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Entoptic phenomena, photopsias, phosphenes

Entoptični pojavi, fotopsije in fosfeni

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Abstract

In medicine the term entoptic phenomena is used to describe perception of visual effects that are rendered by the eye's own structures or visual system under suitable lighting conditions or stimulus. Customary such conditions are rarely met and hence do not produce an image. Entoptic phenomena produced or influenced by the native optical structures of one's own eye result from either refractive or diffractive causes. What all have in common is that they are subjective and require direct attention and cooperation of the observer for their perception. They differ from optical illusions which do not have a physical substrate. Special form of visual disturbances are photopsias and phosphenes. Photopsias are visual symptoms or sensations of structured images such as geometric figures or other simple pictures often recurring in a repetitive pattern in the absence of external light stimuli. Phosphenes are a subgroup of photopsias that patients describe as either static or moving unstructured patterns of colourful lights, sparkles or zig-zag lines. Photopsias predominately suggest ocular causes, less commonly they may suggest neurologic or systemic causes and thus require a meticulous examination as they occur.

Izvleček

Entoptični pojavi v medicini pomenijo zaznavanje struktur in vidnih pojavov v lastnem očesu ob izpolnjenih določenih pogojih osvetlitve ali dražljaja. Ker teh pogojev v vsakdanjih normalnih razmerah ni, ne povzročajo zaznave optične slike. Entoptični pojavi so lahko povezani z lastnostmi optičnih medijev ali s strukturnimi in fiziološkimi lastnostmi mrežnice ter vidne poti. Entoptični pojavi, ki so povezani z lastnostmi optičnih medijev, nastanejo zaradi refraktivnih ali difraktivnih vzrokov. Skupna lastnost vseh entoptičnih pojavov je, da je njihovo dojemanje subjektivno in odvisno od preiskovančeve pozornosti ter sodelovanja. Entoptični pojavi se razlikujejo od optičnih iluzij, ki nimajo osnove v resničnem okolju. Posebna skupina vidnih pojavov so fotopsije in fosfeni. Fotopsija je subjektivno zaznavanje svetlobe brez dejanskega fotonskega ali svetlobnega dražljaja in se pojavlja v obliki strukturiranih slik oz. geometričnih vzorcev ali kot enostavne ponavljajoče se slike. Fosfeni so fotopsije, ki jih bolniki zaznavajo kot nestrukturirane statične ali premikajoče se svetlobne vzorce različnih barv, bliske svetlobe, iskre ali t.i. cik-cakaste črte. Fotopsije v večji meri nastajajo v očesu, redkeje v centralnem živčnem sistemu, ali pa so znak sistemskih okvar, zato je ob njihovem pojavu potreben natančen pregled.

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1 Introduction

Ophthalmologists often encounter concerned patients with a fear of losing their sight when they sense something that has no source in visible reality or when they notice distorted images of objects in their surroundings.

Subjective sensations of structures and phenomena in one's eye or visual system, that under regular conditions does not result in visual perception, are referred to as entoptic phenomena (*gr.* entós + optikós, within the visual) (1-5). These perceptions are often produced or influenced by the native structures of the eye or pathologic imperfections under certain lighting conditions. They may happen as a result of other types of stimulation (mechanical, radiation, endogenous factors) (1-5) but may also indicate pathological activity within the eye or represent symptoms of neurological or systemic diseases that affect the vision (1-4,6-9).

Before the development of ophthalmoscopy, entoptic phenomena were important for discovering ophthalmic pathology. With the help of these phenomena, the French mathematician Claude François Milliet Dechales was the first to describe myopic ocular changes in short sighted people as far back as 1672 (10). Johann Benedikt Listings was the first to use the term "entoptic" to describe some of the optical phenomena in 1845 (11). With the development of modern examination techniques in medicine, entoptic phenomena were gradually becoming less important. Nonetheless, knowing these phenomena can be useful, as changes in the subjective perception of external images commonly precede objectively discernible pathological changes seen by utilizing diagnostic examination techniques (7-9,12). By knowing the causes of entoptic phenomena, thoroughly asking patients about their medical history, and a comprehensive ophthalmologic examination, physicians can exclude the more serious pathological processes with a high level of certainty, putting patients at ease, and avoid sending them for further unnecessary diagnostic examinations (1-4,6-9).

