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# Using Eye Tracking as a Functional Biomarker for Schizophrenia: A Scoping Review

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**Abstract:** Abnormalities in eye movements have been identified as a reliable functional biomarker for schizophrenia, but have not been widely applied in clinical practice. The aim of this study is to review the current literature in order to identify the new unexplored areas of eye tracking methodology. A literature search was followed PRISMA-ScR guidelines and was conducted by using the eLibrary, PubMed, CNKI, and Google Scholar databases in December 2025. The results are summarized according to the main approaches. In the Free viewing paradigm: patients have a reduced number of fixations, longer fixation durations, and a narrower scan path, often focusing on non-important details. In the Smooth pursuit eye movement paradigm: patients demonstrate significant impairment characterized by increased velocity errors and frequent "catch-up" saccades. In saccadic tasks: deficits are observed both in prosaccade (increased latency, reduced accuracy) and antisaccade (significantly increased error rates) tasks. Neuroimaging studies have identified a correlation with dysfunctions in the prefrontal cortex, frontal eye fields, parietal lobes, and cerebellum. These disturbances have been linked to impairments in attention, working memory, and cognitive processing speed. The application of advanced statistical analyses and artificial neural networks has shown a high degree of accuracy in distinguishing patients with schizophrenia from healthy individuals, with reported accuracy rates reaching up to 90%. Therefore, eye tracking is a valid method for identifying oculomotor biomarkers of schizophrenia. However, the dynamics of changes in eye movement in schizophrenia and under the influence of various therapeutic agents are poorly understood.

**Keywords:** schizophrenia, eye tracking, biomarker, endophenotype

## 1. Introduction

In today's digital age, with the integration of new technologies, the range of applications for various devices is increasing, including in the field of diagnosing mental health conditions [1, 2]. Among these techniques, eye tracking has become particularly prominent. Originally developed for fundamental research conducted by neuroscientists, this method has seen a recent increase in applications in clinical settings, particularly in the field of clinical neuroscience [1]. This method involves recording a subject's eye movements and analyzing these micro-movements. It helps determine the focal point of sensory-perceptual activity, study attention, and identify factors that attract a person's gaze in experimental settings. Additionally, it allows us to examine how these factors affect visual perception. Beyond neurophysiology, this method has applications in neuromarketing, education, neurological disease diagnosis, rehabilitation, psychological training, sports, and related fields [3].

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In recent years, there has been a significant increase in the number of important studies on eye movements in various mental health conditions. The potential of eye tracking for the diagnosis and treatment of autism spectrum disorder [4, 5], attention deficit hyperactivity disorder [6, 7], bipolar disorder [8], Parkinson's disease, and other neurological conditions [9, 10].

Eye tracking is a unique area of interest in the diagnosis of schizophrenia [11]. Individuals with this disorder often experience disturbances in cognitive functions, such as abnormal thought processes, disorganized thoughts, and perceptual failures that can manifest as hallucinations. This condition can also lead to impairments in attention, memory, and visual-spatial abilities. As the disorder progresses, patients often experience a loss of motivation, a decrease in emotional responsiveness, and changes in behavior that may be seen as inappropriate by society [12]. This phenomenon contributes to the persistence of disability in patients. The implementation of new, objective methods for diagnosing and assessing mental status could significantly improve the effectiveness and starting time of therapeutic interventions for these patients, leading to a reduction in the incidence of disability. All of this emphasizes the importance of studying eye movement disorders in this condition.

The changes in eye movement patterns in patients with schizophrenia have long been the subject of academic discussion. Preliminary clinical observations have revealed a unique behavior pattern of these patients. Specifically, these empirical observations noted that the patient's gaze appeared to "look through" their talking partner, while a healthy individual's focus remained on the nose of the person they were conversing with. Subsequent analysis using more precise instrumental techniques confirmed these initial findings. Neurophysiological studies have shown that people diagnosed with schizophrenia have impaired visual information processing. The findings from eye-tracking studies are more likely to be a result of objective brain dysfunction than subjective personal responses [13].

