reinforcement learning mechanisms. As illustrated in Figure 2, a specific example of this is a wearable sensor-based token economy system that provides immediate social-comparison feedback and rewards. Such a system makes the healthy choice not just a prudent one but a socially rewarding one.

Beyond the neural systems for valuation and sociality, neuroeconomics also investigates the role of specific neurochemical mechanisms that modulate these circuits. Dopamine, a key neurotransmitter, is fundamental to reinforcement learning and the encoding of reward prediction errors—the difference between expected and actual rewards that drives learning (Schultz et al., 1997). This mechanism is crucial for habit formation; the immediate rewards of digital entertainment efficiently reinforce sedentary habits through precise dopaminergic signalling. As highlighted in Figure 2, a well-designed token economy can emulate such immediate reward delivery, activating the ventral striatum and reducing delay discounting, thereby promoting increased outdoor time and slowing axial elongation. Critically, the ultimate biological pathway through which these neurobehavioral interventions exert their effect is the well-established myopia suppression mechanism: Increased light exposure stimulates retinal dopamine release, which in turn inhibits axial elongation, the key structural change in myopia progression (Morgan et al., 2018). Our framework targets the upstream decision-making process to naturally activate this downstream biological pathway. On the contrary, the neuropeptide oxytocin has been shown to enhance trust, generosity and social bonding by modulating activity in the amygdala (a key region for processing fear and social threat) and the prefrontal cortex (Baumgartner et al., 2008; Zak et al., 2005). This suggests that interventions fostering trust and positive social bonds between parents and children, or within peer groups, could leverage the oxytocin system to reduce the perceived 'social risk' of adopting new health behaviours and increase the reward value of shared outdoor activities. The endocrinological perspective thus moves beyond a purely cognitive model of behaviour change, suggesting that biochemical interventions (e.g. through activities that naturally elevate oxytocin) could potentially lower the neural barriers to adherence. Together, these core neuroeconomic concepts—intertemporal choice driven by competing neural systems, social preferences embedded in specific circuits and behaviour modulated by neurohormones—provide a multi-level, biologically grounded framework for deconstructing the decision-making failures that underpin the myopia epidemic. This framework does not simply describe behaviour but points directly to actionable neural and psychological targets for intervention.

3 | APPLICATION SCENARIOS

Building upon the neuroeconomic framework of decision-making, we can now delineate a series of targeted, mechanism-based intervention strategies for myopia prevention. These strategies are designed to consciously manipulate the neural computations of value, social preference and reward prediction to make protective behaviours more appealing and effortless. A primary application lies in the strategic design of incentive schemes. Traditional advice like 'spend more time outdoors' imposes an immediate cost (forgoing screen time) for a distant benefit. Neuroeconomics suggests transforming this dynamic by embedding immediate, tangible rewards into the decision structure. For instance, a token economy system could be implemented via a digital platform where children earn points or micro-payments (a proximal, certain reward) verifiably linked to outdoor time measured by wearable GPS or light sensors (Loewenstein et al., 2013; Patel et al., 2015). This approach is not predicated on the assumption that outdoor activity is inherently aversive, but rather acknowledges that in modern environments, the immediate and potent rewards of digital entertainment can outcompete the often more abstract and delayed rewards of outdoor play. The token economy serves to temporarily 'bridge the temporal gap' and recalibrate the value signal, making the initial choice to go outdoors more salient. Over time, the goal is for the intrinsic rewards of outdoor play, such as enjoyment, mastery and social connection, to take over as the primary reinforcer, a process that can be facilitated by these very interventions. The seminal work by Volpp et al. on financial incentives for weight loss and smoking cessation demonstrates that

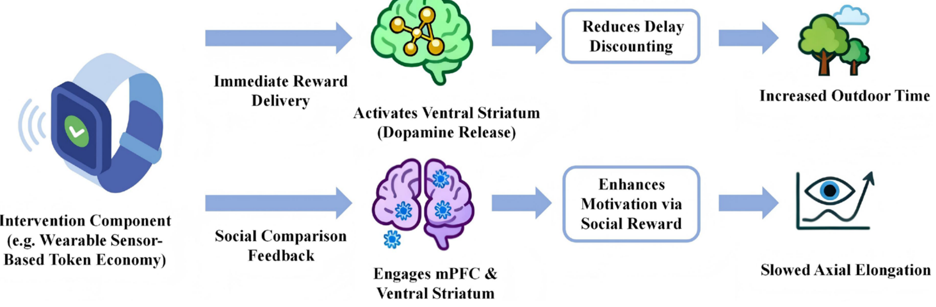

FIGURE 2 Mechanisms of a neuroeconomics-informed intervention for increasing outdoor time.

