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The possible role of the insula in the epilepsy and the gambling disorder of Fyodor Dostoyevsky

DALMA TÉNYI[1]*, CSILLA GYIMESI[1], NORBERT KOVÁCS[1], TAMÁS TÉNYI[2] and JÓZSEF JANSZKY[1]

[1]Department of Neurology, Faculty of Medicine, University of Pécs, Pécs, Hungary
[2]Department of Psychiatry and Psychotherapy, Faculty of Medicine, University of Pécs, Pécs, Hungary

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Background: The retrospective diagnosis of Fyodor Mikhailovich Dostoyevsky's (1821–1881) neurological and psychiatric disease proves to be particularly interesting. Recent neurobiological data suggest a solution to the questions regarding the writer's retrospective diagnosis, claiming the insular cortex to be the origin of the rare ecstatic seizures. Regarding Dostoyevsky's pathological gambling, this hypothesis is consistent with another finding from recent neuroscience, namely that the malfunction of the insula could be an important underlying pathology in gambling disorder. *Case study:* Literary and scientific overview (1928–2015) on the subjects of Dostoyevsky's epilepsy and gambling disorder. *Discussion and conclusion:* Taking Dostoyevsky's neurological (ecstatic seizures) and psychiatric (pathological gambling) disease and the crossroads into consideration, these two disciplines make regarding the underlying pathology, we would like to suggest a speculative theory that these two disorders have a common insular pathomechanism, namely, the malfunctioning of the risk prediction–risk prediction error coding system. Furthermore, based on Dostoyevsky's case, regarding gambling disorder in general, we would like to hypothesize that the three common gambling-related cognitive distortions (near-miss effect, gambler's fallacy, and the illusion of control) can be all attributed to the impairment of the anterior insular risk prediction–risk prediction error coding system.

Keywords: gambling disorder, gambling-related cognitive distortions, risk prediction–risk prediction error coding system, illness of Dostoyevsky, ecstatic seizure

BACKGROUND

Re-evaluation of famous individuals' illnesses in the light of recent neurobiological research data has been a great challenge for medical pathobiographists. The retrospective diagnosis of Fyodor Mikhailovich Dostoyevsky's (1821–1881) neurological and psychiatric disease proves to be particularly interesting. While the Russian writer's retrospective diagnosis of epilepsy is well known, the gambling disorder accompanying him throughout his life is not as widely known. Although the retrospective diagnosis regarding the type of the writer's epilepsy has been raising serious arguments among epileptologists since the 1960s, recent neurobiological data suggest a solution to these questions claiming the insular cortex to be the origin of the seizures. Regarding Dostoyevsky's pathological gambling, this hypothesis is consistent with another finding from recent neuroscience, namely that the malfunction of the insula could be an important underlying pathology in gambling disorder.

METHODS

We performed a literary and scientific overview (1928–2015) on the subjects of Dostoyevsky's epilepsy and gambling disorder, as well as cognitive distortions in gambling disorder. The following search terms were used in the database of PubMed: "Dostoyevsky epilepsy," "Dostoyevsky gambling," "Dostoyevsky illness," "ecstatic seizure," "Dostoyevsky seizure," "Dostoyevsky psychopathology," "Dostoyevsky psychiatric disorder," "gambling cognitive distortion," "gambling near-miss," "near-miss insula," "gambler's fallacy," and "gambling illusion of control." Twenty-five articles and five books were identified and included in this study.

CASE PRESENTATION

The aspect of epilepsy

The ecstatic aura. The reason why Dostoyevsky's epilepsy brought up retrospective differential diagnostic questions is the subject of the so-called "ecstatic aura": a type of simple partial seizure – first described by Moritz Heinrich Romberg

* Corresponding author: Dalma Tényi, PhD student; Department of Neurology, Faculty of Medicine, University of Pécs, Rét u. 2, Pécs 7629, Hungary; Phone: +36 72 536000; Fax: +36 72 535911; E-mail: tenyidalma@gmail.com

in the nineteenth century – Dostoyevsky experienced besides his grand mal seizures (Tényi et al., 2014). Descriptions by the Russian writer himself of ecstatic aura are available in his friends' memoirs and the central character in his novel *The Idiot*, Prince Myshkin, who suffers from epilepsy, also giving a detailed description of this phenomenon. His close friend Nikolay Strakhov quoted a detailed description of these ecstatic seizures of Dostoyevsky:

> "for several brief moments I feel a contentedness which is unthinkable under normal conditions, and unimaginable for those who have not experienced it. At such times I am in perfect harmony with myself and with the entire universe. Perception is so clear and so agreeable that one would give ten years of his life, and perhaps all of it, for a few seconds of such bliss." (Gastaut, 1978, p. 188.)

