

REVIEW ARTICLE

Higher brain function as precipitant of seizure

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Abstract

An epileptic seizure can be induced by higher brain function or mental processes associated with emotion. The precipitation involves verbal, non-verbal and specific thinking with emotion. Some of these patients have symptomatic and focal epilepsies. Others were idiopathic epilepsies, where the hyperexcitable regions and systems provoked by some specific stimuli may produce epileptic seizures that results in symmetrical, asymmetrical, or even localized clinical manifestations. The understanding of precipitation of seizures by higher brain function may contribute to understanding of epileptogenesis and nosology of epilepsies.

The precipitants of reflex seizures or stimulus-sensitive seizures may be simple and complex according to the provocation mechanism. The complex stimuli involve higher brain function or mental processes associated with emotion. Seizures induced by higher brain function may be idiopathic or symptomatic in etiology, and may be focal or generalized. There are also contributions from non-specific precipitating factors such as sleep deprivation. The patients often have seizures that occur spontaneously. These higher brain function sensitive seizures may be more prevalent than commonly realized and the phenomenon awaits further studies.

Table 1 lists the various examples of seizures induced by higher brain function. As early as in 1937, Critchley described cases with musicogenic epilepsy.¹ He noted that there existed a small but well-defined group of patients in whom music precipitated seizures. In 1954, Bickford *et al* reported another important reflex epilepsy induced by reading.² He reported 3 patients where prolonged reading gave rise to convulsions preceded by aura of clicking or movement of the jaw. Since 1960s, seizures induced by doing mathematics or calculations, writing, playing games, using language, making decisions, drawing, thinking, and praxis were also described.

There were important contributions on higher brain function as precipitant of seizure from Asian countries. The first report of game-induced epilepsy were from Shanghai⁵, where 4 young males who had myoclonia or generalized convulsions preceded by adverse movements

were induced by playing or watching chess and cards. Senanayake from Sri Lanka reported cases of seizures precipitated by playing games and doing calculations.¹³⁻¹⁵

INDUCTION BY HEARING MUSIC AND VOICES

Wieser¹⁶ reviewed 83 cases of musicogenic epilepsy. The age of onset of seizure was late at 27 years. There were often seizures that occurred spontaneously as well as those precipitated by music. In one-fifth of patients, the provoking music was specific. The seizure focus was often localized to the temporal lobe, more often right

Table 1: Epilepsies/seizures induced by higher brain function

Musicogenic epilepsy (Critchley, 1937 ¹)
Reading epilepsy (Bickford <i>et al</i> , 1954 ²)
Epilepsia arithmetica (Ingvar and Nyman, 1962 ³)
Graphogenic epilepsy (Asbury <i>et al</i> , 1963 ⁴)
Chess and card game epilepsy (Ch'en <i>et al</i> , 1965 ⁵)
Language-induced epilepsy (Geschwind <i>et al</i> , 1967 ⁶)
Decision-making epilepsy (Forster, 1977 ⁷)
Drawing induced seizures (Brenner <i>et al</i> , 1979 ⁸)
Seizures induced by thinking (Willkins <i>et al</i> , 1982 ⁹),
Thinking epilepsy (Martin da Silva <i>et al</i> , 1989 ¹⁰),
Noögenic epilepsy (Gastaut, 1989 ¹¹)
Praxis-induced seizures (Inoue <i>et al</i> , 1994 ¹²)

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side. Thirty-five of the patients were interested or talented in music. Such interest in the provoking activities is often also seen in other types of seizures induced by higher brain function. Tayah *et al*¹⁷ reported 3 patients with musicogenic epilepsy who had intracranial EEG. The authors concluded that musicogenic seizures could arise from multiple temporal lobe foci, although there was a right side preponderance as well as relationship to emotion.

There was also a report where singing and recitation, but not listening to music, induced seizures with head turning in a very young boy with temporo-central spikes.¹⁸

Forster *et al*¹⁹ reported a patient who had posttraumatic epilepsy precipitated by voices. The focal seizures with aphasia were induced by hearing the voice of an announcer. The voice must have emotional influence to the patient. However, in contrast to the musicogenic epilepsy, this patient had seizure focus on the dominant side. A similar case of voice-induced seizure was also reported from Japan.²⁰ It was a woman who had EEG discharges triggered by verbal stimulation, particularly if someone spoke to the patient directly. These cases share some similarities to the language-induced epilepsy to be discussed later in this article.

EMOTIONAL INDUCTION

There were anecdotal reports that suggested seizure precipitation by emotions. Reisin *et al*²¹ reported a 36 year-old male who presented with epigastric aura followed by automatism since the age of 14 years. Ninety percent of his seizures were triggered by thinking and recollection of his family home or his father, a familiar but unpleasant and fearful emotional recollection. He could also voluntarily trigger the seizures by these thinking and recollections. The seizures had left temporal EEG origin and there was a cortical dysplasia.

