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Psychovisual Effects of Camera Shake: When and Why It Works

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Abstract

This paper examines the psychovisual effects of camera shake and their influence on viewer perception across various media. The study aimed to systematically investigate the psychovisual mechanisms of shaky-cam and determine the conditions under which it is effective as an expressive device in cinema, immersive, and gaming media. To this end, a comprehensive analysis of neurovisual and physiological experiments was conducted, alongside a comparative review of historical and contemporary cinematographic cases, and an overview of industry reports on image stabilization trends. The relevance of the work is justified by the convergence of two opposing market trends: the ubiquitous adoption of hardware stabilization, which renders smooth imagery the default, and the growth of immersive formats, where deliberate camera shake serves to enhance presence and dramatic tension. Of particular significance is the balance between psychological immersion and the risk of visually induced motion sickness in VR and 360° video. The novelty of the study lies in its interdisciplinary approach, which combines fMRI data on cortical MT/MST activity, EEG studies of the motor cortex, measures of sympathetic response (MSNA, HR), assessments of cognitive load, and industry forecasts for the optical-stabilization and VR-headset markets. This synthesis enables, for the first time, the establishment of clear quantitative boundaries for shake amplitude and frequency across different genres and media. The main conclusions suggest that camera shake enhances the subjective sensation of movement by activating the MT/MST complex and the sympathetic nervous system, while simultaneously increasing cognitive load and increasing the risk of cybersickness. The effect depends on the genre: in action films and horror movies, shaky-cam stimulates emotional arousal; in pseudo-documentary comedies, it strengthens viewer rapport; in VR and games, it requires fine-tuning of head bob and targeted vibrations. Effectiveness is ensured by precise dosing of shake, visual and auditory anchors, and the introduction of islands of calm, with subsequent verification through test screenings. This paper will be beneficial to directors, cinematographers, VR application designers, and researchers studying media perception.

Keywords: shaky-cam, optical flow, MT/MST, sympathetic activation, cognitive load, cybersickness, virtual reality.

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1. Introduction

Shaky-cam is an intentional abandonment of complete image stability: the operator holds the camera by hand or simulates such handling in post-production to create visual noise reminiscent of documentary footage or home video. In English-language terminology, synonyms such as shaky camera, jerky camera, and queasy cam have become established; all emphasize that the shake induces in the viewer a sense of direct presence and heightened scene dynamics. Unlike a merely handheld shot, where micro-movements may be random, shaky-cam deliberately amplifies amplitude and frequency, transforming a technical artifact into an expressive device, which is why it is typically contrasted with both the tripod and modern optical-stabilization systems.

The technique emerged almost simultaneously with portable film cameras: as early as the 1920s, newsreels were shot without tripods; however, the aesthetic potential of the shaking frame was only fully revealed after the widespread adoption of 16 mm equipment. At

the turn of the 1950s and 1960s, documentarians Michel Brault and Jean Rouch demonstrated that tripod-less camera breathing enhances the illusion of truth; their method was quickly adopted by the French New Wave and later by cinéma vérité. In the 1980s, the term shaky-cam was popularized by Sam Raimi, who used it in The Evil Dead and Crimewave. He affixed a camera to a board and carried it through the set, allowing the viewer to feel the jolts alongside the protagonist [1]. By the late 1990s, the shaky frame had become the hallmark of found-footage films, such as The Blair Witch Project. It had entered mainstream blockbusters, where restricted visibility and frame instability heightened tension [2].

Two opposing trends drive today's relevance. On the one hand, almost every smartphone now features hardware stabilization. According to Counterpoint Research, in 2023, the number of shipped OIS actuators exceeded 700 million units for the first time, and the stabilization market continues to grow [3]. On the other hand, this smoothness by default makes deliberate shake all the more noticeable: the director gains a quick means to distinguish subjective experience from smooth objective shooting visually, and content creators can underscore authenticity amid flawlessly stabilized footage. An additional layer of significance has been added by immersive media: studies [4] show that excessive camera shake in 360° video statistically elevates VR-sickness, prompting further development of smart post-stabilization and adaptive rendering. In other words, shaky-cam remains in demand precisely because it balances on the boundary between psychological immersion and physiological discomfort, making an understanding of its evolution and perception critically important for cinema, streaming platforms, and XR applications.

