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Physiological impacts of neurochemical regulation by vision in rats

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ABSTRACT

The neurochemical pathways play a crucial role in the central nervous system, transmitting signals and regulating motor, sensory, and visual processes, thereby facilitating receptor function in the human body. However, the impact of neurochemicals, such as glycine, glutamate and serotonin on neuro-receptive actions on vision remains unclear. Thus, this study evaluated the effects of light patterns on neurochemicals. Adult male rats were randomly assigned to 4 groups (n = 6) and exposed for 8 weeks. Group 1 received no exposure (control). Group 2 – total darkness, group 3 – tonic light, and group 4 – rhythmic light 24 h per day. Behavioural tests (for short-term memory and motor functions) – the walk-beam, the rotating wheel and the novel object recognition tests were done. Thereafter, the levels of glycine, glutamate and serotonin in the prefrontal cortex and cerebellum were assayed. We found that the tonic light exposure showed a significant ($p < 0.05$) increase in the levels of prefrontal cortical and cerebellar glycine, leading to increased circadian locomotor activity, recognition memory and enhanced motor coordination compared to control, unlike those associated with total darkness. Tonic light also reduced glutamate and serotonin levels in the prefrontal cortex and cerebellum by 20-30% compared to controls, while total darkness significantly ($p < 0.05$) increased glutamate and serotonin levels in these brain regions. These changes were modulated by rhythmic light relative to tonic light or total darkness. Our study demonstrates that different light conditions influence neurochemical release in the retina, particularly with tonic light reducing glutamatergic and serotonergic transmission, thus preventing damage to the retina in rats.

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Keywords

Glycine, Glutamate, Retina, Glutamate, Serotonin

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Introduction

Neurochemical regulation plays a central role in the physiology of vision, with glycine, glutamate, and serotonin being key mediators of synaptic signalling across the retina and associated cortical regions (Connaughton, 2020; Kolb, 2020; Reggiani *et al*., 2022). Glycine is a multifunctional neurotransmitter that operates as both an inhibitory regulator and a co-agonist of the N-methyl-D-aspartate (NMDA) receptor, thereby shaping excitatory glutamatergic transmission (Stroebel *et al*., 2021; Zafra *et al*., 2021). In the retina, glycine is widely released by amacrine cells to fine-tune inhibitory signalling, sharpen visual contrast, and regulate circadian input to higher-

order visual centres (Joachimsthaler *et al*., 2023; Yan *et al*., 2020; Graham and Wong, 2024). This dynamic role positions glycine as a critical modulator of retinal and cortical activity, particularly under varying light conditions (Sabbagh *et al*., 2021; Di Berardino *et al*., 2025). Additionally, the role of serotonin as an important neuromodulator in the visual pathway has been reported. Serotonin plays an important role in visual orientation processing from the retinal level to cortical integration relevant to specific behaviour and motion detection (Gu and Singer, 1995; Dickson *et al*., 2009). Furthermore, glutamate, an important amino acid metabolite and an excitatory neurotransmitter in the central nervous system, also plays important roles in the stimulation of visual ganglion cells and drives light response in the retina from photoreceptors (Bannai *et al*., 2020; Boccuni *et al*., 2022). Previous studies have shown that alterations in extracellular glutamate are commonly found in several transgenic animal models of eye disease, characterised by structural and functional defects (Majumdar *et al*., 2023), necessitating the need to study the levels of these neurotransmitters following exposures to different light types.