The most well-known description of an ecstatic aura is from Prince Myshkin:

> "All his agitation, all his doubts and worries, seemed composed in a twinkling, culminating in a great calm, full of serene and harmonious joy and hope full of understanding and the knowledge of the final cause [. . .] What does it matter that it is an abnormal tension if the result of the moment of sensation, remembered and analyzed in a state of health, turns out to be harmony and beauty brought to their highest point of perfection, and gives a feeling, undivined and undreamt of till then of completeness, proportion, reconciliation, and an ecstatic and prayerful fusion in the highest synthesis of life?" (Dostoevsky, 1977, p. 258., translated by Magarshack)

As shown in the above paragraphs, these seizures are characterized by *increased awareness* (of self and environment), *increased confidence*, and *extreme joy* accompanied by a feeling of numinosity.

Scientific debate about Dostoyevsky's epilepsy. It is no wonder that this extremely rare and strange manifestation of epilepsy brought up questions – even arguments regarding the possibility of its existence. Freud interpreted Dostoyevsky's grand mal seizures as hystero-epilepsy (Freud, 1945). Building his psychoanalytical hypothesis on the – since queried – fact that the Russian writer had his first seizure after his father's death. This traditional psychoanalytical interpretation could be easily proven to be wrong by examining the seizure semiology. In 1963, Alajouanine interpreted Dostoyevsky's epilepsy as temporal lobe epilepsy, the presence of ecstatic aura being his most important argument (Alajouanine, 1963). Gastaut determinedly denied the existence of ecstatic aura – claiming it to be only the fruits of an extremely talented and creative mind – and denied the retrospective diagnosis of partial epilepsy (Gastaut, 1978). It was an interesting turn when Cirignotta, Todesco, and Lugaresi (1980) first registered ictal temporal discharge on electroencephalogram (EEG) in a patient with ecstatic aura, confirming the temporal lobe as the symptomatic zone – thus ending the 20-year-long scientific debate. Based on this new evidence of the existence of an epileptic ecstatic aura, a consensus formed about Dostoyevsky's epilepsy and his ecstatic seizures being of temporal lobe origin (Baumann, Novikov, Regard, & Siegel, 2005; Hughes, 2005; Rayport, Rayport, & Schell, 2011; Rice, 1985; Rossetti, 2006; Seneviratne, 2010). This localization hypothesis has been considered as valid for almost 30 years although in the light of recent data it has been strongly queried.

Recent neurobiological findings. Insular risk prediction–risk prediction error coding system. The temporal lobe hypothesis established by Cirignotta et al. (1980) was recently confuted. The new theory was based upon a 28-year-old patient's case who had been suffering from psychomotor epilepsy since the age of 3, ecstatic auras preceding the complex partial seizures. Fused single-photon emission computed tomography (SPECT) + MRI images were obtained and showed hyperactivation in the left anterior insular cortex during an ecstatic seizure. Fortifying this finding with subdural EEG recordings led to a new hypothesis: malfunction of the insular cortex could be the underlying cause of ecstatic seizures (Landtblom, Lindehammar, Karlsson, & Craig, 2011).

In this regard, two newly discovered insular functions have to be mentioned that provide further fortification for the insular theory. It has been proposed that parts of the insular cortex have fundamental role in first, *self-awareness*, and second, the *risk prediction–risk prediction error coding system*.

In a three step insular model, Picard and Craig (2009) summarize the role of the insula in *self-awareness* development: (1) the posterior insular cortex supplies the perception of the whole body; (2) this perception's re-representation then takes place in the mid-insula; (3) finally, receiving signals from the mid-insula and the limbic structures, the anterior insula plays the mean role in whole-body-perception as well as emotional perception and integration.