2. Materials and Methodology

The study is based on the analysis of 22 sources, including neurovisual and physiological experiments, systematic reviews, case studies of classic and contemporary films, and industry reports on technological trends. The theoretical foundation comprised works on optical-flow perception: Smith et al. [5] described the sensitivity of cortical areas MT and MST to organized motion patterns, and Heimann et al. [10], using EEG, demonstrated that free camera movement enhances activation in the viewer's motor cortex. Additional neurobiological context was provided by fMRI data on vection encoding and studies of the sympathetic response during passive viewing of dynamic scenes [6]. Meanwhile, Keshavarz et al. [8] and Wen et al. [4] offered insights into the relationship between self-motion sensation and visually induced motion sickness.

Methodologically, the research combines several approaches. First, a systematic review of experimental studies: analysis of data by Brown et al. [6] on increased heart rate and MSNA amplitude during passive viewing of running scenes, as well as results by Breves and Stein [7] and Brighter & Rader [18] on the effects of drastic versus moderate shake on cognitive load and arousal. Second, a comparative analysis of genre and historical cases: from Sam Raimi's pioneering work in The Evil Dead [1] and the found-footage aesthetic in The Blair Witch Project [2, 11] to techniques in Saving Private Ryan [9], La La Land [19], and the one-shot editing in 1917 [20]. Content analyses from the meta-study on found footage [12] and works by Ramella [13] enabled assessment of permissible shake-amplitude thresholds for maintaining immersion without severe discomfort.

The third element was the integration of industry and technical data, including reports by Counterpoint Research [3] on OIS-actuator shipments and forecasts by Global Market Insights and Grand View Research [21, 22] on the growth of the optical-stabilization and VR-headset markets. These data were used to understand the evolution of smoothness in shooting and the need for deliberate frame shake as an artistic highlight.

Finally, the practical measurement of comfort was carried out using test-screening methodologies that incorporated both objective and subjective metrics, including gaze-aversion counts and self-reports of discomfort, which allowed for the verification of the effectiveness of islands of calm and anchor elements (horizon, color, sound) in reducing sensory mismatch.

3. Results and Discussion

The perceived camera shake triggers a cascade of reactions in both the visual and autonomic systems. The first link is optical flow—organized motion of the entire image, which directly stimulates the neurons sensitive to such patterns within the MT/MST complex. fMRI studies show that human MST responds markedly more strongly to structured fields of expansion, contraction, and rotation than to random dot displacement, whereas the adjacent MT region scarcely differentiates motion structure; it is MST that encodes the sensation of self-motion, i.e., subjective presence within the frame's

space. Hence, the key function of shaky-cam is to amplify the flow of visual ego-reception without actual viewer displacement, thereby deepening immersion in the scene [5].

The enhanced motion flow instantly engages the sympathetic nervous system. Even when the body remains stationary, a visual stimulus modeled from the perspective of a running protagonist elevates muscle sympathetic nerve activity (MSNA) and heart rate: in an experiment involving passive viewing of running, participants' average pulse increased by approximately two bpm, and MSNA burst amplitude rose significantly at $p < 0.05$, confirming that mere visual signals can trigger a fight-or-flight response [6], as illustrated in Figure 1.