In the first part of this paper, we focus on entoptic phenomena that occur in optical structures when certain special lighting conditions are met (1-5). In the second part, we focus on photopsias and phosphenes, the phenomena that frequently occur on the retina without any external light stimulus and less frequently occur in the central nervous system (6,14,15). Photopsias most often represent a symptom of pathological developments in the eye itself or in the central nervous system, or they are a result of haemodynamic or other homeostatic changes in the body (6,14,15). They do not represent a pathognomonic sign of a certain clinical entity, but rather indicate a possible deviation from the normal condition. By knowing the causes of photopsias, physicians can perform a more targeted examination and discover specific pathologies (2,3,12,16).

2 Entoptic phenomena

Depending on the location of their origin, entoptic phenomena are subdivided in phenomena that result from irregularities in the optical structures of the eye and phenomena that depend on the physiology of the retina and the visual pathway (Table 1). These two categories are not independent, as unhindered vision requires the coordinated operation of both eye segments.

2.1 Entoptic phenomena related to the characteristics of optical structures

Different and heterogeneous compositions of optical structures result in their different refractive indices. Except for water, these structures are, by the nature of their cellular structure and their irregular refractive indexes, not perfectly transparent (1). The optical density and the refractive index of the structures are important in the formation of entoptic phenomena. The location of the inner-eye structure that casts the shadow can be estimated using relative entoptic parallax (1,2,13). By changing the illuminating angle (using spot lighting), the eye can detect the direction of the movement of the shadow that the object casts on the retina with regard to its anterior or posterior location and distance from the pupil (1,2,13). If the object is located in front of the pupil, the shadow's movement follows the movement of the light, whereas if the object is located behind the pupil the shadow moves against the movement of the light (1,2,13). Therefore, if the shadows are cast on the retina by opacities in the lens or in the vitreous body, they move in the opposite direction to the illuminating source, while the shadows cast by corneal opacities or imperfections follow the movement of the light (1,2,13).

The structure's distance from the pupil also plays an important role. The further away the structure is from the pupil, a greater shift of the shadow is observed

Table 1: Division of entoptic phenomena by location of their origin. Summarized from Trick GL, 2006 (2).

Optic media	Retina and visual pathway
Refractive causes	**Retinal circulation**
Anterior segment: • eyelashes, • tear film (retinal mosaic), • mucous and oil from Meibom's glands, • folds of the Descement's membrane, • pupil. Posterior segment (myodesopsia): • degenerative changes to the vitreous, • vitreous hemorrhage.	• Purkinje tree, • blue field phenomenon.
Diffractive causes	**Retinal pigmentation**
• corneal halo, • ciliary corona, • lenticular halo.	• Haidinger's brushes (carotenoid), • Maxwell's spot (xanthophyll).
	Neuron action and disorders
	• Troxler's fading, • blue arcs of the retina (Purkinje).

(1,2,13). Therefore, patients are most disturbed by structures (opacities) that are located in the posterior vitreous body, creating a disturbing shadow (i.e., a positive scotoma) (1,2,13).

According to the mechanism of their origin, phenomena are divided into those that result from refractive and diffractive causes. Refractive causes occur when the light passes through structures with different density, changing its direction, which is perceived as a shadow (2,13). Diffractive causes occur from the light bending and dispersing on the fringes of imperfections of the optical system (2,17,18).

2.1.1 Entoptic phenomena resulting from refractive causes

Refractive causes that may result in the formation of entoptic phenomena are divided into refractive causes of the anterior and of the posterior ocular segment.

