

A Descriptive Analysis of Seizure Events Among Adults Who Participated in a Computer-Based Assessment

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Abstract: The purpose of this study was to document seizure events associated with the use of a computer-based assessment and to describe the contextual factors surrounding these seizure episodes. Study participants were adults with epilepsy who were enrolled at research sites in Atlanta and Boston. Subjects were asked to complete a computer-based assessment at 3 time points. Fourteen seizure events were documented; they occurred during 1.6% of all completed assessments (896) and affected 4.4% of the participants (320). The mean age of participants who experienced seizure events was 41.4 years; about 70% were female, and 70% were white. A variety of possible precipitating factors for seizure events included hunger, fatigue, stress, and medication changes. Participants indicated computer use could have triggered their seizures in 2 instances. These findings suggest use of computer-based assessments may pose minimal risks for adults with epilepsy, particularly those without a history of photosensitivity epilepsy.

Photosensitivity epilepsy (PSE), a condition in which visual stimuli induce seizure events, occurs in approximately 3% of the 2.7 million Americans with epilepsy (Begley et al., 2000; Centers for Disease Control and Prevention, 2007). These visual triggers include varying intensities of flickering patterns and flashing light. Although PSE does not comprise an epilepsy syndrome on its own, it is the most common type of reflex epilepsy (Guerrini &

Genton, 2004; Parra, Kalitzin, & Lopes da Silva, 2005; Zifkin & Inoue, 2004). People with PSE usually experience generalized tonic-clonic, myoclonic, or absence seizures in response to visual stimuli (Covanis, 2005; Radhakrishnan et al., 2005).

A "photoconvulsive" response was first reported in the 1940s by W. Grey Walter, who observed that seizures can be precipitated in the laboratory by intermittent photic stimulation (Harding, 1994). Since then, environmental visual stimuli that can trigger seizure events in people with PSE, such as computers, televisions, and electronic screen-games, have become almost ubiquitous in daily life. Factors that may contribute to photosensitive response are brightness, changes in luminescence, high contrast, and certain patterns and flash rates. People with PSE are most vulnerable to seizure events when light flashes at frequencies ranging from 10 to 25 Hz (10–25 flashes per second), though seizures can be induced among some people when frequency ranges from 1 to 65 Hz (Fisher, Harding, Erba, Barkley, & Wilkins, 2005; Zifkin & Inoue, 2004).

Images on computer monitors and televisions automatically flash as screens are refreshed. The standard refresh rates of modern computer monitors and televisions in the United States are at least 75 Hz and 60 Hz, respectively, both of which fall beyond the usual range for triggering photosensitive seizures (Kasteleijn-Nolst Trenite, Van Der Beld, Heynderickx, & Groen, 2004). In addition, faster flash rates have been found less stimulating if a

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steady image emerges slowly on the screen because the picture is more stable (Harding & Jeavons, 1994). Seizures can result from the type of visual image on the screen; for example, if the image itself flashes or features certain patterns.

Harding and Jeavons (1994) explained that a critical factor for provoking PSE is luminance contrast. The contrast in brightness of light can be caused by the flash rate of an image or a pattern created by the image itself. They showed that restricting image flash rate to below 3 Hz can greatly reduce seizure events (Harding & Jeavons). Two other studies of photosensitive adolescents and young adults found that only 10%–18% of participants exhibited seizure activity at 2 Hz (Porciatti, Bonanni, Fiorentini, & Guerrini, 2000; Ricci & Vigeveno, 1999).

Certain patterns and contrasts, especially light and dark lines, are more likely to induce seizures. High-contrast stripes, such as black and white stripes, confer the greatest risk, especially when they change direction, flash, or reverse in contrast (Covanis, 2005; Trenite, 2006; Zifkin & Inoue, 2004). As a result of this evidence, the U.S. government and the Epilepsy Foundation developed recommendations to reduce the risk of seizure events resulting from visual stimuli. As part of Section 508 of the Rehabilitation Act passed by Congress in 1998, all Web sites and electronic material for federal agencies must not include images that flash at a rate between 2 Hz and 55 Hz (National Aeronautic Space Administration [NASA], 2006). The Epilepsy Foundation of America Working Group concurred; for television and computers it recommends that image flash rates be limited to less than 3 Hz, and patterns of light and dark stripes should not exceed 5–8 pairs (Harding, Wilkins, Erba, Barkley, & Fisher, 2005).

