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Photic- and Pattern-induced Seizures: Expert Consensus of the Epilepsy Foundation of America Working Group

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Summary: *Purpose:* In August, 2004, the Epilepsy Foundation of America convened a workshop to begin to develop an expert consensus on photosensitive seizures.

Methods: Literature and data were reviewed, and consensus was derived from discussion.

Results: A flash is a potential hazard if it has luminance $\geq$20 cd/m^2, occurs at a frequency of $\geq$3 Hz, and occupies a solid visual angle of $\geq$0.006 steradians ($\sim$10% of the central visual field or 25% of screen area at typical viewing distances). A transition to or from saturated red also is considered a risk. A pattern with the potential for provoking seizures contains clearly discernible stripes, numbering more than five light–dark pairs of stripes in any orientation. When the light–dark stripes of any pattern collectively subtend at the eye from the minimal-expected viewing distance a solid angle of $>$0.006 steradians, the luminance of the lightest stripe is $>$50 cd/m^2, and the pattern is presented for $\geq$0.5 s, then the pattern should display no more than five light–dark pairs of stripes, if the stripes change direction, oscillate, flash, or reverse in contrast; if the pattern is unchanging or smoothly drifting in one direction, no more than eight stripes. These principles are easier to apply in the case of fixed media, for example, a prerecorded TV show, which can be analyzed frame-by-frame, as compared with interactive media.

Conclusions: A consensus view of stimuli likely to provoke visually evoked seizures can be developed. **Key Words:** Seizures—Epilepsy—Photosensitivity—Reflex seizures—Expert consensus.

Seizures can be induced by visual stimuli, usually flicker (photic stimulation), or spatially periodic patterns, such as stripes (pattern stimulation). The seizures have implications not only for the individuals who have them, but also for Public Health agencies; the TV, motion picture, and video-game industries; and those who produce live events comprising intense visual stimuli [for review, see accompanying article (1)].

Public presentation and private use of material with intense visual stimuli has induced seizures in susceptible individuals over the years. A few such incidents in the UK in the early 1990s led the British Independent Television Commission (ITC) to develop guidelines designed to reduce the chances that transmitted material would induce a seizure in someone watching the broadcast. In December 1997, a Pokemon cartoon in Japan led to almost 700 admissions to hospital, mostly because of seizures. The Japanese television community immediately developed their own guidelines, similar to those of the ITC, to address the problem. The ITC guidelines restrict use of bright flashes at frequencies $>$3/s over $>$25% of the screen. Additional restrictions are placed on patterns of repeated light–dark stripes. International organizations, including the International Telecommunications Union and the International Standards Organization, have begun consideration of international guidelines for photic and pattern stimulation in public media to protect individuals with photosensitivity.

At present, with the exception of flashing fire alarms, no recommendations, guidelines, standards, regulations, or rules in the United States specifically address the issue of photosensitivity. Therefore in August 2004, the Epilepsy Foundation convened a workshop in Alexandria, Virginia, to begin to develop an expert consensus on the pertinent information. A working group was formed from interested physicians, scientists, representatives of the Federal Communications Commission, U.S. Access Board, U.S. Consumer Products Safety Commission, the Consumer Electronics Association, attorneys working on the issue, a representative from the video-game industry, and a consumer with epilepsy. The following is a working

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draft from the expert consensus. An accompanying article (1) presents a summary of literature presented to the participants. Although the statements were modified from the ITC guidelines in the UK, they are here offered as a consensus rather than guidelines as such. They have been extended to situations more general than those involving the viewing of video screens, but future work will be required to adapt this consensus to video games, movies, videotape-derived images, DVDs, and public displays of light. Future opinions will evolve in response to new scientific information and future international standards.

DRAFT CONSENSUS

Individuals who are photosensitive are at risk of seizures from flickering or intermittent images and certain types of regular patterns. These images may be encountered in television, video games, computer screens, motion pictures, advertising displays, rock concerts, theater, opera, dance halls, and architectural features. Leading medical opinion and experience of broadcast organizations around the world have led to the formulation of the following recommendations, aimed at reducing the risk of provoking a seizure in susceptible individuals.

To reduce the risk, the following recommendations on visual content are applicable when flashing images or regular patterns are clearly discernible. A flash considered to be a significant hazard for a photosensitive individual occurs when a pair of opposing changes in luminance exists (i.e., an increase in luminance followed by a decrease, or a decrease followed by an increase) of $\geq$20 cd/m^2. Irrespective of luminance, a transition to or from a saturated red also is considered a risk. Single, double, or triple flashes in 1 s are acceptable, but a sequence of flashes is not recommended when both of the following occur:

1. More than three flashes within any 1-s period.
2. From the minimal expected viewing distance, the total area of concurrent flashes subtends at the eye a solid angle of $>$0.006 steradians. This solid angle equates to one fourth of the area of the central 10 degrees of the visual field. For practical purposes, the area can be taken as applying to an area $>$25% of the area of a television screen, assuming standard viewing distances of $\geq$2 m ($\sim$9 feet).