In the past five years, researchers have been focusing on synthesizing knowledge about the potential of eye tracking in various disorders. Changes in eye movement patterns have been considered a transdiagnostic marker for attention impairments [13]. The paradigm of research into eye movement patterns is seen as a distinct approach to scientific work [14]. At the same time, the last scoping assessment of the potential of eye tracking as a biomarker for abnormalities in schizophrenia took place in 2021 [11]. In recent years, there have been major developments in the fields of machine learning and artificial intelligence. These developments have had a significant impact on the area of eye tracking.

The aim of this study is to review the current literature on eye-tracking research in order to identify the new, unexplored areas of this methodology, which hinder the further implementation of this technique in practical medical and psychological settings.

To achieve this goal, the following research questions have been identified:

1) What experimental paradigms and methods are used to measure eye movement responses in individuals with schizophrenia?
2) What neurophysiological and psychological changes are associated with changes detected through eye-tracking technology?
3) Which machine learning and artificial intelligence techniques are used to precisely analyze eye-tracking data?
4) What specific findings are necessary to integrate eye tracking into routine clinical practice?

## 2. Materials and Methods

The review was conducted in accordance with the guidelines of the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses), which were modified for the purpose of the scoping review [15]. The study protocol was not publicly available. No changes were made to the protocol during the course of the study.

### 2.1. Criteria for inclusion

The publication presents the results of an experimental study or review, the research includes analysis of eye-tracking methods to identify functional biomarkers in schizophrenia, the study involved human participants, and the full text of the article is available in English or Russian.

### 2.2. Criteria for exclusion

The criteria for exclusion include unpublished papers, preclinical studies using only animal models, the absence of a patient group diagnosed with schizophrenia by psychiatrists, a lack of a complete eye-tracking experimental protocol, and the unavailability of the article's full text.

### 2.3. Information search strategy

We conducted a review of publications from the eLibrary, PubMed, CNKI, and Google Scholar databases. The search was carried out in December 2025. The following query was used: "eye tracking AND schizophrenia," "oculomotor reactions AND schizophrenia," and "eye tracking for schizophrenia patients". We also used the corresponding phrases in Russian for Russian-language sources.

### 2.4. Source selection

Source selection was carried out in two stages. In the first stage, we screened the selected databases and selected relevant publications based on keywords and abstracts. This work was done by one author (D.K.), who consulted with other authors when some decisions were unclear. In the second stage, two co-authors (I.F. and A.F.) reviewed the articles selected by the first author and checked them for compliance with the inclusion criteria.

We did not limit the time frame for selecting articles, but we focused mainly on works published within the last five years. Although many fundamental works have not lost their relevance over time, we also included more recent studies to ensure that we were up-to-date with the latest developments in eye-tracking research and to understand the current state of the field.

### 2.5. Data extraction process

Data extraction was performed by one author (I.F.) and then verified by another (A.F.). The following data were extracted for analysis: authors, year of publication, study design, psychopathological conditions studied, sampling methods, participant characteristics, eye-tracking paradigms, and results.

### 2.6. Critical assessment of sources and synthesis of results

No critical analysis of the sources was conducted. The data extracted from the selected references were organized into thematic categories. No statistical methods were used to analyze the results.

After the initial stage of the selection process, a total of 489 articles from eLibrary, 1185 publications from PubMed, 19 from the Chinese CNKI database, and 12 from Google Scholar were included in the final set (Figure 1). A significant number of these articles focused on the subject of eye-tracking methodology and the technical equipment used. After carefully reviewing the full-text articles, 42 publications were chosen for the final analysis.

## 3. Results and Discussion

### 3.1. General information about eye movement disturbances

Since the early 20th century, researchers have been studying the characteristics of eye movement in patients diagnosed with schizophrenia. In 1908, the first study examining eye movement in these patients was published. Since then, additional studies have compared groups of healthy individuals with patients. As technology has advanced, so has the precision of measurements, and this trend is expected to continue in the coming decades [16].