The recently discovered *risk prediction–risk prediction error coding system* located in the anterior insula plays an important role in perceiving and processing risk prediction and risk prediction error. Regarding all events that could happen even with the slightest possibility, the brain predicts the most probable outcome. If the outcome matches the prediction, the prediction was correct and no prediction error obtains (Picard, 2013). However, when the prediction and the outcome are different, prediction error occurs. The adequate perception of prediction error has an important role in adaptation because representing the occurring prediction errors toward the other cortical areas is an important basis of adaptation: it helps not to make the same risk prediction mistakes again. This hypothesis is fortified by the neuroimaging investigations by Preuschoff, Quartz, and Bossaerts (2008) who detected two signals in bilateral anterior insula during a simple gambling task: one reflecting risk prediction and other reflecting risk prediction error. Asking the healthy participant to guess a card's value, risk prediction rose indicated by the activation of the rostral part of the anterior insula on functional magnetic resonance imaging (fMRI). Revealing the card's value (when the outcome did not match the prediction), risk prediction error occurred indicated by the activation of the caudal part of the anterior insula (Preuschoff et al., 2008). These two signals were separated not only in space but also in time – giving evidence for the existence of the risk prediction–risk prediction error coding system.

In view of these two newly recognized insular functions, two main symptoms of ecstatic aura can be explained. On the one hand, ictal hyperactivity of the self-awareness coding system results in increased self-awareness, phenomenon patients usually mention to be the characteristic of ecstatic auras (Picard & Craig, 2009). On the other hand, increased confidence, another important symptom, can be attributed to the ictal malfunction of the prediction error coding system (Tényi et al., 2014). Taking all recent data into consideration, there is growing evidence that epileptic malfunction of the insular cortex could be responsible for ecstatic auras after all.

The aspect of gambling disorder

Gambling disorder of Dostoyevsky. Transpassing to the psychiatric aspects of Dostoyevsky's pathology gambling disorder has to be taken into consideration. The Russian novelist struggled with pathological gambling nearly throughout his adult life: his biography researchers usually refer to the fact that he lost all his money on roulette several times. Interesting literary historical fact that one of his famous short novels, The Gambler (a story, inspired by his own gambling addiction), was written under strict pressure in order to be able to pay off his gambling debt. The well-known gambling disorder-related pathological cognitive and behavioral patterns can be recognized in the following letter written to his brother by Dostoyevsky:

> "…in Wiesbaden I invented a system, actually tried it out, and immediately won 1,000 francs. The next day I got excited and departed from the system and immediately lost. In the evening I returned to the strict letter of the system again and soon won 3,000 francs again without difficulty. […] And then to cap it all I arrived in Baden, went to the tables, and within a quarter of an hour I won 600 francs. This whetted my appetite. Suddenly I started to lose, couldn't control myself and lost everything. After that I wrote to you from Baden, took my last money, and went to play. Starting with 4 napoleons in won 35 napoléons in half an hour. I was carried away by this unusual good fortune and I risked all 35 napoleons and lost them all." (Jones, 1991, p. xvi)

The proven role of the insula in gambling disorder. Gambling disorder (previously referred to as pathological gambling and classified as "Impulse-Control Disorders Not Elsewhere Classified" in DSM-IV) has recently been reclassified in the DSM-5 under the subsection of "Non-substance-related disorders" in the category of "Addictions and Related Disorders." This reclassification can be attributed to the significant amount of growing evidence that gambling disorder has similarities to substance use disorders in many levels (i.e., genetics, neurochemical and neurobiological mechanisms, clinical characteristics, and treatment response). In a review published in 2010, van Holst, van den Brink, Veltman, and Goudriaan (2010) identified four important cognitive–emotional processes that initiate and maintain addictive behavior, especially focusing on gambling disorder: (a) reward and punishment processing, (b) impulsivity, (c) attentional bias and cue reactivity, and (d) decision-making and executive function. The insular cortex was identified among the underlying causes in two out of four processes: *attentional bias and cue reactivity* and *decision-making and executive function*.