Light exposure directly influences neurotransmitter release in the retina and downstream neural circuits, impacting locomotor behaviour, cognition, and emotional regulation (Chen *et al*., 2021; Di Berardino *et al*., 2025). Constant or tonic light exposure has been shown to elevate glycinergic activity while simultaneously suppressing glutamate and serotonin release, thereby protecting retinal function and improving motor coordination (Zafra *et al*., 2021; Joachimsthaler *et al*., 2023). In contrast, prolonged darkness enhances glutamatergic and serotonergic signalling, which may induce excitotoxic stress, impair circadian regulation, and negatively affect visual processing (Strac *et al*., 2016; Puledda *et al*., 2023). Rhythmic light exposure, mimicking natural cycles, appears to balance these neurotransmitter shifts and preserve visual integrity (Lunn *et al*., 2019; Pandi-Perumal *et al*., 2020). Beyond the retina, glycine modulates activity in the cerebellum and prefrontal cortex regions critical for motor control, attention, memory, and stress regulation (Stroebel *et al*., 2021; Luo *et al*., 2021). These brain areas form interconnected networks in which neurochemical shifts triggered by light conditions can alter both physiological and behavioural outcomes, including non-spatial and motor behaviour. Glycine has also been shown to influence stress-adaptive mechanisms in prefrontal circuits, further linking sensory-driven neurotransmission to cognitive regulation (Stroebel *et al*., 2021; Luo *et al*., 2021). However, the impact of glycine's neuro-receptive actions on vision remains unclear.

While the effect of bright light (around 460-480 nm)-induced neurochemical release is known to influence alertness, visual attention, and adaptation (Gambichler *et al*., 2002; Blume *et al*., 2019), the simultaneous role of glycine, serotonin, and glutamate on the effect of light on cognitive and motor coordination remains unclear. Given that lights modulate various photoreceptors involved in visual orientation, we hypothesise that altered levels of glycine, serotonin, and glutamate in the synaptic cleft could contribute to the development of visual pathways that influence cognitive and motor coordination behaviour in response to light sensitivity. Thus, this study investigated the neuro-receptive functions of glycine, serotonin and glutamate under different light environments, offering essential insights into the regulatory mechanisms that integrate vision, motor activity, and cognition.

Materials and Methods

Experimental animals

Twenty-four adult male Wistar rats (150–250 g) were obtained from the Animal Unit of the Faculty of Basic Medical Sciences, Delta State University, Abraka. Rats were housed in standard cages under controlled conditions (22 ± 2°C, 50–60% humidity) with a 12 h light/dark cycle during a 2-week acclimatisation period with undisturbed access to food and water. All procedures adhered to ethical guidelines approved by the Animal Ethical Committee, Delta State University (RBC/FBMC/DELSU/24/367).

Experimental design

Rats were randomly assigned to four groups (n=6 per group). Group 1 (control) was maintained under a standard 12 h light/dark cycle. Group 2 (total darkness) was exposed to continuous darkness for 24 h/day. Rats in group 3 (tonic light) were exposed to continuous light (200 lux) for 24 h/day. Lastly, Group 4 (rhythmic light) was exposed to a 12 h light (200 lux)/12 h dark cycle for 8 weeks. To be sure of the rats' feeding when exposed to a dark-light environment, our preliminary study revealed that darkness does not affect rats' ability to navigate and locate food in a dark environment, as rats are known to have excellent low-light vision due to their rod-dominated retinas and highly sensitive whiskers (vibrissae) and food smells (Adibi, 2019).

Behavioural assessments

Behavioural tests were conducted 30 min after the 8 weeks of exposure to evaluate memory and motor coordination, as these are influenced by neurochemical changes in the prefrontal cortex and cerebellum (Ben-Azu *et al*., 2018). The tests were performed in the order presented on the same day.

Novel object recognition test (NORT)

The NORT assessed short-term recognition memory, as described by Amenotie *et al*. (2025), and was conducted for a non-spatial memory test. The apparatus consisted of an open-field arena (60 × 60 × 40 cm) with a flat floor and opaque walls to prevent escape. Two objects with distinct shapes, textures, and colours were used. A video tracking system (EthoVision XT, Noldus, Netherlands) recorded behaviour. Briefly, rats were habituated to the empty arena for 10 min/day for 2 days. On the test day, rats were placed in the arena with two identical objects (familiarisation phase) and allowed to explore for 5 min. After a 1 h interval, one familiar object was swapped with a novel object, and rats were reintroduced for another 5 min exploration phase. We then recorded the time spent with the new object. The discrimination index (DI) was

calculated as follows: DI = (Time with novel object – Time with familiar object) / Total exploration time (Amenotie *et al*., 2025).