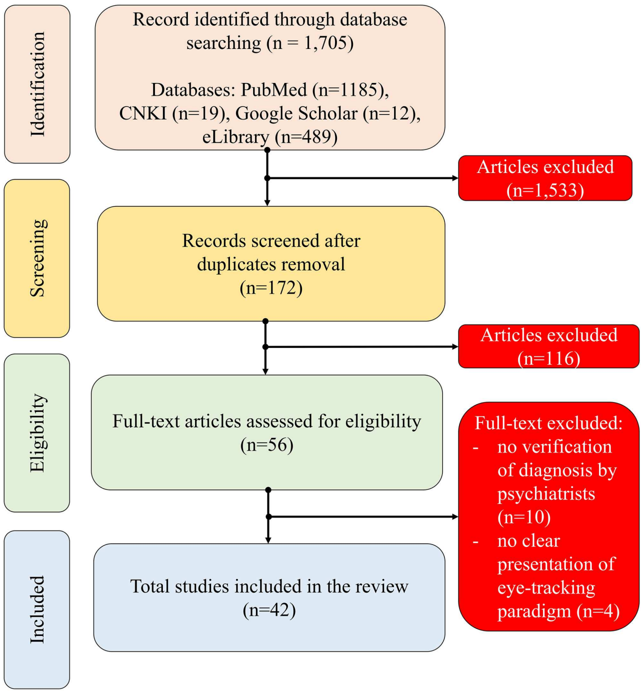


**Figure 1. The flow diagram of selecting literature in accordance with the PRISMA-ScR guidelines**

Eye movements are the result of a complex interaction between several brain regions, including the visual cortex (occipital lobe), quadrigeminal region, brainstem with three oculomotor nerve centers, cerebellum, and frontal lobe. These regions can inhibit reflexive eye movements when cognitive control is present [17, 18].

In addition to eye movements, changes in the peripheral component of the visual system – the eyeball – have been frequently documented in patients with schizophrenia. Visual abnormalities have been identified as an important indicator of the progression of this disorder. Disruptions in the structure and function of the retina and difficulties in information processing may indicate the presence of pathological changes in brain tissue. The retina is a significant diagnostic tool, as it is an embryonic extension of the brain. Therefore, it can be used to indicate pathological processes in the brain in patients with schizophrenia [19].

The limited analytical capacity of the visual cortex gives rise to the idea that human visual perception is influenced by conscious and unconscious filters. The initial recognition of objects, including colors, shapes, and orientations, is assisted by the bottom-up perception, which is closely linked to disturbances in eye movement responses in patients with schizophrenia. These patients experience difficulties focusing on visual stimuli [20].

## 3.2. The methodology for studying eye movement reactions

A comprehensive review of the existing literature reveals several key aspects of the eye movement system, which form the basis for designing eye-tracking experiments.

1) Smooth pursuit eye movement (SPEM) is a process that allows us to track moving objects. Our eyes constantly change position, so the object we are looking at is projected onto the center of our vision, where we can see it best. This ability develops gradually in children and reaches its full potential around the age of two, continuing to improve until adulthood. This mechanism relies on the collaboration of specific oculomotor brain regions [21, 22].
2) Gaze fixation system. It has been defined as the absence of eye movement while tracking a stationary object. This process involves actively suppressing the desire to track unnecessary objects, allowing only minor micro-movements. The frontal eye movement centers, parietal lobes, and specific brainstem nuclei have all been identified as playing a crucial role in this process [23].
3) Saccades. These are rapid movements of the eyes toward a moving object, followed by fixing the gaze on that object. The purpose of this process is to anticipate movement and prepare for it. This function requires voluntary attention and is only partially under voluntary control. Saccades are measured in terms of their direction relative to the movement of the object, their speed, the latency of the reaction, and their accuracy. Anti saccade tasks are used to elicit the suppression of the desire to follow the movement with the eyes. This phenomenon indicates an individual's ability to exercise restraint over their spontaneous oculomotor responses. When observing objects, a typical subject will make three to four saccades per second, with an inter-saccadic interval ranging from 300 to 400 milliseconds [24].

The following experimental paradigms are used to study eye movement responses:

1) Free viewing of natural images

A technique that assesses the positions of gaze fixation, the sequence of shifts in focus, the duration of fixation on different areas, and the distances between these foci. These factors indicate the disturbances of attention. In contrast to healthy individuals, patients diagnosed with schizophrenia have a reduced number of gaze fixations and saccades, as well as longer fixation durations and larger saccade amplitudes (see Table 1 for details).

