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Epilepsy and Videogames

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Summary: Since the first case of videogame (VG) epilepsy was reported in 1981, many cases of seizures triggered by VGs were reported, not only in photosensitive, but also in non–photosensitive children and adolescents with epilepsy. We provide an overview of the literature with overall conclusions and recommendations regarding VG playing. Specific preventive measures concerning the physical characteristics of images included in commercially available VGs (flash rate, choice of colors, patterns, and contrast) can lead in the future to a clear decrease of this problem. In addition to the positive effect of such measures, the collaborative studies performed in France and in the rest of Europe have stressed the importance of a safe distance to the screen of $\geq$2 m, and the less provocative role of 100-Hz screens. **Key Words:** Epilepsy—Photosensitivity—Videogame—TV screen.

The implication of certain videogames (VGs), with a television screen as visual support, in the origin of epileptic seizures or in the occurrence of paroxysmal discharges is well known. The first case was reported by Rushton in 1981 under the title of "space-invader epilepsy." Later, many cases of epileptic seizures triggered by VGs were reported in photosensitive epilepsy subjects (1–4) and in non–photosensitive epilepsy subjects (2–9).

The death in 1992 of a 14-year-old English boy playing a Nintendo game (10) received intensive media coverage and raised many questions; several workshops or studies were performed. In 1993, a workshop was held in London in which nine papers were presented. The conclusions of this meeting were summarized by Takahashi in 1994 in Japanese and in 2002 in his book on photosensitive epilepsy (11): in seizures occurring during VG activities, photosensitivity plays the most important role, but other factors should not be neglected [e.g., the specific cognitive activities associated with decision making and hand movements, the nonspecific emotional factors associated with playing (anxiety, excitement), the nonspecific effects of sleep deprivation and fatigue on seizure threshold, and the chance occurrence of an epileptic seizure in a person who spends large amounts of time playing VGs].

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COLLABORATIVE STUDIES ON VIDEOGAME EPILEPSY

In 1996, a French multicenter study (12) was performed to find out whether VGs could provoke seizures, whatever the type of epilepsy. Television, known to be epileptogenic in predisposed subjects, and several factors were of interest, including the distance between the subject and the TV screen, and the potential difference between 50-Hz TV screens and 100-Hz screens. It also was clear that certain games or patterns induced more paroxysmal EEG abnormalities than did others. With this in mind, 115 subjects were studied: 33 had seizures exclusively under visual stimuli (TV, VGs, or other), 42 had both photogenic seizures and spontaneous seizures, and 40 had nonphotogenic seizures and no abnormal response on intermittent light stimulation (ILS). The protocol [for details, see Badinand-Hubert et al. (12)] included a basic EEG recording, an ILS according to Kasteleijn-Nolst Trenite (3,13,14), a visual stimulation with geometric patterns constituted of disks of different diameters made of vertical and horizontal stripes (3), one TV sequence, three sequences of VGs selected with particular criteria (high-speed shifting or flickering of geometric patterns, stroboscopic effect on one part of the screen, battle scene with emotional connotations). All three sequences were presented successively at different distances (2.1 and 0.5 m) and on 50- and 100-Hz TV screens. At the end of the tape, the patient played actively with a commercial hand-held game module for 10 min. More than 82% of the photogenic patients had paroxysmal discharges on ILS. The prevalence of pattern sensitivity was lower. The authors

showed that VGs were ineffective in nonphotosensitive subjects but may induce paroxysmal discharges in photosensitive subjects, even when ILS is not effective. The 100-Hz screen was significantly safer than that of 50 Hz, the distance to the TV screen being an element of major importance, particularly for the 50-Hz screen (1 m was safer than 50 cm), as were specific image patterns and the act of playing.

A European study (15) including 387 subjects was performed with approximately the same protocol but with a more extensive study of TV programs: a standard program with no material expected to be provocative, a selection of potentially provocative TV programs, a Super Mario World game with active participation, and a Super Mario World received passively in demonstration mode. These programs were presented on both a 50- and a 100-Hz TV at distances of 2.1 and 0.5 m. Eighty-five percent showed paroxysmal discharges on ILS, and 28% were pattern sensitive. In contrast with the previously mentioned study (12), only few more patients were sensitive at a distance of only 0.5 m, compared with 1 and 2 m. Regardless the program, patients were significantly more sensitive to 50-Hz than to 100-Hz TV.

A further European study was conducted in 2002 to look at the impact of specific programmes (16). Viewing of Super Mario World and playing on the 50-Hz and 100-Hz TV was significantly more provocative than viewing a standard program. Super Mario World played on a 50-Hz TV was more provocative than that played on the 100-Hz TV.