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such deposits-based contracts, which leverage loss aversion, significantly improve outcomes (Volpp et al., 2011). Applied to myopia, a child's own modest monetary deposit (or one made by a parent) could be returned or multiplied contingent upon achieving weekly outdoor time goals, thereby making the potential loss of the deposit a potent immediate motivator that activates neural circuits associated with risk and loss avoidance.

Furthermore, the powerful influence of social preferences must be harnessed rather than overcome. Interventions should be designed to shift perceived social norms and leverage the intrinsic reward value of conformity and fairness. This can be achieved through group-based challenges in schools or communities, where rewards are contingent on collective performance (e.g. a class-wide average of 2 hours of daily outdoor time) (Kullgren et al., 2014). Such a design taps into the neural mechanisms for cooperation and collective identity, making compliance a socially reinforcing behaviour that activates the ventral striatum (Falk & Bassett, 2017). Moreover, providing children and parents with feedback on their performance relative to a normative group (e.g. 'Your family is in the top 10% for outdoor time in your city') can exploit the brain's inherent sensitivity to social comparison and status, engaging regions like the medial prefrontal cortex (Meshi et al., 2015). Digital platforms can further amplify this by creating shared, positive social experiences around outdoor activity, using gamification elements like team competitions and leaderboards. This transforms a solitary chore into a socially engaging mission, mitigating the activation of the anterior insula that might be associated with feeling excluded or 'missing out' on indoor social activities. In Figure 3, the core neurocognitive mechanism underlying these interventions involves a shift in behavioural motivation: from passive, screen-based engagement that primarily stimulates the limbic system, toward active outdoor activities that engage the prefrontal cortex and activate adaptive neural pathways. This conceptual model highlights how targeted incentives and social strategies can functionally reorient value computation and reinforce self-regulatory processes.

Finally, neuroeconomics advocates for interventions that reduce the cognitive burden on the fragile executive control system. The necessity for constant self-control depletes cognitive resources, leading to failure (Muraven & Baumeister, 2000). Therefore, the most effective interventions are those that make the healthy choice the default or easier choice, thereby minimizing the need for effortful self-regulation. While our framework focuses on the child's decision-making, the role of parents and schools as architects of the child's choice environment is paramount. Neuroeconomic principles can be extended to guide parental and institutional responsibility. For instance, pre-commitment devices can be used by parents to set automatic screen-time limits on home routers, effectively making reduced near-work the default option (Rogers & Bazerman, 2008). Schools can redesign the choice architecture by integrating outdoor learning sessions and providing engaging playgrounds, thereby reducing the cognitive effort required for children to choose outdoor over indoor activities. Involving these key stakeholders transforms the intervention from a child-centric struggle to a system-wide support structure (Kuang et al., 2023). These strategies work by reducing the activation of the ventral striatum in response to cues for sedentary behaviour and by lowering the cognitive load on the LPFC needed to resist temptation. Similarly, pre-committed plans leverage the neural preference for routine and default options, bypassing the cognitively taxing process of deliberative choice each time (Rogers & Bazerman, 2008). By aligning public health strategies with the automatic, heuristic-based processes of the brain, we can design environments where the healthy choice becomes the path of least resistance, sustainably preserving children's visual health through effortlessly better decisions.