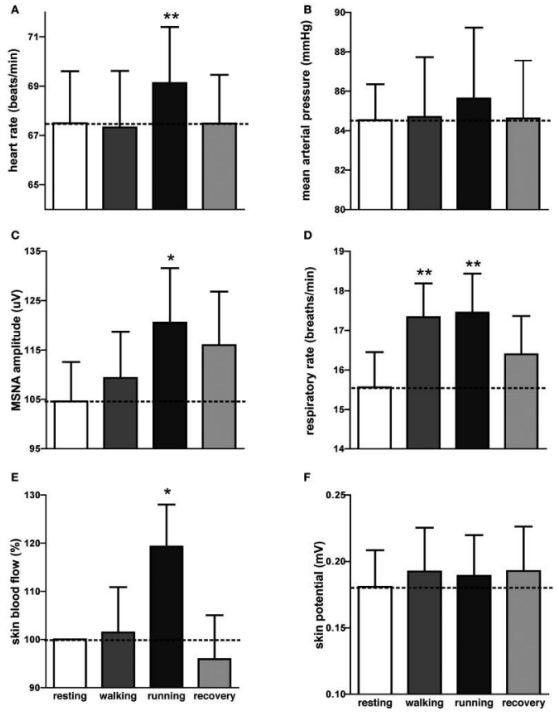

Fig. 1. Mean (±SE) values of heart rate (A), mean arterial pressure (B), MSNA burst amplitude (C), respiratory rate (D), skin blood flow (E), and sweat release (F) at rest, during passive viewing of first-person walking, running, and recovery [6]

Such moderate yet significant activation explains why shaky-cam is intuitively associated with danger and high action intensity.

Concurrently, the increased frame dynamics elevate cognitive load: the viewer must extract meaningful objects from an unstable field, consuming working memory. A laboratory study with 121 participants, comparing the same 360° scene on a laptop screen versus in a VR headset, demonstrated that the immersive (and more mobile) variant produced significantly higher subjective mental load, with cybersickness—rather than presence per se—serving as the mediator [7]. Consequently, shaky-cam can intensify the dramatic effect but simultaneously deplete viewers' resources that could otherwise be allocated to processing the plot or dialogue.

Finally, excessively chaotic optical flow creates a conflict between visual motion cues and the lack of corresponding vestibular input. Sensory mismatch is recognized as the principal mechanism of visually-induced motion sickness: reviews indicate that it is precisely the combination of a strong vection illusion and a stationary body that provokes nausea, disorientation, and dizziness; the greater the conflict, the higher the incidence of cybersickness complaints, especially in consumer head-mounted displays lacking full translational tracking [8]. Thus, shaky-cam works effectively only when its instability is sufficient to engage presence and arousal mechanisms but not so significant as to overload the cognitive buffer or trigger vestibular rejection.

Drawing on the above visual–autonomic mechanisms, cinematographers long ago observed that in scenes of extreme threat, shaky-cam transforms from a formal device into a dramaturgical driver. Combat or disaster sequences demand not so much discernment of detail as a sense of disorientation and bodily involvement; therefore, visual noise reminiscent of war correspondents' footage becomes a marker of the frame's real-time and spatial context. The opening of Saving Private Ryan remains a classic example: Janusz Kamiński deliberately emulated the work of 16 mm frontline cameramen by reducing the shutter angle to 45° and even attaching an eccentric motor to the tripod head so that each explosion would shake the film—an approach designed to infect viewers with the panic of the landing rather than afford them an overview of the battlefield [9]. Additional neuronal evidence came from Heimann et al.'s EEG study: footage with free Steadicam movement induced more pronounced beta-rhythm desynchronization in the motor cortex, interpreted as embedding the observer within the kinesthetic schema of the observed action [10]. This is why, in modern action franchises such as Bourne, the camera remains in the body of the character—an approach that both excites the

sympathetic system and justifies viewers' disorientation in the chaos of the chase.

The same properties make shaky-cam a key tool of horror and the unknown. In the found-footage subgenre, visual instability not only complements the narrative but confirms its documentary status: the shake occurs because the filmmaker is supposedly fighting for survival, not composing the shot. The economic result speaks for itself: The Blair Witch Project, with a budget of $60,000, grossed $248.6 million worldwide, relying almost exclusively on handheld shooting and marketing that exploited viewers' belief in the material's authenticity [11]. A recent meta-analysis of found-footage films indicates that immersion is driven precisely by uncontrolled optics, which shift the audience's focus from the plot to a primary sense of threat and reduce the character–viewer distance [12]. However, this same sensory veracity carries a physiological risk: audiences of Cloverfield and other monster-run films reported dizziness, up to the point of being forced to exit the theater, prompting studios to accompany screenings with warnings about potential nausea [13]. The above visual–vestibular conflict explains the effect; in the absence of actual accelerations, the brain interprets chaotic flow as an orientation error, provoking cybersickness. Thus, in horror, the shake must remain plausible but not uncontrollable: the less the viewer perceives montage intent, the stronger the fear response, provided it does not tip into physiological rejection.