2.1.1.1 Anterior segment

Observing a uniformly lit background through a pinhole (stenopeic vision), the entoptic field is the pupil, which is limited with the internal edge of the iris, and is perceptible as a light field with a jagged edge (the edge of the pupil). It is therefore possible to entoptically observe irregularities on the pupil's edge, as well as its contraction and dilation (2,13). Individuals can occasionally notice jumping shadows from their eyelashes on a brightly lit background (2). In a similar fashion, the tear film can cast a shadow, shaped like horizontal lines (striation); excessive mucus and oil excretion from Meibomian glands can result in perceiving mosaic patterns (1,2,13). Corneal deformations resulting from incorrectly wearing rigid contact lenses or from squinting too hard can result in the formation of shadows that appear as horizontal sets of lines, as well can cause monocular diplopia, and can temporarily reduce visual acuity (2). In cases in which the nucleus of the lens has a significantly different focus than the periphery (e.g., developing cataract), the central bright image may appear broken into multiple images (polyplopia) (2). Opacities in the lens may be evident as dark, granular, stable patterns if their cast shadows reach the retina (2).

2.1.1.2 Posterior segment

With age, the vitreous body begins to change (14). In a structurally and biochemically complex process the vitreous body starts to liquefy and the structure of collagen fibrils breaks down (14). The broken fibrils then pool together and accumulate in the liquefied vitreous body. This results in opacities that cast a shadow on the retina (14,19). Patients describe them as moving spots or dots in their visual field. Occasionally, they describe them as flies, mosquitoes, spiders, lines, clouds, etc. Such opacities move as the eye moves, but do not follow eye movements precisely. They generally pass the location of fixation and can change shape when moving (2,13,14). When attempting to look directly at them, they appear to float away, while blinking does not get rid of them

(unlike transitional corneal surface changes) (14,19). They become most noticeable when looking into a bright and uniformly illuminated light source (the sky or a white background) (14). The perception of floaters is known as myodaeopsia (14). Because of their appearance they are also called muscae volitantes, which is Latin word for flying flies (2,13,14).

Another possible cause for formation of vitreous opacities is mild vitreous haemorrhage (14). It can occur when the posterior vitreous detaches but also as a result of eye injuries, retinal tears or detachment, choroidal melanoma, occlusion of retinal veins and in systemic diseases (diabetes mellitus) (19,20).

Perception of opacities in the visual field is a frequent occurrence, in myopic eyes. This frequently worries patients (19,20). The physician must pay particular attention if the patient notices a sudden onset of thick floaters and flashes of light, as they might be related to posterior vitreous detachment (14,19,20).

2.1.2 Diffractive causes

When observing a point light source, it passes through different ocular structures that behave as diffractive gratings, dispersing the light. The result is a decline in the contrast of the image and the onset of rainbow halos (2,17,18). The size of the perceived halos depends on the distance from the structure, of which the light is diffracted, to the retina. The closer it is to the retina, the smaller the halo (2,17,18). These phenomena can occur in normal (physiological) but also in pathologic conditions.

Physiological phenomena include the ciliary corona, which can be noticed when watching a singular illuminated object in the dark (e.g., a star on a dark sky, a street lamp). The illumination source is surrounded by a changing pattern of many fine, slightly coloured needles (2,17). This is the result of the light reflecting from numerous tiny particles (proteins) in the lens nucleus, and the tiny irregularities in the structure of other ocular parts (deposits on the corneal endothelial cells, the cells in the anterior chamber and the anterior lens capsule) (17). When the pupil is dilated, like in a dimly illuminated room, a lenticular halo may occur, which appears as a ribbon of colour around the illumination source. It is caused by light bouncing from the zonular and anterior parts of the lens, which unlike its axial part has an uneven structure (2,18).

In patients with corneal oedema (acute angle glaucoma, eye injuries, after surgical procedures), the lattice arrangement of the collagen fibrils is disturbed (2). With a disrupted collagen structure, light is scattered in all directions, leading to a corneal halo (2). The presence of mucus, blood or pus on the epithelium additionally intensifies light dispersal. When viewing white light, a white central circle can be perceived, surrounded by multicoloured rings (red-yellow, purple, etc.) (2).

2.2 Entoptic phenomena related to structural and physiological characteristics of the retina and the visual pathway

2.2.1 Retinal circulation

Under normal conditions retinal vessels are not visible because of neuron adaptation (2,7,21). If we shine a light into the eye from a non-physiological angle (e.g., from the side), the shadows of the vessels fall on the unadjusted part of the retina. This allows patients to briefly see the retinal vascular image (2,7,21). If the illumination source does not move, the phenomenon quickly disappears. Patients being examined by a biomicroscope often notice the retinal vascular image (2,7,21). Physiological phenomena of neuron adaptation also include Troxler's fading, where fixating on a certain point or object can result in static images located peripherally from the point of fixation fading and disappearing in the background (22).