Certain mental, physical, and emotional states can increase the likelihood of seizure events for patients with PSE. Several studies found that among people who play video games, those who play games requiring more complex mental activity are more likely to have a seizure (Chuang et al., 2006; Ferrie, De Marco, Grunewald, Giannakodimos, & Panayiotopoulos, 1994; Zifkin & Inoue, 2004). Sleep deprivation, frustration, fatigue, and excitement also contribute to PSE (De Bittencourt, 2004; Ferrie et al.; Kasteleijn-Nolst Trenite et al., 2004).

The current literature on photosensitive epilepsy focuses on seizures induced by television or video games, with little mention of computers outside the context of gaming. Many of these studies concentrate on the effects of photoepileptic events in children watching TV or playing video games (Funatsuka, Fujita, Shirakawa, Oguni, & Osawa, 2001; Pellouchoud, Smith, McEvoy, & Gevins, 1999; Radhakrishnan et al., 2005) because it has been

shown that adolescents are more prone to PSE (Fisher et al., 2005). However, although it is possible for people to outgrow photosensitivity, Anyanwu, Ehiri, and Jones (2003) demonstrated photosensitivity may persist into adulthood, especially for those with a family history of PSE. Several studies examined PSE in a range of ages, but did not explore beyond TV, video games, or clinically induced events (Chuang et al., 2006; Fylan, Harding, Edson, & Webb, 1999; Inoue et al., 1999; Millett, Fish, Thompson, & Johnson, 1999; Porciatti et al., 2000; Radhakrishnan et al.; Ricci & Vigeveno, 1999).

Because computers often are used to conduct assessments in research studies and to deliver educational and clinical interventions, it is necessary to understand the effects of visual stimulation from computer monitors on people with a history of seizures. The purpose of this study was to document seizure events associated with the use of a computer-based assessment taken by adults with epilepsy and to describe the contextual factors surrounding these seizure episodes.

Methods

Data for this study were collected from a larger, longitudinal study of self-management among adults with epilepsy. The goals of the study, called Project EASE, were to examine predictors of self-management and to explore changes in self-management over a 6-month period. Study participants were recruited from two epilepsy centers in Boston and Atlanta and from a neurology clinic in the metropolitan Atlanta area. Participants agreed to complete three computer-based assessments at 3-month intervals—baseline, 3 months, and 6 months. Data collected from these assessments included background information on age, ethnicity, gender, and family income; epilepsy-related variables including frequency and type of seizures; attention and memory (cognitive) tests that incorporated various images, patterns, and sequences; and various psychosocial instruments on self-management practices. To be eligible for the study, subjects had to have had an epilepsy diagnosis for at least 1 year, be receiving a standard treatment for seizures at the time of the study, be between 18 and 75 years of age and able to read and understand English, be mentally competent as judged by a healthcare provider, and demonstrate willingness to participate. Exclusion criteria included a rapidly progressive neurological or medical disorder, history of a psychiatric syndrome that could limit participation, exclusive non-electrical seizure events that were not treated with antiepileptic medications, and history of significant substance abuse within the past year. Initially, people with any history of sensitivity to photo or pattern stimulation on electroencephalograph

(EEG) were disqualified from participation. To bolster study enrollment, 6 months into the study people who had a photosensitive response on EEG but did not have a history of seizures triggered by computer use during the previous year were allowed to participate if they received medical clearance from their neurologists.

Safeguards were established to help prevent seizures in those who participated in the computer-based self-management assessment and interview. An LCD display, which is a flicker-free computer monitor, was used to conduct cognitive and psychosocial testing. Low-intensity images presented during cognitive testing flashed at a rate of 1 Hz, which is significantly lower than the rate of 3 Hz found by Harding and Jeavons (1994) to reduce seizure events. Participants were allowed breaks from the computer and were provided ample opportunity to complete the assessment on a self-pace basis for up to 3 hours.

All people who volunteered to participate signed an informed consent form. A total of 320 men and women who met the inclusion criteria were recruited into the study between December 1999 and January 2002, and data collection continued until July 2002. The focus of the current study was on seizure events that occurred during or after the assessments; any person reporting a seizure at the study site or later in the day after leaving the study site was included in the analysis. A descriptive analysis was completed on the 14 participants who reported seizures during this time period. The institutional review boards of all participating institutions approved this study.

Results

The 320 participants were 19–74 years of age, with a mean age of 43.7 years. About 52% were men, 82% were white, and 75% had reported at least one seizure during the past year (DiIorio et al., 2006).