In both contexts—from the Normandy landing to the rustle of the forest—the same pattern emerges: the closer visual instability approaches the threshold of sensory tolerance, the more pronounced subjective presence and dramatic effect become. Scene construction thus reduces to the precise dosing of this instability, since even a few extra hertz or percentage points of amplitude can transform viewer arousal from a valuable emotional resource into distraction or even physical malaise.

In pseudo-documentary comedies, camera shake functions differently than in action or horror films: it does not frighten or disorient, but rather establishes a confidential contact between characters and viewer. The Office was deliberately shot with a single cinéma-vérité–style camera and without a laugh track; its gentle micro-movements and uneven zoom constantly remind us that these people know they are being filmed, and it is precisely from this awareness that the humor of awkwardness arises, when a character glances into the lens seeking audience sympathy. The formula proved contagious: even eight years after its finale, the series remained the most in-demand catalog title on streaming platforms, accumulating 57.1 billion minutes of viewing time in 2020 alone, which confirms the long-term stickiness of documentary aesthetics for comedy [14].

A similar effect was employed in Modern Family: in the early seasons, the presence of the filming crew was explained, but subsequently, the shaky camera became a purely visual device, while retaining the viewer-approved direct looks and confession-style interviews. According to actor Jesse Tyler Ferguson, by season 11, the cast no longer considered filming logic—the audience had accepted the convention as part of the comedic language, and the micro-shake remained only as a visual marker of spontaneity [15]. Practice shows that for humor, amplitude at the level of natural breathing is sufficient, as it creates the illusion of a live shoot without impeding the reading of facial reactions. This is why later mockumentaries almost completely abandoned the sharper shake characteristic of found-footage.

In virtual reality and game cinematics, the task of pseudo-presence is achieved by simulating head bobbing and applying targeted camera vibrations during gunfire or explosions. The need to fine-tune this effect has spawned an entire research strand: a Frontiers systematic review counted 1,055 studies on cybersickness, but only 88 experiments passed critical selection as truly demonstrating symptom reduction via modifications to visual dynamics [16]. Game developers rely on this data: in shooters, head bobbing is constrained within a defined range, while in narrative cutscenes, it is almost entirely removed, delegating cinematography to the virtual camera operators. Such solutions align with findings [17] that the motional impact of game angles is determined by the dose of the invisible cameraman that the player can endure without losing control of the character.

Thus, shaky-cam in comedy, VR, and games follows the same logic: it must be just sufficient for the viewer to believe in the operator's presence, without feeling physically threatened by its instability. Minimal image breathing creates intimacy and facilitates humor; moderate shake adds energy to action; excessive shake destroys immersion. Maintaining this balance is the director's chief task when translating the psychovisual mechanisms described above into a concrete expressive tool.

The neurophysiological mechanisms that render shaky-cam convincing in threat scenes become an interference when the viewer's primary task is to assemble meaning rather than feel an adrenaline rush. In dialogue-driven and expository episodes, the brain requires cognitive resources to process text and spatial relations; extraneous sensory instability depletes these resources. The effect intensifies at scene transitions: in a study measuring pupil size as an indicator of load, a geographically establishing shot with a stable angle reduced average dilation compared to its absence, directly lowering cognitive load during the transition [18]. Therefore, in verbally rich episodes, shake adds no drama but only impedes decoding of lines and orientation in space.