**Table 1. Experiments to assess the eye movement responses of patients diagnosed with schizophrenia when presented with static images**

| Experiment title | Experiment description | Measured parameters | Differences between schizophrenic patients and healthy controls |
|---|---|---|---|
| Fixation stability | Fixation of gaze on a stationary object for a specified period of time | The number of microsaccades, the distance from the target (drift distance), and fixation stability | Patients with schizophrenia have a high fixation instability and an increase in the number of microsaccades [10, 25] |
| Free viewing | Free viewing of images or photos that may be difficult to understand | Fixation time at each point, number of areas searched during the examination (adaptive search width), and fixation time in each zone | Patients with schizophrenia have a smaller adaptive search width, focus on unusual and insignificant points, and longer fixation [26–28] |

2) The evaluation of tracking moving objects

This method focuses on three key aspects of oculomotor behavior: tracking accuracy, the nature of corrective saccades, and the latency before the start of movement. The use of an antisaccade task, which requires the active suppression of eye movements in the direction of an object and the subsequent direction of gaze, helps to evaluate voluntary control over eye movements. Patients with schizophrenia, regardless of the treatment they receive, as well as their first-degree relatives, demonstrate significant impairments in the ability to follow smooth motion. This has been considered a specific endophenotypic marker. Their eyes lag behind the moving object, and they make many errors in the antisaccade test (see Table 2).

**Table 2. Experiments to evaluate eye movement impairments while tracking moving objects**

| Experiment title | Experiment description | Measured parameters | Differences between schizophrenic patients and healthy individuals |
|---|---|---|---|
| Prosaccade task (PS) | The participant's eyes are fixed on the center of the screen. When a dot suddenly appears on the edge of the screen, they are required to move their eyes to that dot, i.e., make a saccadic movement | The latency of the response is measured to be between 70 and 90 milliseconds after the stimulus is presented, and an "express saccade" occurs, which is a reflexive reaction. Then, at 200 milliseconds, the primary saccade happens, showing a greater dependence on cognitive processes. Additionally, it is possible to measure the peak velocity of the eye movement and the accuracy of the movement | There is an increase in latency, a decrease in accuracy (hypo-metric), and impaired accuracy. These deviations correlate with working memory impairments [24] |
| Antisaccade task (AS) | The subject is required to keep their gaze centered on the screen, but when a stimulus appears on the periphery, they must consciously move their eyes in the opposite direction. This is known as an antisaccade, and it requires the inhibition of a reflex called the prosaccade. This reflex is controlled by the prefrontal cortex, which inhibits the movement of the eyes. The success of the experiment depends on the ability to inhibit this reflex | The following parameters are measured: latency, error rate (in cases where the direct saccade was not inhibited), error correction rate, and antisaccadic accuracy | The observed phenomenon can be summarized as an increase in error rate, a decrease in error correction rate, and an increase in latency, which has been correlated with atrophy of the premotor cortex and has been observed prior to the onset of psychosis [16, 29] |
| Switch task (PS/AS switching) | The participant will be required to perform a prosaccade task, followed by an antisaccade task, and then another prosaccade task. Research has shown that the second switch can lead to an increase in the reaction time for prosaccades | The following variables were measured: the reaction latency during the second switch to prosaccades (also known as "switching cost") and the number of errors made | Increased "switching cost," more errors when switching tasks [1, 16] |
| Smooth pursuit eye movements (SPEM) | The subject must follow a smoothly moving horizontal object on the screen | The speed of eye movement and its ratio to the speed of the tracked object are evaluated | Patients with schizophrenia show a greater temporal discrepancy between their eye movements and those of a tracked object. Additionally, these patients often engage in saccades, which are rapid eye movements commonly referred to as "catch-up saccades" [30, 31] |

### 3.3. The use of eye tracking for the differential diagnosis between schizophrenia and other disorders

Compared to patients with other mental disorders and healthy individuals, people with schizophrenia are more likely to experience eye movement problems. These impairments are also more common in the close relatives of people with schizophrenia, which is why they are seen as a marker of such an endophenotype [32, 33]. Arolt et al. [22] found significant differences between a group of healthy individuals and patients with schizophrenia who had experienced two episodes of the disease with residual symptoms. These findings suggest that the disturbances associated with the disorder do not disappear as it progresses. Patients with schizophrenia were found to have abnormal gaze patterns, fewer fixation points, and longer fixation durations [22].