Out of a possible 960 computer-based assessments scheduled for the study, 862 (89.8%) were completed on the computer, and 34 (3.5%) were completed on paper or by telephone. The paper version of the assessment was used for a small number of subjects who did not want to use the computer or could not access a computer when it was available. Telephone assessments were conducted with participants who were not able to come to the study site at the required times for follow-up assessments. The remaining 64 (6.7%) assessments were not completed because subjects withdrew from the project or missed a follow-up assessment (Table 1).

Seizure events occurred either during or after 14 assessments, representing 1.6% of all completed interviews ($N = 896$). Fourteen participants experienced seizures, with 6 reporting seizures at the baseline interview, 7 at the 3-month interview, and 1 at

Table 1. Mode of Delivery and Completion of Self-Management Assessments

Study Site	Enrolled Participants	Total Possible Assessments (3 per Participant)	Total Assessments Completed		Computer Assessments Completed	Paper Assessments Completed	Assessments Not Completed Due to Withdrawal	Assessments Not Completed Due to Missed Visits	Seizure Events
			Completed	(%)					
Atlanta	169	507	480	(94.7)	461	19	8	19	3
Boston	151	453	416	(91.8)	401	15	23	14	11
Total, N (%)	320	960	896 (93.3)		862 (89.8)	34 (3.5)	31 (3.2)	33 (3.4)	14 (1.5)

the 6-month interview (Table 2). These participants ranged in age from 21–57 years with a mean age of 41.4 years (Table 3). About 71% were women, 71% were white, and all had reported seizures within the past year. Four participants experienced simple or complex partial seizures (28.6%), 3 had generalized seizures (21.4%), and the remaining seizures were not classified ($n = 5$, 35.7%).

Of these 14 participants, 12 attributed their seizures to precipitating factors such as fatigue, hunger, stress, or medication change. Two had seizures not associated with computer use; 1 had a seizure at the beginning of the assessment during background information collection, while a second participant experienced a seizure while completing a paper version of the assessment. These 12 participants expressed a strong desire to continue in the study, and after receiving approval from their physicians, they were allowed to complete the next scheduled interview(s). Five participants successfully completed two additional interviews, and 6 completed one additional interview without seizures. Among this group, the physician assessment of the events indicated that most were judged to be unrelated to the interview or that the relationship to the interview was “unknown.” Only two events were considered possibly related to the computer interview.

Two of the 14 participants believed the computer might have been a factor in triggering their seizures. Both individuals withdrew from the study after consulting with their physicians. One participant said visual and auditory stimulation during the baseline cognitive function testing triggered the seizure. The physician who reviewed the event agreed it may have been related to the interview. The second participant reported “feeling funny” when she used the computer. These seizures occurred after the 3-month interview was completed, however. At the initial screening, this participant did not report a history of seizures during computer use to the study staff and did not have a seizure at the baseline assessment. A physician determined the seizure was “probably not” related to computer use, but perhaps tied to medication change and fatigue.

Discussion

The purpose of this study was to monitor seizure events during the computer-based assessments conducted as part of a larger study on epilepsy self-management and to determine if there was an association between computer use and seizure events. The results of this study indicate that seizures did occur during assessments, with 11 of the 14 participants with seizures reporting events during a computer-based assessment. Of the remaining 3 participants, 1 reported a seizure while completing background information (which occurred during

an interview with the study staff), 1 experienced a seizure while completing a paper version of the assessment, and the final participant had a seizure after taking the computer-based assessment. The number of computer-based assessments in which a seizure occurred represents about 1.6% of all the completed computer-based assessments. The low percentage of seizure episodes in this study suggests computer-based assessments may pose minimal risks for adults with a history of seizures. The risk of seizure events during an assessment or intervention exists regardless of interview method, as demonstrated by the 3 participants who experienced seizures even though they were not using the computer at the time of their seizures.

The low percentage of seizure episodes in this study suggests computer-based assessments may pose minimal risks for adults with a history of seizures.

Participants known to have a history of sensitivity to photo or pattern stimulation on EEG and seizures caused by computer use within the past year were initially excluded from the study. This restriction greatly reduced the likelihood of enrolling individuals with PSE. However, 2 participants directly attributed their seizures to computer use. One said the black and gray patterns along with audio provoked the seizure, and the other noted a history of “feeling funny” when using the computer. The remaining participants said factors other than the computer were likely the cause of their seizures. These factors included stress, fatigue or sleep deprivation, medication change, hunger, and menstruation. They also noted the seizures they had were not unlike their usual patterns. These findings are consistent with other research that has shown factors not related to computer use can increase sensitivity to light and patterns for those with PSE and trigger seizures in nonphotosensitive people who experience seizures while using the computer or playing video games (Chuang et al., 2006; De Bittencourt, 2004; Ferrie et al., 1994; Kasteleijn-Nolst Trenite et al., 2004; Zifkin & Inoue, 2004). The top three reported seizure precipitants among a general population of people with epilepsy are emotional stress, sleep deprivation, and fatigue (Frucht, Quigg, Schwaner, & Fountain, 2000). Consequently, some seizure events that occurred during the assessment may have occurred even if the participants were performing other tasks.