Beam walking test

The beam walking test was used to assess motor coordination and balance, as previously described (Omorogbe *et al*., 2018). The apparatus was a narrow wooden beam (1.5 cm wide and 1 m long, elevated 50 cm above a padded surface). A goal box (20 × 20 × 20 cm) at one end motivated crossing, and a 200 lux light at the start was used to encourage movement toward the dark goal box, and the data were collected through video recording. Rats were trained over 3 days (3 trials/day) to cross without falling, starting from the beam and crossing within 60 s. On test days, three trials per rat were recorded, including foot slips and crossing latency. Trials ended if the rat fell or took over 60 s. Average foot slips and latency were calculated, assessing motor impairments possibly linked to neurochemical changes in the cerebellum and prefrontal cortex (Omorogbe *et al*., 2018).

Rotating wheel test

We conducted a rotating wheel test using an acrylic running wheel with a diameter of 55 cm and a width of 15 cm, as previously described (Chen *et al*., 2016). At the end of the 8-week exposure, animals were trained for 6 min at 30 rpm by 8 am. Thereafter, the tests were conducted on the treadmill for another 6 min, with a 5 h interval at 1:00 pm. Trials were terminated after 5 min or when the rat fell.

Sample collection

After the last behavioural tests, rats were anaesthetised with ketamine (50 mg/kg, i.p.) and euthanised via cervical dislocation. The brain was excised, and the prefrontal cortex and cerebellum were isolated on a cold ice tray, homogenised with 1 mL of phosphate buffer solution (PBS), and centrifuged at 10,000 rpm for 10 min at 4°C and stored at -20°C for subsequent assays, following methods outlined by Chen *et al*. (2023).

Biochemical assays

Biochemical assays quantified glycine, glutamate, and serotonin levels in homogenised prefrontal cortex and cerebellum tissues using enzyme-linked immunosorbent assay (ELISA) kits (Abcam, UK) and colorimetric assays, following manufacturer protocols. Tissue homogenates were prepared in phosphate buffer solution, and protein content was determined using the Bradford assay (Ben-Azu *et al.,* 2019).

Biochemical assay of glycine levels

Glycine levels were measured using a commercial ELISA kit (Cat. No. ab282902, Abcam, UK), which employs a competitive binding technique. In this technique, glycine in the sample competes with a glycine conjugate for antibody binding sites, producing a colorimetric signal inversely proportional to glycine concentration, as per the manufacturer's protocols. Absorbance was read with a microplate reader (Bio-Rad, USA). Briefly, homogenised tissue (prefrontal cortex, cerebellum, retina; 100 µL) was added to a 96-well plate pre-coated with anti-glycine antibodies. Standards and samples were incubated with glycine conjugate for 1 hour at 37°C. After washing with PBS, a horseradish peroxidase (HRP)-conjugated secondary antibody was added and incubated for 30 min at 37°C. Following additional washes, 100 µL of tetramethylbenzidine (TMB) substrate was added, and the plate was incubated for 15 min in the dark. The reaction was stopped with 100 µL of stop solution, and absorbance was measured at 450 nm using a microplate reader. Glycine concentrations were calculated from a standard curve and normalised to tissue protein content.

Biochemical assay of glutamate levels

Glutamate levels were quantified using a commercial ELISA kit (Cat. No. ab287801, Abcam, UK), based on the competitive binding of glutamate in the sample with a glutamate conjugate, producing a colorimetric signal (Chen *et al*., 2023). Homogenised tissue (100 µL) was added to a 96-well plate pre-coated with anti-glutamate antibodies. Standards and samples were incubated with glutamate conjugate for 1 h at 37°C. After washing with PBS, HRP-conjugated secondary antibody was added and incubated for 30 min at 37°C. Following washes, 100 µL of TMB substrate was added, incubated for 15 min in the dark, and stopped with 100 µL of stop solution. Absorbance was measured at 450 nm with a microplate reader (Bio-Rad, USA), and glutamate concentrations were calculated from a standard curve, normalised to protein content.