In addition to patients and their close relatives, researchers also study individuals at high risk of developing schizophrenia. Eye-tracking technology has been shown to be a reliable method for early diagnosis of the disorder, allowing for the timely initiation of treatment. As the disease progresses, cognitive impairments increase, which can be detected by tracking gaze patterns [34]. In a systematic review, Ricci et al. [35] synthesize evidence from 60 studies (2000–2025) examining prodromal symptoms and psychotic onsets. In conclusion, it is stated that neurobiological markers demonstrate stepwise brain alterations, with machine learning approaches achieving clinically meaningful prediction accuracy (77.6% for eye tracking; AUC = 0.84 for multimodal assessment).

One of the characteristics of eye movement in patients is "ballistic movement". Patients are instructed to delay their gaze behind an object and then shift it to the object. Subjects diagnosed with schizophrenia have demonstrated a superior ability to discern differences between images compared to healthy subjects. However, due to perception disorders, some subjects either do not recognize this difference or do not become aware of it until later [4].

The use of eye-tracking technology allowed us to establish a difference between the control group and patients diagnosed with schizophrenia with an accuracy of 87.8% [25]. Subjects were instructed to view static images. These findings demonstrate that the results were not influenced by gender, age, or the duration of the disorder. A prominent issue in perception is the tendency for patients with schizophrenia to focus on bright, but unimportant details, failing to differentiate between important and unimportant objects.

Anticipatory tracking has become a topic of interest in the study of schizophrenia. It is a behavioral mechanism that occurs in response to movement on and off the retina. Information about movement is derived from the perception of image movement across the retina. When the target disappears or lags behind, healthy individuals continue to track it using an anticipatory mechanism. This mechanism is based on an internal representation of the target's movement. A comparative study by Sreeraj et al. [23] was conducted between schizophrenia patients, their siblings, and a control group of healthy individuals. The task at hand was to track a moving target that momentarily disappeared and then reappeared. The results showed that the anticipatory tracking function was impaired in a group of patients with schizophrenia and their siblings. This eye-tracking technique not only helps identify individuals with a predisposition to the disease but also allows anticipatory tracking to be considered a potential endophenotype for future genetic research.

### 3.4. The impact of psychopharmacotherapy on eye movement disturbances

A particular focus should be placed on studies that investigate the effects of various psychopharmacological drugs on eye movement. It is generally accepted that antipsychotic medication has minimal impact on eye movement disturbances [36]. It has been found that in patients with schizophrenia, the administration of oxytocin leads to an increase in the number of eye fixations and a decrease in their duration. This finding is contrary to the typical symptoms of the underlying condition [36]. The effects of different generations of antipsychotic medications, their dosages, and the duration of treatment on the results of eye-tracking tests have not been sufficiently studied.

### 3.5. The effect of the duration of schizophrenia on eye movement disorders

The duration of the disorder also affects eye movement functions and visual information processing. Patients who experience multiple episodes of the disease show more severe dysfunction in object tracking and more significant impairments in tests that assess the condition of the prefrontal and left temporal cortex of the brain [37]. As the disease progresses, there is an increase in cognitive impairments related to attention, behavior, and visual information processing. This is evident by the patient's difficulty focusing on a specific object and paying attention. This can interfere with the ability to perform gaze fixation tests, as the disorder progresses [38].

### 3.6. The connection between eye movement disorders and dysfunction in various parts of the brain

Studies combining the comparative assessment of eye movement abnormalities and objective methods of brain dysfunction assessment have identified the areas of the brain that are most involved in the process of eye tracking. Patients with schizophrenia may have damage to the frontal motor areas, which causes a deficit in movement processing that affects their ability to follow a target. During smooth tracking, they show increased activity in the hippocampus, thalamus, and right fusiform gyrus. During predictive tracking, cerebellar activity is reduced, and activity in the right anterior cingulate cortex is increased [17]. Another study found that when it comes to smooth object tracking, impairments are localized in the frontal lobes, the frontal eye fields, and the parietal-temporal regions [31]. It is known that the cerebral cortex, brainstem, and cerebellum work together to help us maintain smooth eye movements. People with schizophrenia, however, have difficulty suppressing reflexive saccades. Neuroimaging studies have shown that there are significant changes in the frontal lobes of people with schizophrenia. These changes can lead to a greater number of errors when participants with affected frontal lobes try to make eye movements [39]. Cerebellar abnormalities can contribute to deficits in smooth pursuit. Activation of the cerebellum affects smooth pursuit performance in patients with schizophrenia. Dysfunction of the prefrontal cortex is associated with impaired smooth eye tracking in both Alzheimer's disease and schizophrenia, which explains the similarities in the pathogenesis of these conditions [37].