The aesthetic of grandeur—period dramas, musicals, or operettas—rests on the opposite principle: the viewer must freely perceive costume composition, set symmetry, and mass choreography. Cinematographers of classic and modern musicals emphasize that the camera itself becomes a dancer, moving smoothly and predictably; a linear trajectory allows the viewer to synchronize attention with the music's rhythm. Linus Sandgren, describing the staging of La La Land, stated explicitly that their goal was to follow the scene's emotional movement, not the physics of shake, which is why numbers were filmed in long, continuous tracking shots without coverage, so as not to disrupt the illusion of ballet between camera and actors [19]. Such smoothness creates a sense of luxury and control; any chaotic movement in this context is perceived as a technical defect rather than an artistic statement.

Long plan-sequence shots impose even stricter requirements on stability. Their dramatic power relies on a sense of real time and continuous operator presence within the events; if the frame begins to jitter, the viewer instantly sees the seams and loses belief in the take's integrity. In 1917, Sam Mendes went further: to immerse viewers in every breath of the soldiers, the entire film was edited as a single continuous track, necessitating cranes, stabilizers, and precisely calculated transitions; the director himself emphasized that the choice of no visible cuts was emotional, not technical, and any extraneous vibration would have destroyed the sense of presence [20]. Consequently, shaky-cam is detrimental when dramaturgy is built on textual clarity, display of refined movement, or the illusion of seamless observation: in such cases, the viewer benefits from a smooth, invisible cameraman rather than nervous frame tremor.

The decision to consciously shake the image appears in the industry today not despite, but because of, market dynamics: source [21] estimates that the global optical-image-stabilizer sector will grow by an average of 8.7% per year—growth that means smooth imagery will soon become the default, forcing directors to seek ways to highlight tense moments, as shown in Figure 2 visually.

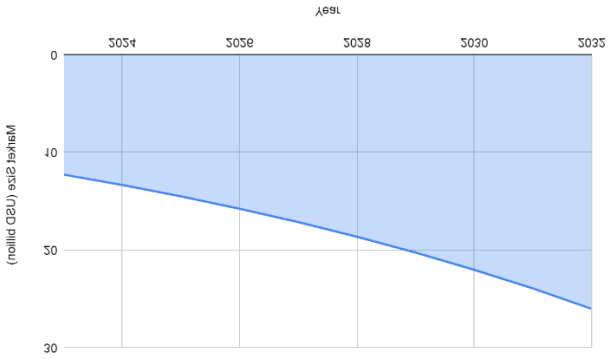

Fig. 2. Optical Image Stabilizer Market [21]

Analysts concurrently forecast that the VR headset segment will grow even more vigorously, at approximately 30.6% per year, thereby elevating the issue of viewer comfort and shake control from a niche technical concern to a priority for mass content [22], as shown in Figure 3.

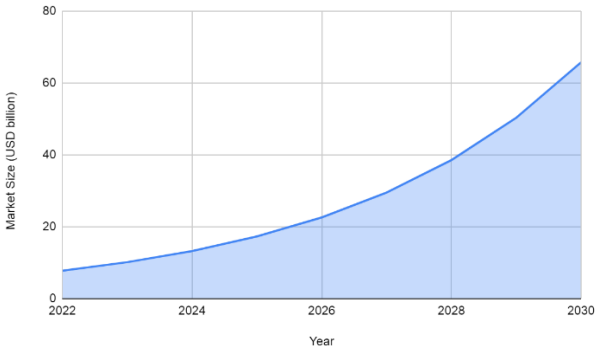

Fig. 3. Virtual Reality Headset Market Size [22]

When staging a scene, the cinematographer plans a gradual escalation: cameras begin with a steady frame, then the shake intensifies toward the dramatic peak and subsequently subsides, allowing the viewer to recover. Such a breathing motion profile is perceived as natural and does not provoke rejection. In contrast, an abrupt start at maximum vibration often results in rapid eye fatigue and loss of engagement.

Maintaining this balance is aided by a system of visual and auditory anchors. A fixed horizon line, a contrasting color, or a stable audio tone provides the visual cortex with a reference point, thereby reducing sensory mismatch. If the compositional core remains legible, even a relatively free camera is perceived as a deliberate artistic gesture rather than a technical defect.