Analyzing *reward and punishment processing*, patients with gambling disorder (as well as patients with substance use disorder) have lower sensitivity for reward, thus they are more susceptible for initiating reward seeking behavior (van Holst et al., 2010). This theory is consistent with the fMRI findings that showed lower ventral striatal and ventromedial prefrontal cortex activity during monetary gains in pathological gamblers compared to controls (Reuter et al., 2005). Regarding punishment processing, patients with gambling disorder are considered to have diminished sensitivity to punishment, creating the risk for poor choices through insufficient feedback (van Holst et al., 2010).

Regarding *impulsivity*, neurocognitive studies indicated that the process of ignoring irrelevant information and inhibiting irrelevant behaviors is impaired in patients with gambling disorder (Goudriaan, Oosterlaan, de Beurs, & van den Brink, 2004). Impulsivity playing an important role in initiating and maintaining gambling behavior is fortified by the high comorbidity of attention deficit hyperactivity disorder with pathological gambling.

Cue reactivity in patients with gambling disorder was also analyzed with neuroimaging; however, the results of the different fMRI studies are inconsistent. Although not analyzing patients with gambling disorder, an interesting study pointed out the role of the insula in drug urges and craving: patients with damage to the insular cortex were more likely to manage to go through a disruption of smoking addiction (Naqvi, Rudrauf, Damasio, & Bechara, 2007). This interesting finding raises the hypothesis of the insular cortex playing a sufficient part in craving and drug urge, maintaining addictive behavior.

Regarding the role of the insula in gambling disorder, the processes of *decision-making and executive function* are the most relevant. As the Iowa Gambling Test indicates, patients with gambling disorder ignore long-term consequences to obtain fast short-term gratification – in other words, they are "myopic for the future" (Bechara, Dolan, & Hindes, 2002). In patients with gambling disorder, impaired decision-making is attributed to three main cognitive distortions: the "near-miss effect," the "gambler's fallacy," and the "illusion of control." Insular involvement in all of these three cognitive impairments has been indicated in separate neuroimaging and lesion-control investigations.

The first distorted construct is the "*near-miss effect*," a belief that the outcome of "almost winning" is closer to winning than losing. This effect can be best demonstrated with the slot machine game, in which case – after pressing the "start" button – win occurs when three identical figures show up in the same row (i.e., apple–apple–apple). However, a result with "apple–apple–orange" does not win, the patient with gambling disorder do not identify it as a pure loss but claims it to be closer to winning. The results of neuroimaging studies gave explanation to the near-miss effect showing that near-misses show overlapping activation with wins in the bilateral insula, ventral striatum, and medial prefrontal cortex in patients with gambling disorder (Chase & Clark, 2010; Clark, Lawrence, Astley-Jones, & Gray, 2009; Dymond et al., 2014). The second cognitive distortion that is commonly observable in gambling disorder is the "*gambler's* *fallacy"* (also known as Monte Carlo fallacy): a belief that the chance of an outcome (e.g., heads or tails) is not independent from the previous outcomes but rather depends on them. For example in the case of playing heads or tails, after a row of 34 heads (which is statistically rare but can happen), the gambler thinks that the outcome of the next throw will more likely be tails than heads (however, the next outcome's chance is still fifty-fifty percent theoretically). In a lesion-control study Clark, Studer, Bruss, Tranel, and Bechara (2014) found that patients with damage to the insular cortex ($n = 8$) are no longer susceptible to the "gambler's fallacy" and the "near-miss effect" – giving evidence that the insula may be the underlying pathology in these cognitive distortions. The third cognitive distortion patients with gambling disorder are more susceptible to the "illusion of control": the misbelief that personal participation in the gambling process has a positive effect on the outcome. The belief of the significant positive effect of pressing the "start" button personally rather than leaving it up to a computer is commonly observable in slot machine players. Significantly enhanced connectivity between the insula and the ventral striatum was detected in the "illusion of control" contrast during gambling in an fMRI investigation (van Holst, Chase, & Clark, 2014). The authors hypothesized excessive insular recruitment during illusion of control to be a risk factor in maintaining gambling behavior.