In another report of a 32 year-old woman with idiopathic generalized epilepsy, the absences were precipitated by conversations about unpleasant experiences, usually about her childhood experience of sexual abuse, her epilepsy or her father's difficulties with his schizophrenia. Ninety three percent of her seizures occurred during conversations about these subject matters.²²

The relation between emotion and seizure precipitation has not been systematically studied. Some authors asserted that most seizures appear to occur spontaneously independent of any environmental precipitant or intrinsic alterations

of the body. On the other hand, others thought that no seizures are truly spontaneous. All seizures are results from interactions of the various intrinsic and external excitatory and inhibitory factors.²³ There should be more studies addressing these issues.

LANGUAGE-RELATED INDUCTION

There was a recent report of a case of telephone-induced temporal lobe epilepsy. The patient's seizures consisted of dizziness, distortion and attenuation of sound, inability to understand language, slowing or arrest of speech. The seizures were induced only by answering telephone. Ictal EEG started in the probable language dominant temporal lobe.²⁴ We also reported a similar patient whose seizure often occurred when he was conversing or reading. The seizures consisted of fluent paraphasia, paraphagia and comprehension deficit. The syllables uttered during seizures contained many neologisms and the same syllables were often repeated and tended to rhyme.²⁵

Brodtkorb *et al*²⁶ described a patient whose seizures were triggered by unexpected interruption by verbal command. During seizures, voices became distorted. The patient had difficulty understanding conversations and to trace the spatial direction of sounds. The syllables floated together with an echoing character. He could not understand the words and express himself. Other auditory stimuli did not provoked seizures. There was a family history of autosomal dominant lateral temporal lobe epilepsy with mutations in leucine-rich glioma-inactivated 1 gene (LGI1). The prominent feature of aphasia and the auditory precipitant of seizure may help to identify this syndrome.

The first description of language-induced epilepsy goes back to 1980. Lee *et al*²⁷ described a 48 years old man with probable left middle cerebral artery stroke. Speaking induced jaw jerking. Silent reading induced jerking of right face, jaw and neck. Reading aloud induced stuttering and writing induced dysgraphia

Recently Valenti *et al*²⁸ reported a large family where stuttering was induced by speaking, reading, and calculation. The stuttering was due to positive focal myoclonus of the jaw. Some of the family members also had myoclonus of the arms. Although there were focal spikes in EEG, the authors concluded that the patients had idiopathic generalized epilepsy (IGE) rather than focal epilepsy.

READING EPILEPSY

Primary reading epilepsy is a well-known syndrome.²⁹ The mean age of seizure onset is 17-18 years. About half of the case had affected relatives, and more than half of the family members affected also have primary reading epilepsy. Reading aloud rather than silent, irrespective of the content of the reading materials, induces localized, rarely bilateral perioral reflex myoclonus. Perioral reflex myoclonus may manifest as stuttering. Speaking, less often, writing, and reading of musical scores can also precipitate seizures. Thus, the provocations of seizures involve transformation of linguistic material into speech.

The EEG is normal in 80% of cases. However, reading provokes unilateral or bilateral paroxysms, often in parieto-temporal region. There were unilateral facial myoclonus with bilateral EEG discharges, and bilateral myoclonus with unilateral discharge. These findings are not typical of focal epilepsy, but are suggestive of generalized epilepsy.

Mayer *et al*³⁰ examined the precipitation in juvenile myoclonic epilepsy (JME). They sent questionnaire to 86 JME patients. They found perioral reflex myoclonus induced by talking and reading in half of the responders. Speaking and reading activated EEG paroxysmal discharges in 36% of the investigated cases. The perioral reflex myoclonus seen in JME was indistinguishable from that seen in primary reading epilepsy. The seizures in JME may also manifest as myoclonic movement or sensation of orolaryngeal muscles. This study suggests a close relationship between reading epilepsy and JME.

PRAXIS INDUCTION

Chuang *et al*³¹ investigated cases of mah-jong induced epilepsy and divided the cases into two groups. The first group was attributed to certain focal or diffuse pathologic changes of cortex with later age at onset. The second group had both game-induced seizures and seizures occurring spontaneously, with absence, myoclonus or generalized tonic clonic convulsions as seizure manifestations. The seizure onset age of the second group was younger during adolescence, and the seizures were usually responsive to antiepileptic drugs. The second group was thought to have idiopathic generalized epilepsy with praxis-induced seizures.