When observing a uniformly illuminated blue background (e.g., blue sky), it is possible to notice fast moving shooting spots of light in an apparent random order. This is called the blue field entoptic phenomenon or Scheerer's phenomenon, and is attributed to the movement of leukocytes in the retinal capillaries (2,8,23). The phenomenon is also useful to estimate the blood flow in the retinal capillaries, by using blue field entoptoscopy (2,23).

2.2.2 Polarizing light (Haidinger's brush)

The human eye is capable of detecting the direction of polarized light with the assistance of the so-called Haidinger's brushes entoptic phenomenon (2,7,9). When looking at a source of polarized light, many people can notice the pale interlinked blue and yellow bar or bow tie shape, visible in the centre of the visual field. At fixation this phenomenon fades in approximately five seconds, but can be sustained if the direction of the polarization changes. The phenomenon is the result of dichromatic carotenoid pigments in the macula, which are on average arranged perpendicular to Henle fibres

(2,7,9). The phenomenon is useful for early detection of macular dysfunction as patients are unable to visualize Haidinger's brushes even before the onset of clinically apparent signs of macular disease or oedema (7-9).

2.2.3 Retinal pigmentation (*Maxwell spot*)

When observing a source of neutral light through a fast-alternating green and blue filter a person can notice a central dark point, surrounded by a brighter circle with a halo (2,7). The central dark circle is the result of blue light absorption in the xanthophyll pigment of the central fovea. The phenomenon can be used to test eccentric fixation (deviation of concentric circles) and for monitoring the course of central serous retinopathy (the spot begins to reappear when the condition improves) (2,7).

2.2.4 Blue arc phenomenon

When viewing a pale illumination source in a darkened room and when the temporal parafoveal retina is stimulated, we can observe two blue-grey gently flickering arcs spiralling above and below the fixation point for a short period of time (up to 1 second) (2,7). These arcs arise at the illumination source and extend to the blind spot (2,7). The position and orientation of the arcs are generally held to correspond to the route of the parafoveal arcuate nerve fibre bundles extending to the optic disk (2,7). This visualization is thought to be the result of secondary electrical stimulation of the retina whereby action potentials in the arcuate bundles excite adjacent neurons (2,7).

3 Photopsias and phosphenes

Photopsias are defined as subjective perceptions of light without an actual photonic or light stimulation (6,14,15). Photopsias (flashes) (*gr.* phos – light + opsis – perception or sight) occur in the shape of structured images, i.e., geometric patterns (triangles, cubes, pyramids, etc.) or as simple recurring images (16). Photopsias can accompany numerous pathological ocular or systemic conditions, and determining their origin can be a diagnostic challenge (15).

In the majority of cases the unilateral photopsias have their origin in the eye (15). Even photopsias that were primarily unilateral and then spread to both sides, most often have the origin in the eye (15). Bilateral photopsias suggest abnormalities in the central nervous system or systemic conditions (6,15). In such cases the physician must first obtain thorough information from the patient on any known comorbidities, potential malignant diseases, previous ocular, intracranial or other surgical procedures, as well as whether they are taking any drugs or substances with known toxic side effects (15).

A special group of photopsias are unstructured photopsia or phosphenes. Phosphenes (*gr.* phos – light + phainein – show) are described by patients as unstructured static or moving light patterns of different colours, flashes of light, sparks or zig-zag lines (6,15,16).

3.1 Photopsias

Photopsias most often occur as result of direct retinal stimulation (vitreomacular traction, neovascular age related macular degeneration and optic disc oedema) (6,15). It is assumed that their origin is primarily in the retina, and that only in about 10% of the cases they result from abnormalities in the central nervous system or systemic disorders (6,15).