Biochemical assay of serotonin (5-HT) levels

An enzymatic assay was used to quantify 5-hydroxyindole-3-acetic acid (5-HIA), which is formed when 5-HT is converted to 5-HIA by monoamine oxidase (MAO) (Fernández-Pastor *et al*., 2020). Thus, 5-HT levels were quantified using a commercial ELISA kit (Cat. No. ab133053, Abcam, UK), which employs a competitive binding technique where serotonin in the sample competes with a serotonin conjugate for antibody binding sites, producing a colorimetric signal inversely proportional to serotonin concentration (Ben-Azu *et al*., 2018). This method was chosen for its high sensitivity and specificity in detecting serotonin in neural tissues compared to enzymatic assays. Similarly to the other preparations and procedures, serotonin concentrations were calculated from a standard curve and normalised to tissue protein content based on the manufacturer's protocol.

Statistical analysis

Data were analyzed using GraphPad Prism version 9.0 (GraphPad Software, USA). Results were expressed as mean ± standard error of the mean (S.E.M.). One-way analysis of variance (ANOVA) followed by Tukey's post-hoc test was used to compare neurochemical levels (glycine, glutamate, serotonin, and xanthine oxidase) and behavioural outcomes (beam walking, rotating wheel, and novel object recognition) across the four experimental groups (control, total darkness, tonic light, and

rhythmic light). Statistical significance was set at $p < 0.05$.

Results

Bright and rhythmic short-term memory light exposure improves short-term memory

As shown in Figure 1, rats exposed to tonic light spent significantly more time exploring the novel object compared to the rhythmic light, control, and total darkness groups ($p < 0.05$). Rhythmic light exposure moderately increased novel object exploration compared to control ($p < 0.05$). By contrast, total darkness produced no significant improvement over control, indicating impaired memory performance relative to tonic light.

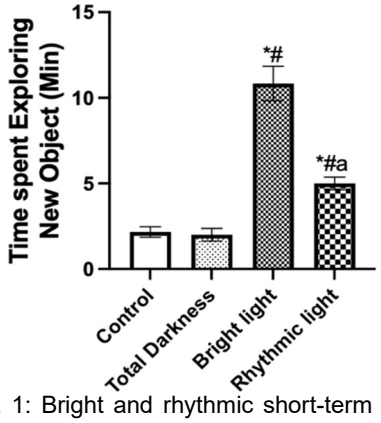

Fig. 1: Bright and rhythmic short-term light exposure improves short-term memory. Data represent mean ± S.E.M. (n = 6). One-way ANOVA with Bonferroni post hoc test. *p < 0.05 vs. control; [a]p < 0.05 vs. tonic light; #p < 0.05 vs. total darkness.

Tonic light and rhythmic but not total darkness improve motor coordination

Beam walking performance, as shown in Figure 2, was significantly influenced by light exposure. Rats exposed to tonic light exhibited the highest motor coordination scores ($p < 0.05$ vs all groups). Rhythmic light exposure also improved performance compared to total darkness ($p < 0.05$), but to a lesser extent than tonic light. Rats in total darkness displayed impaired motor coordination relative to all other groups.

Tonic light increases locomotor activity in circadian locomotor activity using the walking beam test

The result of the rotating wheel test is presented in Figure 3. Circadian locomotor activity differed significantly across light exposure groups. Rats exposed to tonic light demonstrated a marked increase in locomotor activity compared to the control, rhythmic light, and total darkness groups ($p < 0.05$). Conversely, rats exposed to total darkness showed a significant reduction in locomotor activity compared to all other groups ($p < 0.05$). The rhythmic light group showed intermediate activity, indicating a modulatory role relative to tonic light and darkness.

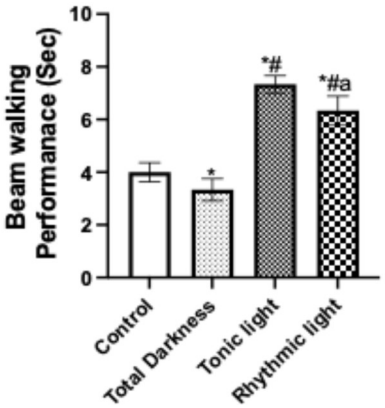

Fig. 2: Tonic and rhythmic lights improve motor coordination in the motor coordination test, but not total darkness. Data represent mean ± S.E.M. (n = 6). One-way ANOVA with Bonferroni post hoc test. *p < 0.05 vs. control; [a]p < 0.05 vs. tonic light; #p < 0.05 vs. total darkness.