DISCUSSION

There is a long-recognized association between epilepsy and compulsive behavior: it has been previously described that they tend to be co-occurring disorders. Seizure-evoking irritative lesions of the temporal and frontal lobes were described to possess the ability to elicit compulsive behavior (Bartolomeil et al., 2002; George & Greenberg, 1997; Kaplan, 2010). In an article discussing the epilepsy and gambling behavior of Dostoyevsky, Hughes (2005) concluded that this common ground-sharing comorbidity could be applied to the Russian writer's case as well; however, he did not propose a detailed hypothesis about the exact pathomechanism. Based on our findings regarding the ecstatic seizures and the pathological gambling of Dostoyevsky, we raise the speculative hypothesis that these two disorders shared common pathomechanistic ground, namely, the malfunctioning of the insular risk prediction and risk prediction error coding system.

Based on the neuroimaging and lesion-control studies, the three impaired cognitive processes can all be connected to the malfunction of the insular cortex. Although the neuroimaging investigations mostly indicate excessive insular recruitment, the exact pathomechanism underlying these cognitive distortions is still unknown. We would like to raise the speculative hypothesis that the three cognitive distortions observed in gambling disorder (near-miss effect, gambler's fallacy, and the illusion of control) are the results of the impaired functioning of the insular risk prediction–risk prediction error coding system (Table 1). Near-misses showing overlapping recruitment with wins can be interpreted as the impaired functioning of the prediction error coding system, failing to issue an appropriate error signal when losing: that is why the patient interprets near-miss an entity being closer to "win" than to "loss." On the other hand, "gambler's fallacy" and the "illusion of control" can be attributed to the malfunction of the risk prediction coding system. Both the irrational misbelief that an outcome of a single event is dependent on the previous outcomes (gambler's fallacy) and the cognitive distortion that personal involvement is beneficial in a chance situation (the illusion of control) can be interpreted as impaired risk assessment (Table 1).

Table 1. Gambling-related cognitive distortions and insular functioning

	Evidence				Hypothesis
	Role of insula	Study	Nature of study	Finding	Insula pathomechanism
Near-miss effect		Clark et al. (2009)	Functional neuroimaging	Near-misses recruited insular circuitry and this activity correlated with gambling propensity.	
		Dymond et al. (2014)	Functional neuroimaging	Near-misses recruited similar brain regions to wins, including the insular cortex.	
	Proven	Dymond et al. (2014)	Magneto-encephalography	Increased theta oscillations to near-misses were measured in the insula.	Impaired functioning of the *risk prediction error* coding system.
		Clark et al. (2014)	Lesion control	Damaged to the insula abolished motivation to play after near-misses in slot machine task.	
Gamble's fallacy	Proven	Clark et al. (2014)	Lesion control	Gambler's fallacy, measured by roulette task, was disrupted in patients with insula damage.	Impaired functioning of the *risk prediction error* coding system.
Illusion of control	Proven	van Holst et al. (2014)	Functional neuroimaging	Insular connectivity correlated with gambling severity in the illusion of control contrast.	Impaired functioning of the *risk prediction error* coding system.

Although the retrospective diagnoses of both Dostoyevsky's gambling disorder and epilepsy are widely accepted assumptions in the literature, due to the nature of this topic, EEG, neuroimaging, and thorough psychiatric evaluation data are not available for assessment. Even though after careful consideration of these certain limitations, in our opinion, proposal of these speculative hypotheses could serve to be relevant and useful in the light of Dostoyevsky's medical pathobiographic evaluation, as well as the clinical management of the two discussed disorders.

CONCLUSION

Taking Dostoyevsky's neurological (ecstatic seizures) and psychiatric (pathological gambling) disease and the crossroads into consideration, these two disciplines make regarding the underlying pathology, we would like to suggest a speculative theory that these two disorders have a common insular pathomechanism, namely, the malfunctioning of the risk prediction–risk prediction error coding system. Furthermore, regarding gambling disorder, we would like to hypothesize that the three common gambling-related cognitive distortions can be all attributed to the impairment of the anterior insular risk prediction–risk prediction error coding system. We would like to point out that the Russian novelist's story is an instructive example how a medical pathobiographic case could provide further evidence to the recent fast-developing neuroscientific researching methods.

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