3.1.1 Vitreous detachment

Posterior vitreous detachment is among frequent causes of photopsias (6,14,15,19,20). Patients notice unilateral flashes of light in the peripheral part of their visual field. They also frequently notice floaters. The separation of posterior vitreous from the optic disk results in appearance of central large annular opacity (Weiss ring). With vitreous detachment there is no central or peripheral loss of vision (19,20). When examining the fundus, we must look carefully for the presence of Weiss's ring and the pigment cells in the anterior vitreous (tobacco dust, Schaffer's sign), which are strongly suggestive of retinal tear (19,20). A visual field defect can be a sign of retinal detachment (19,20). Patients often describe this as a shadow or a curtain that blocks their view and is spreading from the periphery towards the centre (19,20).

3.1.2 Age-related macular degeneration

Age-related macular degeneration is a frequent cause of photopsias (6). Approximately 50% of the patients with this type of macular degeneration notice white flashes, pulsations and twinkles (6). With the advancement of the disease and the onset of choroidal neovascular membranes, the probability of photopsias increases (6). Unlike posterior vitreous detachment, where the internal part of the retina is stimulated, in age related macular degeneration outer retinal layers (photoreceptors)

are stimulated (6). Differentiation between the two based only on photopsias can be difficult. In age-related macular degeneration photopsias are more often located centrally, whereas in cases with posterior vitreous detachment they tend to be peripherally located (6).

3.1.3 Central serous chorioretinopathy

Patients with a serous detachment of the macular neurosensory retina with adjacent loss or hyperplasia of the retinal pigment epithelium have unilateral central white flashes, which last up to a few seconds (6,15). Flashes can occur on a daily basis or a few times per week. Similar photopsias are also caused by other conditions that disrupt photoreceptors (Best disease, macular dystrophies) (6,15).

3.1.4 Diabetic retinopathy

Diabetic patients with a proliferative diabetic retinopathy can develop formation of fibrovascular tissue as a result of long-term retinal hypoxia (24). This tissue's growth and contraction causes traction of the retina, which causes photopsias. This traction can lead to tractional retinal detachment with potential vitreous haemorrhage (24). Patients with tractional retinal detachment can also notice floaters, flashes (photopsias) and a visual field defect.

Bilateral photopsias have been observed in insulin dependent diabetic patients during episodes of hypoglycaemia. They disappeared when blood sugar levels normalized (6).

3.1.5 Optic neuritis

Patients with optic neuritis can have photopsias alongside pain that is induced by eye movement (25-27). Patients notice photopsias when entering a darkened room, and describe them as bright colourful short-lasting flashes. Eye movement in the horizontal direction aggravates them (25-27). It was noted that the phenomenon is not maintained and temporarily ceases by repeated eye movements (25-27). The cause for photopsias is attributed to a mechanical deformation and firing of hyperexcitable nerve axons secondary to demyelization process. It is described as a visual equivalent of Lhermitte's sign (25-27).

3.1.6 Retinitis pigmentosa

Patients with retinitis pigmentosa often notice bilateral small, white flashes of light in the central part of their visual field, both in dark and bright conditions (6,15). They may persist throughout the day, while some patients only notice them several times daily (6,15). They may also be triggered by intense blinking (6,15).

3.1.7 Paraneoplastic retinopathy

In paraneoplastic retinopathy photopsias are caused as a result of dysfunction of the photoreceptors. In cancer associated retinopathy antibodies against retinal antigens develop (28-30). It occurs most frequently with small cell lung cancer (28-30). Patients may also complain of flickering, reduced visual acuity, reduced colour vision, night blindness and scotomas (28-30).

3.1.8 Vertebrobasilar insufficiency

Patients with vertebrobasilar insufficiency may notice bilateral photopsia, manifested as jagged flashes that last from a few seconds to a few minutes (6,31). This condition is often accompanied by vertigo, nausea, ataxia and general weakness (31). Symptoms may be similar to migraine attacks, but do not last as long, and are not followed by a headache (6,32).

3.1.9 Photopsias related to severe coughing attacks

There have been reports of patients who noticed short-term, bilateral, temporal, flashes of light during severe coughing attacks (6). They appeared on both temporal visual fields at once or alternating from one to another visual field at different intervals. The reason for the onset is attributed to fast movements of the vitreous during straining, and consequent retinal traction (6). There were no cases of confirmed vitreous detachment (6).