In praxis-induced seizures, the seizures or discharges were precipitated when a patient is required to think of a task in a sequential fashion,

to make decision and to give response by the use of a part of his/her body under the stress of circumstances. The most potent precipitation is "non-verbal" that involves spatial processing and ideation or execution of praxis. Transcoding processes of thinking into voluntary or intentional acts seem to be involved in the epileptogenesis. The praxis is not necessarily accompanied by actual motor movement, but must include ideation of motor activity.¹²

Matsuoka *et al*³² studied 480 patients with EEG during neuropsychological tasks. The tasks included reading, speaking, writing, written and mental arithmetic, and spatial construction. The authors found 38 patients who have paroxysmal EEG changes or clinical seizures triggered by various praxis activities. Out of these, 36 patients have IGE. The triggers include writing, spatial construction, and calculation.

Thus, the precipitation of seizures in praxis induced epilepsy includes higher cortical activity with spatio-manual involvement. Types of seizures induced are typical of juvenile IGE. Unprovoked seizures are also common.

As mentioned, there are many similarities between primary reading epilepsy and praxis-induced seizures. Both are of juvenile onset, idiopathic, has a benign course and is responsive to similar antiepileptic drugs, involving both higher cortical and motor performances together, and ictal motor symptoms start in the same motor segment where the precipitating activity takes place.

REFLEX EPILEPSY AND NOSOLOGY OF EPILEPSY

In summary, patients whose seizures are induced by higher brain function may have symptomatic focal epilepsy, or idiopathic localization-related or generalized epilepsies. The various types of epilepsies and seizures induced by higher brain function are schematically represented in Figure 1. As shown, the majority of the seizures with emotion and experience as precipitants are focal epilepsies, whereas the vast majority of reading and praxis induced epilepsies are idiopathic epilepsies and especially generalized ones. In the latter cases, the hyperexcitable regions and systems activated by stimuli, that can be diffuse but not necessarily uniform and differ in degree and extent, may produce epileptic activity that involves the cortico-reticular or cortico-cortical pathways, with the result of generalized or bilateral epileptic events.³³ The induced clinical manifestations may be symmetrical or asymmetrical, even localized.

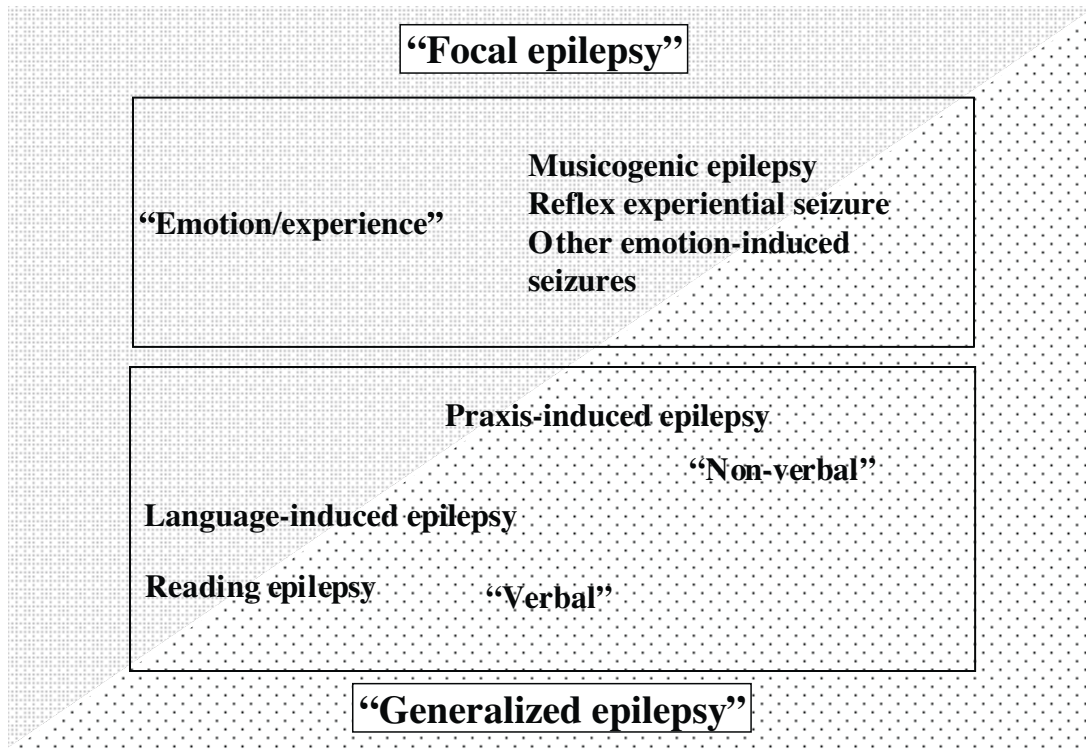


Figure 1: Schematic representation of various epilepsies and seizures induced by higher brain function. The left top half represents focal epilepsy and the bottom right half generalized epilepsy.

A greater appreciation of seizures with higher brain function as precipitants may thus contribute to greater understanding of epileptogenesis, but also of nosology of epilepsies.

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