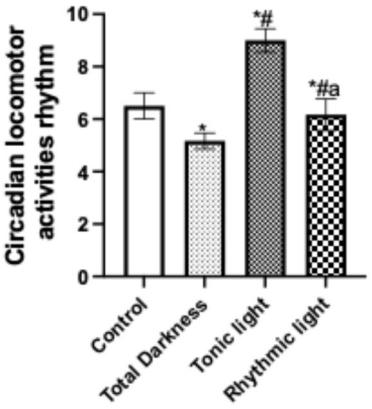

Fig. 3. Tonic light increases locomotor activity in circadian locomotor activity using the rotating wheel test. Data represent mean ± S.E.M. (n = 6). One-way ANOVA with Bonferroni post hoc test. *p < 0.05 vs. control; [a]p < 0.05 vs. tonic light; #p < 0.05 vs. total darkness.

Effects of different light patterns on serotonin levels in the prefrontal cortex and cerebellum

Serotonin levels are presented in Figure 4a–b. Rats exposed to total darkness showed significantly elevated serotonin levels in both the prefrontal cortex and cerebellum compared to controls and other light conditions ($p < 0.05$). In contrast, tonic light exposure significantly decreased serotonin levels in these brain regions ($p < 0.05$), while rhythmic light maintained values between the tonic and darkness groups. This suggests that tonic light suppresses excessive serotonergic transmission, which may protect against stress-induced neural changes.

Effects of different light patterns on glutamate levels in the prefrontal cortex and cerebellum

Figure 5a–b shows glutamate levels. Total darkness induced a significant increase in glutamate concentrations in both the prefrontal cortex and cerebellum ($p < 0.05$). Tonic light exposure, in contrast, produced a significant reduction in glutamate levels compared to control and darkness ($p < 0.05$). Rhythmic light again exerted an intermediate effect, moderating excitatory activity without the extremes observed in tonic or dark conditions.

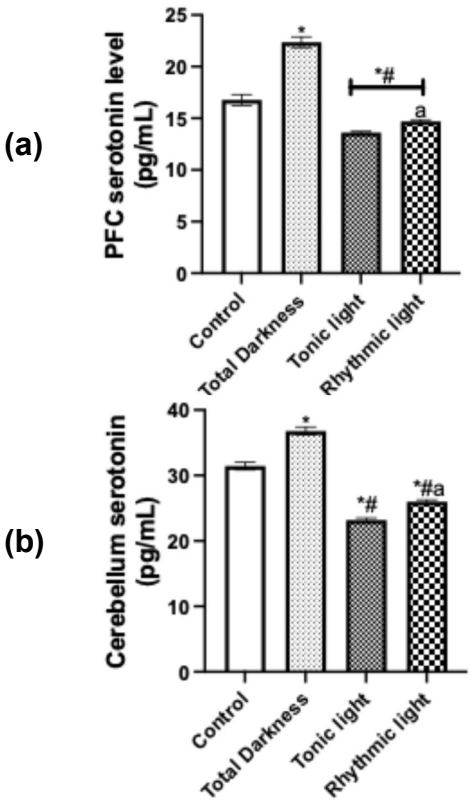

Fig. 4: Effects of different light patterns on serotonin levels in rat prefrontal cortex (PFC) (a) and cerebellum (b). Data represent mean ± S.E.M. (n = 6). One-way ANOVA with Bonferroni post hoc test. *p < 0.05 vs. control; ᵃp < 0.05 vs. tonic light; #p < 0.05 vs. total darkness.