Another factor not mentioned by participants is the possibility that their stress related to taking the assessment may have been an additional factor in

Table 2. Characteristics of Study Population with Seizure Events

Case	Occurrence		Interview Method	Situation and Associated Factors	Clinician's Assessment			Study Completion	Diagnosis
	Interval	Time of Event			Type of Seizure	Severity of Event	Likelihood Event Was Caused by Study Procedure		
1	Baseline	DI	Computer	Two episodes during neurocognitive testing Felt lightheaded, slightly confused, foggy, and experienced visual disturbances Said the black and gray pattern on the screen along with the audio provoked episodes	Unknown	Mild	Possibly	Withdrawn	CP and Gen
2	Baseline	DI	Computer	Six events consisting of coldness with occasional numbness to left hand and leg Two seizures typical of usual events	Unknown	Mild	Probably not	Completed	SP and P2nd
3	3-month	DI	Computer	Has intractable seizures, often has more than one seizure a day	Unknown	Mild	Probably not	Completed	Gen
4	3-month	PI	Computer	Four seizures directly after interview Recent medication change and fatigue were possible contributing factors	Gen	Moderate	Probably not	Withdrawn	Gen
5	3-month	DI	Computer	Reported to doctor feeling "funny" with use of computer in the past, though she did not share this information with the study staff Two auras in waiting room Two seizures—one while interviewer was gathering background information and one during the neurocognitive testing	TC	Mild	Probably not	Completed	SP, Gen, and Atonic
6	3-month	PI	Computer	Clusters of seizures not unusual Experienced symptoms typical of usual postictal state in evening after the interview	Unknown	Moderate	Unknown	Completed	SP and CP
7	6-month	DI	Paper	Stated fatigue was a possible contributing factor (worked before the interview) Stated had not eaten all day, so hunger was a potential factor	CP	Mild	Probably not	Completed	SP and P2nd
8	3-month	DI	Computer	Reported having a possible seizure during neuro-psychological testing	Unknown	Mild	Unknown	Completed	Absence and Gen
9	Baseline	DI	Computer	Also reported increased seizure activity over the following 2 days	SP	Mild	Probably not	Completed	SP and P2nd
10	Baseline	DI	Computer	Possible contributing factors include a seizure earlier in the day, change in medication 3 days prior, menstrual period, did not eat breakfast	Possible Gen	Moderate	Possibly	Completed	Unknown
11	Baseline	DI	Computer	Experienced four nonepileptic events typical of stress-induced events Became upset at the end of the testing, which may have contributed to the events	NES	Mild	Possibly	Completed	Gen
12	Baseline	DI	Computer	Had worked the night shift before arriving to take the survey, thus lack of sleep may be a contributing factor	SP	Mild	Probably not	Completed	P2nd
13	3-month	DI	Computer	Seizure typical of usual events	SP	Mild	Definitely not	Completed	CP

(continued)

Table 2. Characteristics of Study Population with Seizure Events (continued)

Case	Occurrence		Interview Method	Situation and Associated Factors	Type of Seizure	Clinician's Assessment			
	Interval of Event	Time of Event				Severity of Event	Likelihood Event Was Caused by Study Procedure	Study Completion	Diagnosis
14	3-month	DI	No Computer (face-to-face)	Seizure typical of usual events; occurred as interviewer was gathering background information Participant had frequent seizures	2nd	Mild	Unknown	Completed	CP and P2nd

Note. CP = complex partial; DI = during interview; Gen = generalized; NES = nonepileptic seizure; P2nd = partial seizure with secondary generalization; PI = postinterview; 2nd = secondary generalized; SP = simple partial; TC = tonic-clonic.

precipitating seizures. Participants were asked to first complete a series of neuropsychological tests that required memory and speed. The tests were followed with questions about their seizures, mood, support network, and self-management practices. Answering the questions may have raised awareness of issues that are stressful for participants.