4 | METHODOLOGICAL APPROACHES

The rigorous development and validation of neuroeconomics-informed interventions necessitates a multi-methodological approach. While large-scale implementation may ultimately rely on scalable digital tools, initial proof-of-concept studies require deep mechanistic validation to ensure interventions are targeting the intended neural processes. This entails employing a suite of behavioural tasks, physiological measures and neuroimaging techniques to objectively quantify the mechanistic impact of an intervention on the targeted decision-making processes. Firstly, behavioural economic tasks provide a validated and scalable tool for assessing individual differences in the cognitive traits underlying myopia-risk behaviours. A temporal discounting task, for instance, can be administered to children to derive a quantitative discount rate (k-value)

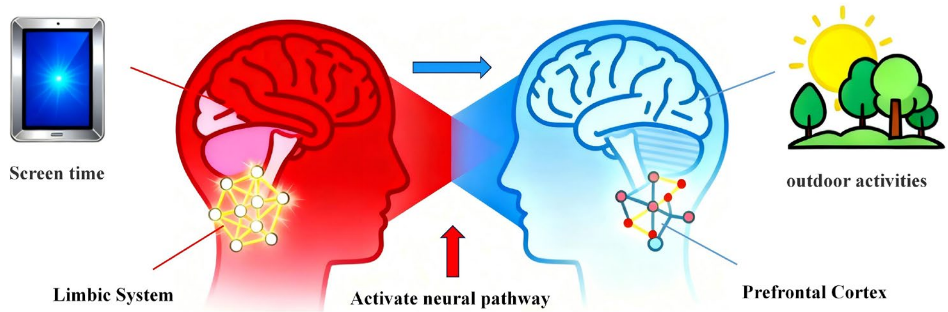

FIGURE 3 Neurocognitive shift from screen time to outdoor activities through limbic and prefrontal engagement.

that captures their propensity to devalue future rewards (Epstein et al., 2014). A high *k*-value, indicating strong preference for immediate gratification, could serve as a predictive biomarker for poor adherence to outdoor time recommendations. Similarly, tasks measuring risk aversion (e.g. lottery choices) and social preferences (e.g. a child-adapted Trust Game or Ultimatum Game) can identify subgroups for whom specific intervention components (e.g. guaranteed vs. probabilistic incentives; individual vs. group-based rewards) would be most effective (Falk et al., 2011; Fehr & Camerer, 2007). These behavioural assays provide a crucial link between theoretical constructs and real-world behaviour, allowing researchers to stratify participants and personalize intervention strategies based on their cognitive phenotype.

To capture the subconscious and automatic neural responses that often precede deliberate choice, physiological and neuroimaging methods are indispensable. Functional near-infrared spectroscopy (fNIRS) is particularly well-suited for paediatric neuroeconomic research due to its high tolerance to motion, portability and relatively low cost (Piper et al., 2014). An fNIRS study could measure hemodynamic activity in the prefrontal cortex (PFC) of children as they view stimuli promoting sedentary (e.g. a new video game) versus active outdoor activities. A successful intervention designed to enhance cognitive control should manifest as increased PFC activation when resisting sedentary temptations, providing a neural correlate of its efficacy (Falk & Bassett, 2017). Furthermore, eye-tracking and pupillometry offer non-invasive and highly precise measures of attention and cognitive effort. For example, measuring pupil dilation (a reliable indicator of cognitive load and affective arousal) while children make decisions about screen time can reveal whether an intervention reduces the internal conflict associated with choosing the healthier alternative (Laeng et al., 2012). These tools can be deployed in real-world settings, such as schools or homes, to provide ecologically valid insights into the decision-making process as it unfolds.

To objectively quantify the key behavioural risk factors for myopia, wearable devices like smart watches or companion sensors could be used to estimate near-work duration via proximity sensing or inertial measurement units that detect a sustained, static head-down posture typical of reading and screen use (Hartwig et al., 2011; Liang et al., 2024). Combining this with ambient light sensing creates a comprehensive digital phenotype of high near-work/low outdoor light exposure, which stands in contrast to the desired profile of low near-work/high outdoor light exposure. This dual-parameter approach provides a richer basis for just-in-time adaptive interventions than either measure alone. Finally, integrating biological sampling into study designs allows for the investigation of neuroendocrinological pathways. Salivary assays to measure cortisol levels can objectively quantify the stress associated with behaviour change (e.g. the stress of device separation), while measuring oxytocin levels before and after a family-based outdoor activity intervention could provide a biological basis for enhanced social motivation and bonding (Grewen et al., 2005; Van IJzendoorn & Bakermans-Kranenburg, 2012). Crucially, the combination of these methods will yield a powerfully comprehensive model of how and why an intervention works. This multi-level assessment framework is essential for moving from merely demonstrating efficacy to understanding the precise mechanisms of behaviour change, thereby enabling the iterative optimization of neuroeconomics-informed strategies for protecting childhood vision.