Equally important are the brief stabilized islands of calm between shaking segments. A few seconds of stillness enable the viewer's vestibular system to resynchronize with what is seen, while preserving the emotional charge of the climax. Transitions between dynamics and calm are best planned at the same visual rhythm as the dramatic arc, so that the pause is perceived as part of the intention rather than as an editing patch.

The final check is a test screening on a large screen or in a headset, during which not only subjective assessments but also objective measures—such as the number of gaze aversions—are recorded. At the slightest sign of discomfort, the amplitude or duration of the shake is adjusted, because preserving the perceived reality of the moment is more valuable than achieving maximal physical verisimilitude at the edge of tolerance.

In summary, the reviewed studies and practical examples demonstrate that shaky-cam is not merely a stylistic device but a finely calibrated psychovisual lever that balances between presence and the risk of overloading the visual and vestibular systems. By leveraging mechanisms of MT/MST activation, sympathetic arousal, and cognitive load, the director can incrementally heighten dramatic tension or, conversely, create a trusting atmosphere in real-time. However, any exceedance of permissible shake amplitude or frequency can result not in emotional engagement, but in physical discomfort and distraction from the narrative.

4. Conclusion

The present review shows that shaky-cam constitutes a complex psychovisual instrument grounded in the interaction of several key visual and autonomic mechanisms. First, enhanced optical flow activates the MT/MST neural complex, which encodes the sensation of self-motion, thereby fostering deeper subjective immersion in the depicted events. Second, the visual simulation of movement without actual kinetics triggers sympathetic activation, elevating heart rate and muscle nerve activity, which induces a mild stress response associated with the fight-or-flight response. Simultaneously, excessive frame dynamics increase cognitive load, depleting resources needed for plot and dialogue comprehension, while overly chaotic optical flow produces sensory mismatch and cybersickness.

Practical examples from cinema and immersive media confirm that the effect of shaky-cam varies according to genre and the director's objectives. In action and war dramas, intentional shaking amplifies the sense of chaos and danger, generating dramaturgical impetus. In horror and found-footage films, it reinforces the documentary illusion and primal fear response, yet must not exceed physiological tolerance thresholds to avoid rejection. In pseudo-documentary comedies and mockumentaries, slight camera breathing instead establishes a confidential rapport with the viewer while preserving facial readability and clarity of reactions. In virtual reality and game cinematics, head bobbing and targeted vibrations complement narrative immersion, but require fine-tuning to prevent cybersickness and maintain user control.

The key takeaway is that the efficacy of shaky-cam depends on the precise dosing of shake amplitude and frequency. The director must strike a balance between enhancing presence and risking overload of the visual and vestibular systems. To this end, visual and auditory anchors (such as horizon, color, and sound), islands of calm between dynamic episodes, and test screenings employing both objective and subjective comfort metrics are utilized. Only by maintaining this balance does the shaky frame remain a powerful expressive device, capable of intensifying dramatic tension or evoking a here-and-now atmosphere without devolving into a technical flaw or a source of physical discomfort.