This study's results suggest most properly screened adults with epilepsy can engage in computer activity without fear of seizures. In addition, research shows many individuals with PSE can remain seizure-free with medication management or preventive measures (Parra et al., 2005). Adhering to recommendations from the Epilepsy Foundation and Section 508 of the Rehabilitation Act may best prevent visually induced seizure events. These guidelines suggest using images that do not flash between 2 Hz and 55 Hz. They also promote using a flicker-free screen, a monitor-glare guard, and nonglare glasses, and stress the importance of allowing participants to take frequent breaks (Epilepsy Foundation, 2004; NASA, 2006).

Nursing Implications and Future Research

This study has implications for how nurses can address clinical or research-based computer use among patients with epilepsy. Although the risk of experiencing a visually induced seizure is minimal, nurses should inform patients with epilepsy of the potential risks and also other nonvisual factors that may precipitate seizures. Nurses should also ask patients to describe any history of photosensitivity or seizures associated with computer use or video games. This information should be included on the consent form for any research study. When developing computer-based interventions or assessments, researchers should take into account the potential effects of visual stimuli including flash frequency, pattern, color, image contrast, and exposure time. With these factors and the preventive measures in mind, nurses can use computers as an effective method to deliver assessments, information, and interventions to people with epilepsy.

This was a descriptive study of seizure events that occurred while conducting a study about self-management in people with epilepsy. The main study was not designed to control for factors that might affect the relationship between computer-based assessments and seizures; consequently, these results are incidental to the main study. It is recommended that future studies be designed to systematically explore this relationship. Investigators could study individuals with and without a history of PSE in controlled settings in which visual stimuli are standardized, for example. Moreover, investigators could study how factors such as length of time using the computer, computer images, mood, and fatigue affect seizure occurrence during computer use. The

Table 3. Summary of Participant Characteristics

Characteristic	Participants Who Experienced Seizure Event <i>n</i> = 14
Age (in years)	
Range	21–57
Mean	41.4
Gender	<i>n</i> (%)
Male	4 (28.6)
Female	10 (71.4)
Ethnicity	
Caucasian	10 (71.4)
African American	3 (21.4)
Hispanic	1 (7.1)
Interview Type	
Computer	12 (85.7)
Noncomputer	2 (14.3)
Outcome	
Completed	12 (85.7)
Withdrew	2 (14.3)
Occurrence	
Baseline	6 (42.9)
3 months	7 (50.0)
6 months	1 (7.1)
Seizure Type^a	
Simple partial	4 (28.6)
Complex partial	4 (28.6)
Generalized	3 (21.4)
Partial seizure with secondary generalization	2 (14.3)
Absence	1 (7.1)
Nonepileptic	1 (7.1)
Diagnosis^a	
Simple partial	5 (35.7)
Complex partial	4 (28.6)
Generalized	5 (35.7)
Partial seizure with secondary generalization	6 (42.9)
Absence	1 (7.1)
Atonic	1 (7.1)
Unknown	1 (7.1)

^aThe total number does not equal 14 because people can experience or be diagnosed with multiple seizure types.

information from these studies could provide both clinicians and researchers with more specific guidelines about computer use for people with seizures. This information is particularly important as computers and computer-like devices become increasingly pervasive in our daily lives.

Summary

The purpose of this study was to evaluate seizure events that occurred among participants in a longitudinal study of epilepsy self-management. Fourteen seizure events occurred during or after planned assessments; 11 of these occurred during computer-based assessments, representing about 1.6% of all computer-based assessments.

Precipitating factors for the seizure events included hunger, fatigue, stress, and medication change. Two participants noted that the computer possibly triggered their seizures. The findings suggest use of computer-based assessments may pose minimal risks for adults with epilepsy, particularly those without a history of PSE.

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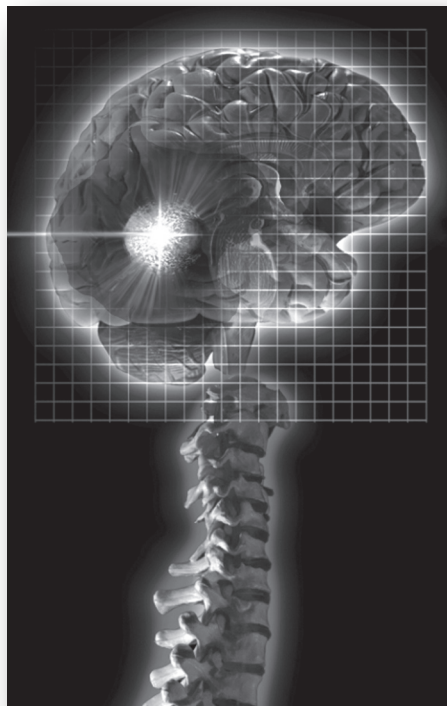
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