Rapidly changing image sequences are provocative if they result in flashes in the central visual field, in which case, the same constraints apply as for flashes. A pattern with the potential for provoking seizures in pattern-sensitive individuals is one that contains clearly discernible stripes, numbering more than five light–dark pairs of stripes in any orientation. The stripes of concern can be parallel or radial, curved or straight, or formed by rows of repetitive elements, such as polka dots. If the stripes change direction, oscillate, flash, or reverse in contrast, they are more likely to provoke seizures than if they are stationary. If the patterns obviously flow smoothly across, into, or out of the visual field in one direction, then they are less likely to provoke seizures.

When the light–dark stripes of any pattern collectively subtend at the eye, from the minimal expected viewing distance, a solid angle of $>$0.006 steradians, and the luminance of the lightest stripe is $>$50 cd/m^2, and the pattern is presented for $\geq$0.5 s, then the pattern should display no more than

1. Five light–dark pairs of stripes, if the stripes change direction, oscillate, flash or reverse in contrast.
2. Eight light–dark pairs of stripes, if the pattern is unchanging or continuously and smoothly drifting in one direction.

For practical purposes, these limits on the luminance, duration, and number of stripes may be taken as applying to patterns with a total area $>$25% of the area of a television screen, assuming standard viewing distances.

These principles are easier to apply in the case of fixed media (for example, a prerecorded TV show), which can be analyzed frame-by-frame. Interactive media, such as video games, may afford essentially limitless pathways through the game, depending on user actions. Therefore the working group recognizes that in the case of video games, the consensus recommendations apply to typical pathways of play but cannot cover every eventuality of play.

RATIONALE FOR THE RECOMMENDATIONS

The determination of the upper acceptable limit of flash rate (three flashes/s) originates in the studies of Jeavons and Harding (2). In a study of 170 patients, they demonstrated that only 3% of patients would be at risk with flashes at a rate of three per second or fewer. Above that flash rate, the probability of producing a photoparoxysmal response increased rapidly, reaching 65% at 10 flashes/s. Based on these and other studies, a maximum flash rate of three per second was selected by U.K. authorities to represent an acceptably small risk. The determination of the parameters of flash luminance and contrast (the difference between the opposing changes in luminance) was based on studies by Harding and Fylan (3) and Wilkins et al. (4). On the basis of their results, it was possible to estimate the proportion of patients affected as a function of the difference between screen luminance and luminance of the flash (5). Although flashes from stroboscopes in EEG laboratories have high intensities and short durations, they have seizure-provoking effects similar to those of other forms of visual stimulation. Stroboscopic stimuli also can be found in discotheques and in the theater. In the U.K., these are controlled by the "Health and Safety Executive Advice" on strobe lights.

The specification of the critical area was based on the knowledge that each of the visual cortices is independently sensitive, so that stimulation of the left or right half of the visual field results in equal sensitivity when compared with the whole field (6). It was therefore possible to determine that one fourth of the central 10 degrees of the visual field (0.006 steradians subtended at the eye) would provide protection for ~60% of the population at risk. The detailed justification for this specification can be found in Binnie et al. (5). Once 10 degrees of the visual field is affected by flickering or patterned stimuli, further increases in area of the affected visual field has little significance for the photosensitive response (7).

Binnie et al. (5) provide a description of the guidelines adopted in the U.K. with respect to regular patterns. However, more recent considerations (7) suggest that a simpler and more protective specification of pattern limits can be deduced. Based on the data obtained from Wilkins et al. (4,8) and Harding and Fylan (3), it was possible to determine the proportion of patients who would produce photoparoxysmal responses from a large pattern of bright stripes. Both the luminance of the dark stripe and the contrast between the bright and darker stripes could be used to deduce the risk for a variety of luminance differences. In addition, the previous data referred to allowed the production of guidance with regard to pattern area. All these considerations determined that if the luminance of the lightest stripe was >50 cd/m^2, and the pattern was presented for periods >0.5 s, and the pattern occupied the central 10 degrees of visual field, then the patterns could be a hazard. If the direction of the stripes changed or oscillated, only five pairs of stripes should be present. If the stripes were unchanging, eight stripes gave an equivalent theoretic level of risk because constant patterns are in general less provocative. In the context of television, experience indicates that drifting patterns have risks similar to those that are stationary. The determination of the period of 0.5 s was based on experiences of both Wilkins and Harding that paroxysmal discharges very rarely occurred in response to patterns with <0.5-s duration. Although color is an additional important factor in determining response to photic stimuli (9), its role is not yet sufficiently quantified to include recommendations on color in the consensus statement.

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