5 | CHALLENGES AND ETHICAL CONSIDERATIONS

The translation of neuroeconomics into public health practice, particularly within the sensitive domain of paediatric myopia prevention, is fraught with significant methodological and ethical complexities that must be rigorously addressed. A primary challenge concerns the developmental trajectory of the paediatric brain. The neural circuits central to neuroeconomic models—especially the prefrontal regions governing cognitive control and future planning—undergo profound maturation throughout childhood and adolescence (Casey et al., 2005). This necessitates that interventions and measurement tools are meticulously tailored to be age-appropriate. A behavioural task or neuroimaging protocol validated in adults may not accurately capture the decision-making processes of a younger child, whose cognitive capacities and neural responses are still in flux. Consequently, longitudinal studies are imperative to track how the efficacy of a specific intervention (e.g. a certain incentive structure) might evolve as children's brains develop, ensuring that strategies remain effective across different age groups (Steinberg, 2008).

Beyond methodological hurdles, the deployment of neuroeconomic interventions raises profound ethical dilemmas. The most pressing concern is that of informed consent and assent. Given the complex and sometimes covert nature of nudges and neural manipulations, obtaining truly informed consent from parents and meaningful assent from children is challenging. Participants must fully understand that interventions are designed to subconsciously alter their value computations and behaviours, which goes beyond the transparency typically required in clinical research (Blumenthal-Barby & Burroughs, 2012). This is further complicated when using neuroimaging (e.g. fNIRS) or physiological monitoring in minors; the potential for coercion, even if unintentional, must be vigilantly guarded against.

The collection of highly sensitive neurological and behavioural data introduces serious privacy and security risks. A child's brain activation patterns, cognitive biases and genetic predispositions constitute exceptionally personal information. The misuse or breach of such data could lead to social stigmatization or discrimination in the future (Illes & Bird, 2006). Robust data anonymization protocols and secure storage solutions are non-negotiable, and policies must clearly define who can access these data and for what purposes, strictly limiting its use to the stated research objectives.

Furthermore, there is a tangible risk of exacerbating health inequities. Neuroeconomics-informed

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interventions, particularly those leveraging wearable technology and digital platforms, may be more readily adopted by families of higher socioeconomic status, potentially widening the disparity in myopia prevalence across social strata (Halpern et al., 2012). If financial incentives are used, their motivational value may be disproportionate across income levels, raising questions of fairness and distributive justice. Therefore, a critical ethical imperative is to design interventions that are accessible, effective and equitable across diverse populations.

Finally, the very goal of manipulating decision-making for a child's 'own good' ventures into ethically ambiguous territory. While the intention—preserving eyesight—is unequivocally beneficial, the means involve deliberately bypassing rational deliberation to influence choices subconsciously. This prompts a essential debate on autonomy and paternalism: Where is the line between legitimate public health nudging and an unethical manipulation of a developing mind? (Wilkinson, 2013). Furthermore, the risk of external rewards undermining intrinsic motivation requires careful consideration. Over-reliance on tangible incentives could potentially diminish a child's inherent enjoyment of outdoor play. To mitigate this, interventions should be designed with a 'fading' strategy, where tangible rewards are gradually replaced by social reinforcement and opportunities for self-monitoring and mastery. The ultimate goal is for the intrinsic rewards of outdoor activity, such as fun, autonomy and social connection, to become the primary motivator, with the initial extrinsic reward serving merely as a catalyst to overcome decision-making inertia. This approach also guards against the risk of creating excessive dependency on external rewards, which could otherwise compromise the development of genuine internal motivation for healthy behaviours. Consequently, a crucial ethical imperative is to design interventions that not only demonstrate short-term effectiveness but also actively promote long-term autonomy and sustainable habit formation, ensuring both the means and ends remain ethically justified.