Philip S. Holzman's study also found similar disturbances in close relatives of patients, which may indicate a stable predisposition to schizophrenia. This pattern is also observed in individuals with cognitive impairments, who have damage to areas of the brain that are sensitive to movement, such as the parietal lobe, the middle temporal region, the medial superior temporal region, and the connecting network between the frontal and prefrontal cortex [34].

### 3.7. The correlation between eye movement disturbances and other cognitive functions and psychological test results

The “object exclusion” methodology helps to evaluate the generalization and abstraction abilities of patients’ thinking, as well as identify cognitive disturbances. The study included 45 patients with paranoid schizophrenia and 59 healthy participants. The results showed that people with schizophrenia tended to focus intensely on specific aspects of visual stimuli and had an unorganized, chaotic eye movement pattern when looking at cards. This observation suggested that these individuals needed more time to accurately identify images and detect common features. The study found that the experimental group showed a higher number of fixations and longer fixation times on objects. Their thought processes were based on minor, non-significant patterns. In contrast, the group of healthy individuals showed longer fixations on “extra” objects and studied all cards in a sequential rather than random order. The distinctive features of oculomotor activity in individuals with schizophrenia are associated with impaired cognitive processing of visual information. Eye tracking allows for a more detailed examination of eye movement patterns, which can help establish objective methods for diagnosing perceptual and cognitive pathology [40].

Attentional disturbances in individuals with schizophrenia have been linked to changes in smooth tracking. When individuals with this condition are faced with two competing tasks, their smooth eye-tracking performance is impaired due to attentional deficits. Network analysis provides quantifiable criteria for evaluating neurophysiological and neurocognitive abnormalities in patients with schizophrenia-spectrum disorders. This helps to identify key targets for managing these conditions and improving cognitive function [1].

A generalized deficit in information processing is observed in schizophrenia when it comes to emotion recognition. People with this condition have a reduced tendency to focus on faces and show a better ability to recognize positive emotions compared to negative ones. The perceptual disturbance is more noticeable in people who have had a first psychotic episode. These individuals performed worse on the task compared to those with chronic schizophrenia [29]. Furthermore, the use of eye tracking extends beyond the realm of diagnosis and into the area of patient rehabilitation, especially in cases of schizophrenia. A specialized training program called “Training of Affect Recognition” aims to restore cognitive functions by teaching individuals how to recognize emotions. This process has been shown to activate compensatory mechanisms in the brain that are involved in perception, attention, and the processing of emotional stimuli [37].

### 3.8. Machine learning and artificial intelligence techniques for phenotyping patients with schizophrenia by using eye-tracking data

In recent years, there has been a growing number of publications presenting the results of different approaches to machine-based analysis of eye-tracking data. These approaches aim to improve the accuracy of the results, automate computational processes, and uncover new and intricate connections between the phenomena under study. The raw data collected during eye movement recordings in various experimental settings can be subjected to further mathematical analysis. Several studies have used artificial neural networks, which outperformed the accuracy of differentiation results achieved with traditional multivariate analysis, reaching 98% [41]. Multivariate analysis has allowed us to identify key indicators and develop a formula for prognosis. It’s important to note that the treatments given to patients can also affect their visual acuity and cognitive abilities. Therefore, further research is needed to explore this relationship in more detail.

Dang et al. [42] trained a neural network to distinguish between patients with schizophrenia and healthy individuals using three eye-tracking parameters. Their model achieved an accuracy of 89.04%, specificity of 90.56%, and an F1 score of 87.87% in this task. Incorporating additional cognitive markers significantly improved the performance of the model. In a pilot study, Contreras-Chávez et al. [39] applied machine learning algorithms based on support vectors using data from three eye-tracking experiments. This approach led to the development of a model that can distinguish between patients diagnosed with schizophrenia and healthy individuals with an accuracy, sensitivity, and specificity of approximately 90%. However, as the number of participants in the experimental samples increases, the accuracy of the differentiation based on the results of eye-tracking experiments decreases. For example, in Meyhofer et al. [32], the number of patients and healthy individuals in the samples exceeded 300, and secondary validation was performed on other samples. The accuracy of the differentiation based on the machine learning model was 64%. However, the authors concluded that eye movement indicators while observing moving objects were a biomarker for schizophrenia.