3.1.10 The Charles Bonnet syndrome

With injury or damage of the visual pathway, unilateral or bilateral so-called release hallucinations may occur as part of the Charles Bonnet syndrome (33,34). Patients see multicoloured shapes, patterns, even faces and silhouettes, which can last between a few seconds and a few minutes (6). They are aware that the phenomena are not real (33,34). The mechanism is not yet fully explained, but in general the sensory deprivation theory has been accepted. According to that theory long-term visual cortex stimulus deficiency results in disinhibition of visual cortical neurons, which in turn lead to random

activation of action potential even without stimulation (35). The phenomenon is more common in individuals with bilateral reduced visual acuity and patients who had their eye covered for a long time after eye surgery (33-36).

3.1.11 Migraine headache

Binocular photopsias or flashes most frequently represent visual auras as part of migraine headaches and are often referred to as "visual migraines" (6,15,37-39). Their source is in the occipital lobe of the brain and not in the structures of the eye or the retina; therefore, it affects the vision of both eyes at the same time (37,38). These photopsias are also known as scintillating scotoma (*lat.* scotoma scintillans) and represent a characteristic symptom preceding the headache. They rarely occur without a headache (acephalgically) (6,15,37-39). They usually begin bilaterally as a point of flickering light close to the centre of the visual fields, gradually spreading outwards. The vision outside the scotoma's edges is generally undisturbed, although scotoma can sometimes fill the entire visual fields (6,37,38).

3.1.12 Retinal migraine

Retinal or ocular migraine should be distinguished from the headache type migraine or migraine with aura (37,39). The former has its origin in the eye and therefore impacts the vision unilaterally, namely in the eye where it develops (37,39). Characteristic for retinal migraine are transitional unilateral episodes of gradually spreading positive or negative phenomena in the visual field, lasting up to an hour. Positive phenomena include flashing beams of light, zig-zag patterns and perception of flickering-coloured tracks, rings or diagonal lines, while negative phenomena is characterized by blurred vision, dark spots – scotoma or transitional total blindness (37,39). These may be accompanied or followed by a migraine headache within an hour (37,39). Pathophysiology of retinal migraine is not completely understood. According to one theory, the cause is in the vasospasm of the retinal or ciliary circulation, which causes ischaemia of the optic nerve, while according to another the cause is in the spread of depolarization over retinal neurons (37,39). Medical exam should exclude all other possible causes of transient unilateral visual field loss (a diagnosis of exclusion). *Aamaurosis fugax* must always be excluded first (37,39).

3.1.13 Other causes of photopsias

Even though they are not the leading symptom, photopsias accompany numerous other conditions. The presence of the permanent violet flashing indicates a retinal ischaemia (6). It has been described to accompany the blockage of the central retinal artery, its branches and with the blockage of the central retinal vein (6,15). Similarly, photopsias have been reported in cases with optic nerve oedema and optic neuropathy (15).

Bilateral photopsias can also occur in patients with orthostatic hypotension (6) and in cases where posterior visual pathway is affected, e.g., with vascular causes (arteriovenous malformations, transient ischaemic attacks, cortical venous sinus thrombosis, stroke in the occipital lobe), occipital epilepsy and prion diseases (15).

A more detailed list is included in Table 2.

3.2 Phosphenes

Phosphenes are photopsias usually described separately since patients describe them as unstructured static or moving multi-coloured light patterns (rainbow, white, black), or as sparks, flashes and zig-zag lines (16). They are associated with random activation of individual neurons at any part of the visual pathway (from the retina to the geniculate and striate cortex) (5,12,16,27). The most frequent type are deformation phosphenes, which are caused by the digital pressure to the eyeball (3,5,12). They may also be caused by: traction and pressure on the optic nerve (2,3), contraction of the ciliary muscle (2,40), the effect of extraocular muscles on the retina with a rapid accommodation or overaccommodation (2,40,41) and with convergence (2,3,40).