6 | FUTURE DIRECTIONS

Future research must prioritize a translational agenda that moves from mechanistic proof-of-concept studies to scalable public health implementation. An essential direction involves developing developmentally-stratified interventions. For younger children (e.g. under 8 years), whose prefrontal regulatory systems are still maturing, strategies should emphasize environmental nudges and parent-led routines. For school-aged children, immediate token economies and peer-group challenges can effectively leverage their increasing sensitivity to social rewards and fairness. For adolescents, interventions could incorporate goal-setting apps and appeal to autonomy and identity, aligning with their advanced but still developing cognitive control and self-concept (Chen et al., 2025; Crone & Dahl, 2012). Building on this developmental framework, a critical next step is the development of personalized intervention strategies based on individual neurobehavioral phenotypes. Research should investigate whether children with high temporal discounting rates or specific neural activation patterns respond more favourably to certain incentive structures (e.g. immediate versus delayed rewards, guaranteed versus probabilistic) (Onnela & Rauch, 2016). This precision public health approach, leveraging biomarkers from tasks and wearable sensors, could maximize efficacy and resource allocation.

Furthermore, the integration of digital health technologies presents a fertile ground for innovation. Longitudinal studies are needed to explore the use of smartphone-based ecological momentary assessment (EMA) to capture real-time decision contexts (e.g. location, social setting, mood) that precipitate risky near-work behaviours, allowing for the development of just-in-time adaptive interventions (JITAIs) that deliver personalized nudges at moments of high vulnerability (Nahum-Shani et al., 2018). Finally, the cross-cultural validation and equitable implementation of these strategies are paramount. Research must test whether the neural mechanisms and intervention efficacy generalize across diverse cultural contexts with varying norms around parenting, play and education. We must develop low-cost, low-tech versions of interventions (e.g. group-based rewards not reliant on personal wearables) to ensure accessibility and prevent the exacerbation of health inequities, especially in low-resource settings. This imperative is further underscored by variations in myopia prevalence across different regions (e.g. East Asia and the West) and across varying levels of urbanization (e.g. highly urbanized vs. rural settings). It is also amplified by divergent cultural attitudes, including prevailing educational philosophies, differing parental perceptions of risk and benefit, and contrasting social norms around leisure and academic work, all of which require more granular investigation. It is therefore imperative to investigate whether the neural mechanisms underpinning relevant decision-making are universal or culturally modulated (Henrich et al., 2010). This line of inquiry must explicitly examine how environmental factors such as access to green space, educational pressure and local behavioural norms shape the drivers of near-work and outdoor behaviour. For example, in rural settings where outdoor time is often integral to daily life, interventions could focus less on incentivizing 'going outdoors' and more on reducing competing indoor attractions. Conversely, in dense urban areas with limited outdoor space, strategies may need to address the perceived opportunity cost of outdoor time and leverage localized social influences. Research must therefore test the efficacy and neural correlates of such interventions across urban–rural and socioeconomic spectra to ensure that neuroeconomics-informed strategies are both equitable and globally applicable—ultimately fulfilling their potential to help curb the myopia pandemic.

7 | CONCLUSION

Neuroeconomics provides a transformative framework for understanding and addressing the behavioural components of the myopia pandemic. By moving beyond traditional models of rational choice, it illuminates the

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neural and computational mechanisms that underlie decisions favouring immediate screen-based gratification over long-term visual health. This review has argued that effective interventions must be strategically designed to target these mechanisms—recalibrating value signals, leveraging social rewards and reducing cognitive effort. While significant ethical and methodological challenges remain, integrating neuroeconomic insights into public health strategies offers a promising pathway to develop more effective, scalable and personalized interventions for preserving the vision of future generations.

AUTHOR CONTRIBUTIONS

Conception and design: Chen-Wei Pan and Dan-Lin Li. *Analysis and interpretation*: Dan-Lin Li. *Data collection*: Dan-Lin Li. *Drafting of the manuscript*: Dan-Lin Li and Ting-Han Guo. *Critical revision of the manuscript*: Ting-Han Guo, Andrzej Grzybowski and Chen-Wei Pan. *Overall responsibility*: Chen-Wei Pan.

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