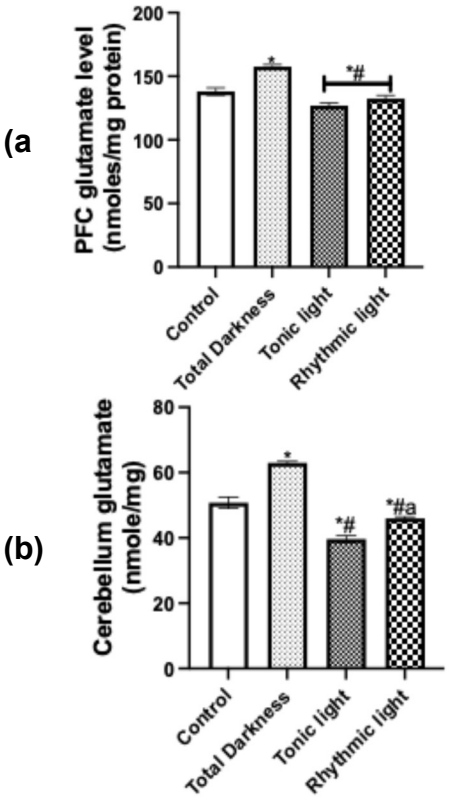

Fig. 5: Effects of different light patterns on glutamate levels in rat prefrontal cortex (PFC) (a) and cerebellum (b). Data represent mean ± S.E.M. (n = 6). One-way ANOVA with Bonferroni post hoc test. *p < 0.05 vs. control; ᵃp < 0.05 vs. tonic light; #p < 0.05 vs. total darkness.

Effects of different light patterns on glycine levels in the prefrontal cortex and cerebellum

The glycine levels are presented in Figure 6a–b. Rats exposed to total darkness showed a dramatic reduction in glycine levels in both the prefrontal cortex and cerebellum compared to controls ($p < 0.05$). Conversely, tonic light exposure significantly increased glycine concentrations in these regions relative to control, darkness, and rhythmic light groups ($p < 0.05$). Rhythmic light produced a moderate increase, indicating a partial enhancement of glycinergic transmission.

Discussion

The present study investigated the effects of different light exposure patterns – tonic light, rhythmic light, and total darkness – on circadian locomotor activity, motor coordination, short-term memory, and neurochemical levels, such as serotonin, glutamate, and glycine, in the prefrontal cortex and cerebellum of rats. The rotating wheel test demonstrated that tonic light exposure significantly increased circadian locomotor activity compared to control, rhythmic light, and total darkness groups, while exposure to total darkness markedly reduced activity.

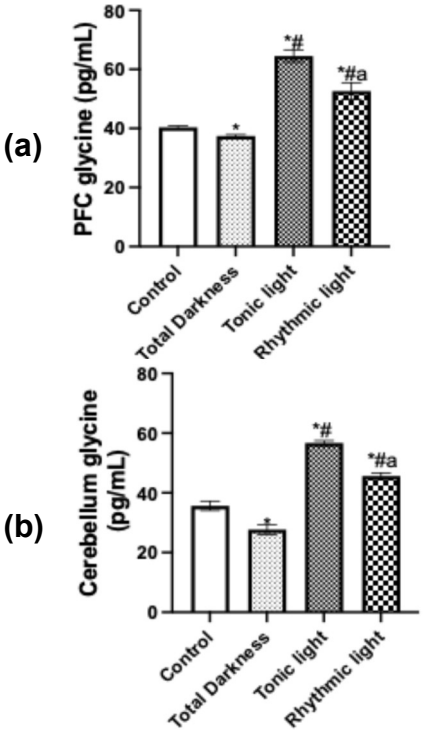

Fig. 6: Effects of different light patterns on glycine levels in rat prefrontal cortex (PFC) (a) and cerebellum (b). Data represent mean ± S.E.M. (n = 6). One-way ANOVA with Bonferroni post hoc test. *p < 0.05 vs. control; a p < 0.05 vs. tonic light; #p < 0.05 vs total darkness.