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Figure

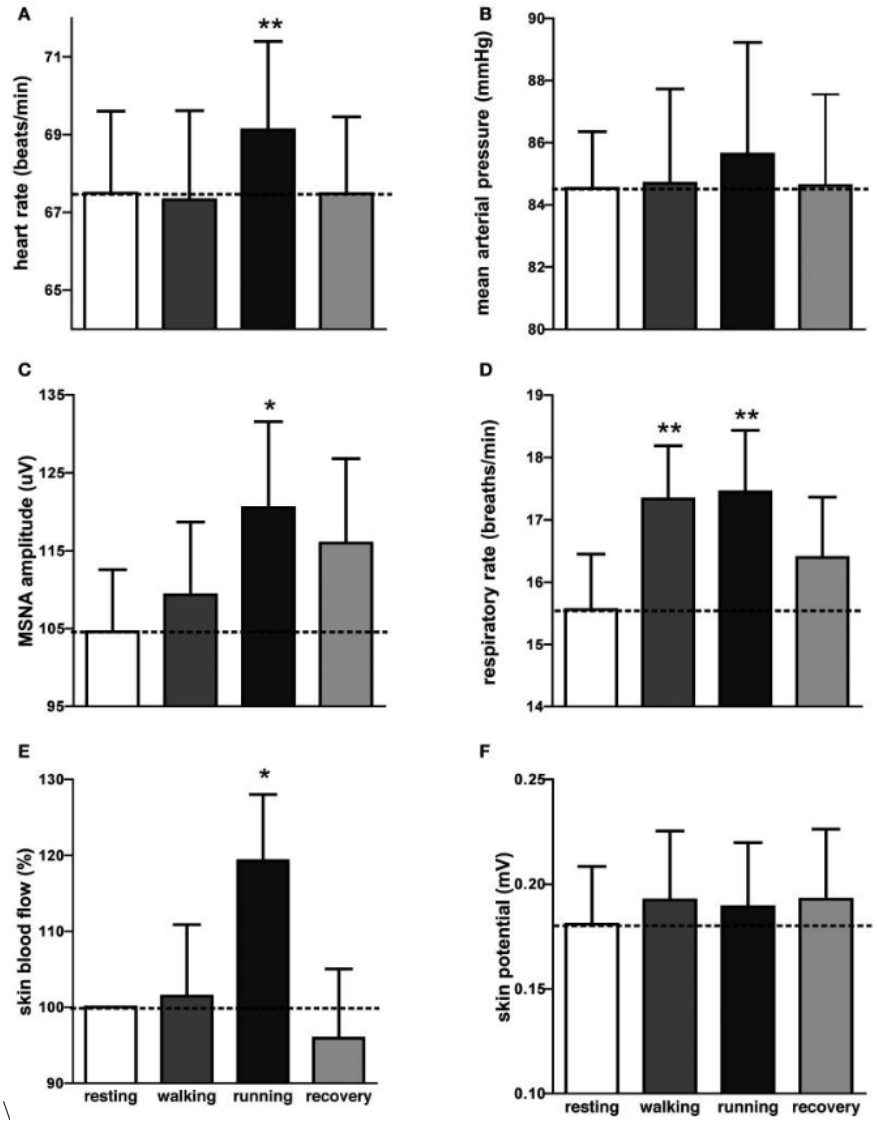


Fig. 1. Mean (±SE) values of heart rate (A), mean arterial pressure (B), MSNA burst amplitude (C), respiratory rate (D), skin blood flow (E), and sweat release (F) at rest, during passive viewing of first-person walking, running, and recovery [6]