Machine learning-based modeling further supports the hypothesis that eye tracking can serve as a biomarker for the specific endophenotype of schizophrenia, as has been observed in first-degree relatives of patients. In a study by Tsui et al. [43], the researchers demonstrated that a model based on the analysis of behavioral patterns during talking and eye-tracking data can differentiate between patients with an ultra-high risk of psychosis and healthy individuals. The model demonstrated 86.1% sensitivity and 82% specificity, with an area under the curve (AUC) of 0.893. This indicates that the model is highly accurate in its predictions. The use of machine learning techniques allows for the development of advanced screening systems, which, when validated on large populations, can help identify individuals at high risk for developing schizophrenia [36]. Eye tracking can be a valuable tool in these systems, as it is both accessible and sensitive. A comparison of the accuracy of psychiatrists’ diagnoses and machine learning models’ assessments of patients with a first psychotic episode found no significant difference in accuracy. This suggests that machine learning models can be just as accurate as human psychiatrists in diagnosing these conditions [44].

### 3.9. The comparison of various types of devices for measuring eye movement: features, price, and range of applications

A comprehensive analysis of the devices used in the articles included revealed that infrared cameras provide optimal convenience for recording eye movement patterns. This technology allows for the most accurate tracking and processing of eye movements through computer analysis [45]. These cameras can be divided into several main categories, ranging from the most expensive models to the least expensive.

1) Devices designed specifically for scientific research purposes. These devices have an accuracy of up to 0.01 degrees, a refresh rate of up to 1200 Hz, and a price exceeding $25,000. The results recorded by these cameras allow for the most accurate analysis in all experimental paradigms. Their use is more suitable for research and identification of fundamental eye-tracking patterns [46].
2) The integration of eye trackers with virtual reality devices is a significant development in the field. These devices offer exceptional precision, with resolutions as precise as 0.5 degrees and discretization rates up to 200 Hz. They are also highly specialized for scientific applications, but their cost exceeds $30,000, making them expensive for general use [47].
3) Cameras of intermediate price equipped with infrared technology. These devices cost approximately $1000 and have a gaze accuracy of up to 0.5 degrees and a refresh rate of 20–60 Hz. They can be used in clinics and for pilot studies [48].
4) Non-specialized webcams and smartphone cameras are suitable tools for this task. However, these sensors have the lowest accuracy levels, with an approximate error of 2 degrees and a low frame rate of approximately 30 frames per second. They are, therefore, suitable for use in wearable devices or smartphone apps for dynamic patient monitoring [19].

## 4. Conclusion

The eye-tracking method holds great potential for use in practical medicine and psychology. According to available research, eye movement abnormalities can be used as an objective biomarker for schizophrenia, and they may form a predisposition to the onset of the disorder. These abnormalities are often associated with hypofrontality, which is a decrease in the activity of the prefrontal cortex, and can lead to a decrease in inhibitory effects. Assessing the characteristics of eye movements during tasks such as viewing static images or tracking moving objects can help differentiate between patients with schizophrenia and healthy individuals with high accuracy. This is especially true when using modern statistical tools for analysis. However, the dynamics of changes in eye movements as the disease progresses and under different therapeutic approaches remain an understudied area. Started from the early eye-tracking studies was underlined the necessary of longitudinal setting of future experiments [49]. The development of therapeutic approaches to restore the perceptual abilities through the use of oculomotor training is also a promising and important area of research.

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## Ethical Statement

This study does not contain any studies with human or animal subjects performed by any of the authors.

## Conflicts of Interest

The authors declare that they have no conflicts of interest to this work.

## Data Availability Statement

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

## Author Contribution Statement

**Ilya Fedotov:** Conceptualization, Methodology, Software, Writing – original draft, Writing – review & editing, Visualization, Supervision. **Anna Faustova:** Validation, Writing – original draft, Writing – review & editing, Project administration. **Darya Kryazhkova:** Resources, Data curation, Writing – original draft.

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