These results align with previous findings showing that blue light exposure (465–475 nm) enhanced the robustness of circadian locomotor rhythms in aged rats by strengthening superchiasmatic nucleus (SCN) signalling, confirming that consistent light exposure reinforces circadian entrainment (Silva *et al*., 2023) and impacts psychophysical activity (Ohwin *et al*., 2024). Similarly, LeGates *et al*. (2012) reported that aberrant light schedules, such as constant darkness, disrupt circadian locomotor rhythms in mice by desynchronising SCN activity, leading to reduced activity levels. The intermediate effect of rhythmic light in our study suggests a modulatory role, potentially balancing photic stimulation with periods of darkness to maintain circadian alignment without overstimulation, consistent with studies showing that cyclic light-dark schedules stabilise circadian rhythms (Fonken *et al*., 2016).

The beam walking test, a widely used behavioural assay to assess motor coordination and balance in rodents, measures the time taken and the number of foot slips while traversing a narrow beam, providing a sensitive index of fine motor control and sensorimotor integration (Carter *et al*., 2020). The test revealed that tonic light exposure significantly enhanced motor coordination, followed by rhythmic light, while total darkness impaired performance. These findings are consistent with a study by Huang *et al*. (2025), who demonstrated that prolonged exposure to blue-enriched light improved motor function recovery in 1-methyl-4-phenyl-1,2,3,6-tetrahydropyridine (MPTP)-induced Parkinsonian rats, potentially through modulation of dopaminergic and glycinergic pathways. Additionally, it is demonstrated that chronic exposure to chronic dim light at night altered motor coordination in mice, linking circadian disruptions to impaired motor performance (Bedrosian *et al*., 2011). The enhanced motor coordination under tonic light in our study may be attributed to increased glycine levels, which stabilise inhibitory neural circuits involved in motor control. The impaired coordination in total darkness aligns with evidence that a lack of visual input reduces sensory feedback to motor circuits, disrupting balance and coordination (Angelova *et al*., 2023). Rhythmic light's moderate effect suggests partial restoration of motor function, likely due to periodic light exposure supporting neural synchronisation.

The NORT, a widely used behavioural assay to evaluate short-term recognition memory in rodents, measures the time spent exploring a novel object versus a familiar one, with a higher novel object exploration time indicating better memory performance (Lueptow, 2017). This test is critical for assessing cognitive function, particularly hippocampal-dependent memory, and is valuable for studying the effects of environmental factors like light on neuroplasticity. In the NORT, tonic light exposure significantly improved short-term memory, with rhythmic light showing a moderate effect and total darkness showing no improvement over controls. These results resonate with findings by Shang *et al*. (2020), who reported that bright light exposure (1000 lx) enhanced spatial memory in rats by modulating hippocampal neuroplasticity. Similarly, Campbell *et al*. (2023) demonstrated that light exposure, particularly in the blue spectrum, improved cognitive performance in rodents via non-visual retinal pathways. The superior memory performance under tonic light may be linked to increased glycine levels, which modulate NMDA receptor activity, a critical mechanism for memory consolidation (Kenney and Manahan-Vaughan, 2013; Bannerman *et al*., 2019). The lack of improvement in total darkness supports findings who showed that long-term darkness induces dementia-like cognitive deficits in rats through oxidative stress and circadian misalignment (Sharma and Goyal, 2020). Rhythmic light's intermediate effect suggests a balanced modulation of neurochemical pathways, supporting memory without excessive photic stimulation.