Phosphenes also occur when a person is exposed to electromagnetic radiation, e.g., during transcranial magnetic stimulation (2,5,12,42,43), or when exposed to alternate current during transcranial electric stimulation (2,5,12,16,42,43). There are reports of homogeneous green tinting of the whole field of vision after being exposed to x-rays. The cause is assumed to be direct ionizing effect on the pigment of rods and cones (44). Because the phenomenon is only possible in the eye, that is capable of detecting light, it is potentially useful for testing the retinal function when optical media are completely opaque (43,44). Patients who were exposed to ionized radiation (β-rays) noted a similar phenomenon (2,5,12,44). Astronauts exposed to cosmic rays during space flight also reported flashes and beams of blue-white light (2,5,12,16,45).

Table 2: Causes of photopsias. Summarized from Virdee J, 2020 (15).

Causes of unilateral photopsias		
	mechanical	posterior vitreous detachment
		retinal tear/detachment
Macula		age-related macular degeneration
		central serous retinopathy
	hereditary	Best's disease
Retina	inflammation	white dots syndrome: APMPPE, MEWDS, AZOOR, MCP, including idiopathic blind spot syndrome, birdshot chorioretinopathy, serpiginous choroiditis,
		acute macular neuroretinopathy
	neoplastic	choroidal melanoma
		choroidal metastasis
	venous	retinal artery occlusions (central, cilioretinal)
Optic nerve		unilateral optic disc swelling optic neuropathy
Unilateral photopsias can gradually expand to both eyes		
Causes of unilateral photopsias		
		optic nerve papilledema
	paraneoplastic	cancer-associated retinopathy
		melanoma-associated retinopathy
Anterior visual pathway		Charles-Bonnet syndrome
Posterior visual pathway		migraine with aura
		aura without migraine
		occipital lobe epilepsy
		visual snow syndrome
	venous	transient ischaemic attack
		stroke
		cortical venous sinus thrombosis
		vertebrobasilar insufficiency
		arteriovenous malformation
	inflammation	posterior reversible encephalopathy syndrome
	iatrogenic	deep-brain stimulator
	infective	prion diseases (Creutzfeldt-Jakob's disease)
	neoplastic	any type

3.2.1 Side effects of certain drugs

More than 300 drugs from different groups have been reported to cause visual sensations (phosphenes, as well as visual hallucinations) as a side effect (46). Phosphenes often occur in patients who receive drugs from the group of phosphodiesterase inhibitors, calcium channel blockers and cardiac glycosides (12,47). Digoxin ocular toxicity causes bilateral yellowish flashes of light (6,15). High doses of the antipsychotic quetiapine (Kventiax, Kvelux) and the antimycotic voriconazole (Vfend) can cause persisting flashes of light (15). Recreational drugs from the alkyl nitrite group (so-called poppers) can cause flashing as well as morphological changes in the macula, reducing visual acuity (so-called poppers maculopathy) (15).

4 Conclusion

In most cases, the entoptic phenomena described in the first part of the paper do not represent serious or threatening conditions. Photopsias and phosphenes described in the second part of the paper are conditions that physicians should always take seriously when reviewing the patient's medical history. Patients must be carefully asked about the time the phenomena occur, their duration and interval, any potential trigger factors and a detailed description of the phenomena itself (localization, colour, shape, movement). Localization of the flashing phenomenon is important. Flashes of light in the periphery of the visual field are in most cases a sign of traction on the peripheral parts of the retina. When light flashes occur more centrally, they indicate macular diseases or changes to the central nervous system.

Laterization is also important. Unilateral photopsias are mostly of ocular origin, while the occurrence of bilateral photopsias is usually a sign of disorders in the central nervous system or general conditions, such as hyperglycaemia, hypoglycaemia or orthostatic hypotension.

For physicians, and especially ophthalmologists, it is essential to know entoptic phenomena, photopsias and phosphenes, not only to enrich their medical knowledge, but also in order to more exactly interpret symptoms that patients may detect.

Even though patients describe these phenomena subjectively and differently, a good clinician will always listen to the patient's complains, the description of symptoms and strive to ascertain whether this is a serious phenomenon that requires extended diagnostics or a non-dangerous, physiological phenomenon that presents no risk to the patients' health and does not require a broader or invasive diagnostic evaluation.

Conflict of interest

None declared.

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