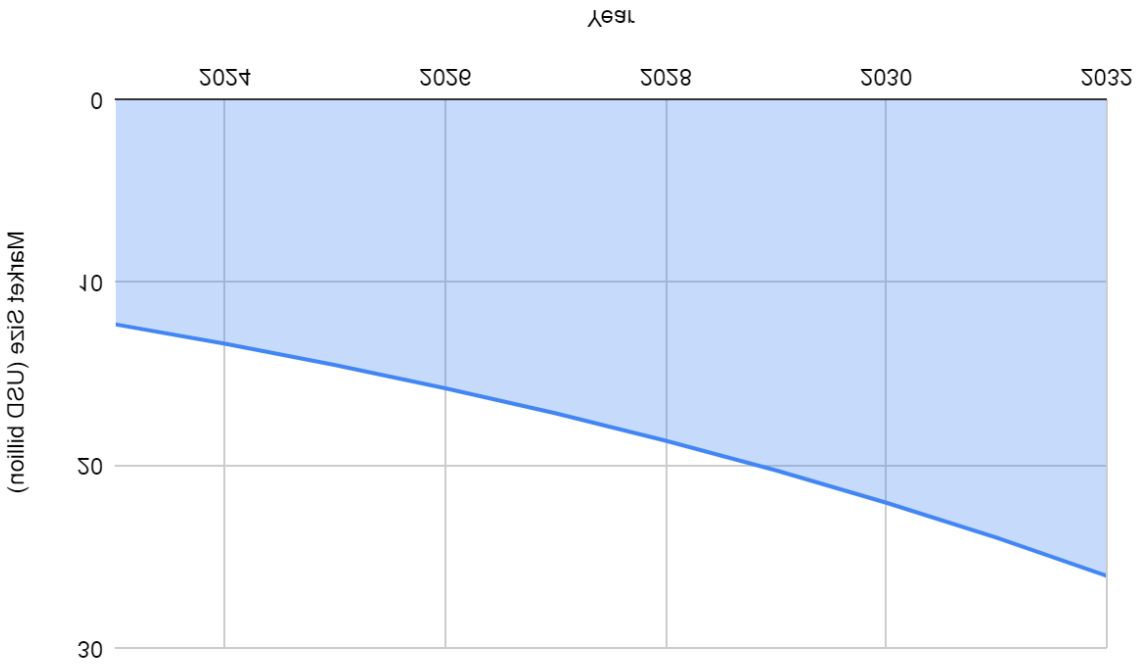
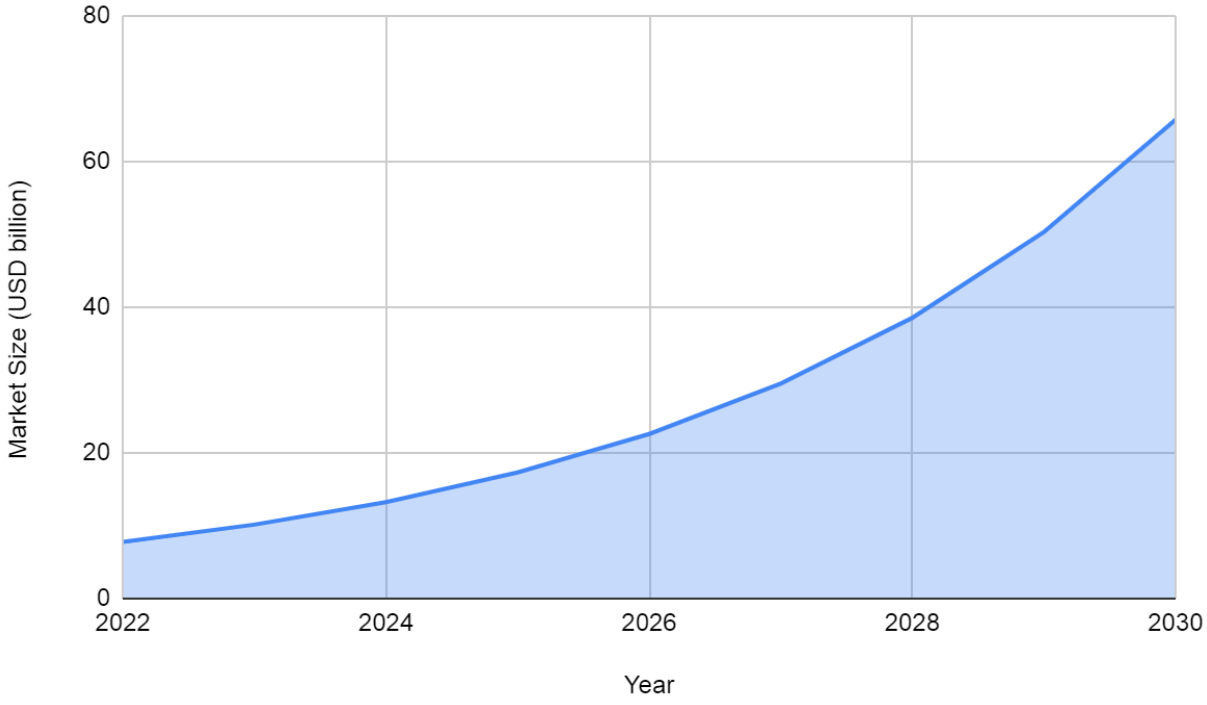


Fig. 2. Optical Image Stabilizer Market [21]



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