One important contribution of this study was the need to investigate the simultaneous roles of glycine, serotonin, and glutamate on the effect of light on cognitive and motor coordination following exposure to various light intensities. Hence, the neurochemical analyses from our study revealed that total darkness increased serotonin and glutamate levels while decreasing glycine levels, whereas tonic light reduced serotonin and glutamate and increased glycine. However, rhythmic light produced intermediate effects. These findings provide relevant preclinical evidence for the use of various light intensities in the modulation. These support previous studies demonstrating light-dependent modulation of neurotransmitter levels in the brain and retina, although not in the context of cognitive and motor function. Given that lights modulate various photoreceptors involved in visual orientation (Bannai *et al*., 2020), it is not surprising to observe that altered levels of glycine, serotonin, and glutamate in the synaptic cleft could influence cognitive and motor coordination behaviours in response to light sensitivity. This conclusion is based on the role of these various neurotransmitters in regulating cognition and motor functions (File *et al*., 1999; Ben-Azu *et al*., 2018, 2023). Although previous reports show that neurochemical release influences alertness, visual attention, and adaptation (Gambichler *et al*., 2002; Blume *et al*., 2019), no study has shown the specific concentrations of these neurochemicals modulating these functions in response to rhythmic, tonic, or total darkness. For instance, Huang *et al*. (2020) reported that prolonged darkness elevated serotonin and glutamate in the rat hippocampus, potentially due to reduced photoreceptor input to non-visual pathways. Conversely, tonic light exposure was shown to enhance glycine release in retinal amacrine cells, aligning with increased inhibitory signalling (Sabbagh *et al*., 2021). Additionally, rhythmic light has been associated with balanced neurotransmitter dynamics, producing moderate effects on serotonin and glutamate compared to constant light or darkness (Fisk *et al*., 2018). These findings align with a study by González *et al*. (2017), which further supports the role of light in modulating neurochemical profiles. For glutamate, previous studies have reported that light deprivation in rats with depression-like behaviour increased prefrontal glutamate levels, reflecting heightened excitatory transmission under stress (Huang *et al*., 2025). In this study, the reduction in glutamate under tonic light may protect against excitotoxicity, consistent with find-

ings that light exposure stabilises glutamatergic signalling in the retina and brain (Chou and Porciatti, 2019). Regarding glycine, while direct studies on light effects are limited, a recent study by Zhang *et al*. (2018) used optical sensors to monitor hippocampal glycine levels, highlighting its role in modulating inhibitory neurotransmission, which could be influenced by visual inputs (Zhang *et al*., 2018). The elevated serotonin and glutamate in total darkness may reflect a stress response, as high corticosterone levels have been linked to increased excitatory transmission (Popoli *et al*., 2011). The increase in glycine under tonic light is particularly significant, as glycine enhances inhibitory neurotransmission and NMDA receptor function, which may contribute to improved motor coordination and memory.

While these findings emphasise the critical role of light in modulating neurochemical and behavioural outcomes through the visual system, the limitations of the study do not allow us to correlate the outcomes. Further studies are recommended to provide molecular evidence of this modulatory potential in various light types. However, the protective effects of tonic light against excessive serotonergic and glutamatergic transmission suggest potential therapeutic applications in neurodegenerative conditions such as Alzheimer's and Parkinson's diseases, which are associated with memory and motor impairments (Videnovic *et al*., 2014). Darkness effects highlight light cues' importance for circadian and cognitive health, as human studies link circadian misalignment to cognitive deficits (Chellappa *et al*., 2011; Wright *et al*., 2024). Rhythmic light's intermediate effects indicate a balanced approach to light exposure, guiding lighting design in controlled environments to enhance physiological health.

Conclusion

This study demonstrates that different light patterns significantly influence glycine, glutamate, and serotonin levels in the prefrontal cortex and cerebellum, affecting visual perception, motor coordination, and memory performance. The novelty of this study provides preclinical evidence that rhythmic, tonic, and total darkness affect cognitive and motor coordination through mechanisms involving modulation of glycine, glutamate, and serotonin in neuro-receptive systems functions. These findings have major implications for non-pharmacological interventions for neurodegenerative conditions such as Alzheimer's and Parkinson's diseases, which are associated with memory and motor impairments.

Declaration

Acknowledgement

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Conflict of interest

None declared.

Ethical approval

All experiments were approved and conducted in accordance with the guidelines established by the Faculty of Basic Medical Sciences at Delta State University's Animal Ethics Committee (RBC/FBMC/DELSU/24/367), as well as the National Institutes of Health Guide for the Care and Use of Laboratory Animals (Publication number: 85-23, revised) (1985).

Authors' contribution

Conceptualisation: EPO, OOO, and BZO; data curation: EPO, OOO, GO and OSA; writing original draft preparation: EPO, GO, MO; review and editing: EPO, MO, BBA, OMO, VE; Supervision: EPO, OOO; funding acquisition: TETFUND grant. All authors have read and agreed to the publication of the manuscript.

Availability of data and material

Available upon reasonable request.

Consent to participate and publish data

Not applicable

The use of generative artificial intelligence

Not applicable

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