The conclusions of these very important studies are the following:

1. The study of Badinand-Hubert et al, (12) shows that non-photosensitive epileptic subjects do not present paroxysmal EEG abnormalities induced by visualization of a television screen or by video games, results confirmed by Millett et al. (17).
2. Programmes shown on a 100-Hz TV screen induce paroxysmal discharges in photosensitive epilepsy patients less frequently compared with a 50-Hz screen, as previously shown by several authors (3,9,18) and confirmed by Ricci et al. (19). The final flicker rates are 50 and 25 Hz for 50-Hz TV sets, and 100 and 50 Hz for 100-Hz TV sets. The lowest frequencies are perceived when the subject is close to the screen (<1.5 m) (18). The protective effect of a 100-Hz screen is due to the fact that the frequency perceived at distances of 1 and 0.50 m is in the order of 50 Hz, which in most patients is outside the photosensitivity range (9). However, because certain patients still show photoparoxysmal responses at 0.5 and 1.0 m with the 100-Hz screen, it is clear that the latter type of screen does not protect totally against epileptic seizures in predisposed subjects.
3. The risk of paroxysmal EEG discharges and consequently of clinical epileptic manifestations is indeed increased by the shortness of the distance between subject and TV screen, as was shown by early authors (20).
4. Photosensitive subjects also can be sensitive to geometric patterns, especially stripes, and to certain colours, especially alternating red and blue, and to a combination of such stimuli [review in Kasteleijn et al. (21)]. Such combinations were indeed responsible for the "Pokemon" incident that occurred in December 1997 (22); they participate in the genesis of VG-induced seizures (23). In the collaborative French study, certain sequences including geometric patterns were more likely to induce paroxysmal EEG abnormalities, but only for the 50-Hz TV screen.

Types of seizures and epilepsies in patients with videogame-induced seizures

Most of the studies looking at the syndromic classification of epilepsy in photosensitive patients show a predominance of idiopathic generalized epilepsies (IGEs): two thirds in the article of Ferrie et al. (8), of whom 70% were intermittent photic stimulation (IPS) positive. In the last third, the epilepsy was considered to be focal, mainly of the occipital type. For Graf et al. (2), 63% had generalized tonic–clonic seizures (GTCSs); 6%, absences; 19%, simple partial seizures; 11% complex partial seizures; and 4% had other seizure types. The study of Takahashi (11) included 20 cases: six had partial epilepsy, three had juvenile myoclonic epilepsy (JME), two had "photosensitive epilepsy," two had GTCSs on awakening, and five had a single epileptic seizure. In the European study (15), most of the 387 subjects had a history of tonic–clonic seizures, myoclonic, or absence seizures; only a minority (fewer than 60) had partial or secondarily generalized seizures. Inoue et al. (24) studied magnetoencephalograms (MEGs) and EEGs in 29 patients: 19 (66%) had an IGE (childhood absence epilepsy in one, juvenile absence epilepsy in one, JME in 11, and other IGE in six), two (0.7%) had symptomatic generalized epilepsy, three (10%) had partial epilepsy (occipital lobe, frontal lobe, and other, one each), undetermined epilepsy in two, benign adult familial myoclonic epilepsy in one, and dentatorubropallidoluysian atrophy in two. The latter study shows that VG sensitivity is found in epilepsies other than IGE.

A special syndrome described as "idiopathic photosensitive occipital lobe epilepsy," which appears to be far from uncommon, has been recently delineated, in which long-lasting seizures originating from the occipital lobe were provoked by TV viewing, and specifically by VGs in two of the 10 patients reported (25).

Another very recent and detailed study in nine children with a history of TV- or VG-related seizures and generalized epileptiform activity during VG provocation in the laboratory looked into the clinical manifestations recorded during video-EEG recordings. Signs and symptoms during VG playing were compared with those provoked by IPS and by pattern stimulation. All children showed clinical signs, and the majority also showed symptoms (67%). The different phenomena seen during IPS and pattern could be seen also during VG playing and were very consistent within a patient. Oral signs and dysphasia occurred during VG playing only. Focal signs were seen in eight patients and especially during VG playing. No clear relation was found between duration of epileptiform EEG activity and clinical symptoms except for loss of consciousness and confusion. Although all were visually sensitive (IPS, TV, and VG), they had different types of seizures and epilepsies. The VG-evoked signs were less intense than the IPS-evoked signs. Parents and doctors should therefore be aware of minor ictal events to prevent major seizures provoked by VG playing (M. Piccioli et al., unpublished observations).

CONCLUSIONS

VG-induced seizures became a prominent and much advertised cause of seizures in photosensitive patients when VGs became a household standard. VG-induced seizures can either reveal photosensitivity, which is often most prevalent in the age classes that are most likely to use VGs, or can complicate treatment of epilepsy or social integration of young patients with epilepsy. Specific preventive measures concerning the physical characteristics of images included in commercially available VGs (flash rate, choice of colours, patterns, and contrast) have led in recent years to a clear decrease of this problem. In addition to the positive effect of such measures, the collaborative studies performed in France and in the remainder of Europe have stressed the importance of a safe distance to the screen of $\geq$2 m and the less provocative role of 100-Hz screens.

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