



A historical review of functional neurological disorder and comparison to contemporary models

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ABSTRACT

Over the centuries, various etiologies have been proposed to explain functional neurological disorders (FND), including functional seizures. These have included models relying on supernatural influences upon the body, emphasis on consequences of malfunctioning reproductive organs, the bodily expression of painful emotions involving traumatic memories, or cognitive distortions through attention and predictive biases. Many theorists, especially since the 19th century, have had overlapping themes that continue to be relevant in modern clinical use. Treatments developed in accordance with different conceptual mechanisms. Given the heterogeneity of the disorder and the variable response to individual treatments obtained through history, physicians must consider symptom expression of an FND as an overestimation. An appreciation of multiple theories allows flexible development of unique treatment plans for individual patients.

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Introduction

Functional neurological disorder (FND) has gone by many names throughout history, reflecting its various proposed etiologies: hysteria, nervous system disorder, conversion disorder, psychogenic or non-organic illness, functional neurological disorder, etc. Even amidst specific symptomatology, a wide array of descriptors may refer to the same phenomenology, such as functional seizures, psychogenic non-epileptic seizures, dissociative seizures,

hysterical seizures, and pseudoseizures. This shifting nomenclature may suggest something about the difficulty of the medical field in describing the phenomenon in a way that is acceptable and understandable to both physicians and those suffering from it. Despite our knowledge growth in recent decades, our understanding of FND is not as advanced as it is for other neuropsychiatric disorders.

Throughout this paper, in an attempt to provide some sense of integration, historical concepts will be linked to modern language while also referencing formerly used terms. Language is precise and there is no doubt meaning is lost, at least to some degree, when old terms are replaced with newer ones to refer to the same

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phenomenon. Modern terminology, such as FND, is more agnostic in terms of implicit explanatory mechanisms (for instance, compared to conversion disorder) and lacks the negative bias that often is associated with outdated terminology. Alternatively, some argue that the trend towards complicated terminology may result in a strange and mysterious notion to the patient, obscuring psychological contributions [1]. Additionally, it should be noted that current day conceptualizations of mental health are contextualized within our modern society. Whereas we explore similarities in clinical descriptions, it presents a challenge to take a timeless position and ascribe a DSM diagnosis within other historical cultural settings [2].

Accurately identifying functional symptoms in historical texts with a relatively scant description of patient history and physical examination poses a significant barrier to diagnosing FND as we describe it today. Therefore, one must admit the limitations of a retrospective clinical description. While some reports may be diagnostically ambiguous, some descriptions can be convincingly functional, such as eyesight restored by means of suggestion.

Table 1 summarizes the specific aspects of the changing conceptualizations of FND over time: from early supernatural explanations to modern cognitive and neurocircuitry-based models.

Supernatural causes of FND

Supernatural causes of functional symptoms emerged as understandable conclusions that people drew based on their societal beliefs and medical knowledge of their time. Descriptions of what can be conceptualized as post-traumatic stress disorder in ancient Mesopotamia include associated symptoms that could be characterized as probably functional, such as loss of intelligible speech in the context of depression following a traumatic event. The explanation given to such disorders, as well as many other diseases, was of the gods punishing individuals by sending spirits, ghosts, or demons that were the cause of symptoms [3].

Similarly, in ancient Greece there too was historical evidence to assume gods were to blame for the development of functional symptoms, with elaboration of which particular god was accountable based on the semiology of the symptom. For example, in the tale of Epizelus, an Athenian soldier at the Battle of Marathon became blind during combat after witnessing the man next to him be killed. Epizelus himself was not physically harmed and it was believed the theft of his eyesight was caused by divine intervention.

Citizens could seek treatment of their functional woes from Temples of Aesculapius, the demi-god of medicine. This treatment could include an incubation or “temple sleep”, during which Aesculapius, the physician demi-god, would send the dreaming patient visions. After awakening, they would explain their dreams to a priest, who would interpret them as a guide for therapeutic measures [4]. It is recorded that, through this ritual, patients could recover their lost vision, voice, or ability to walk [5].

In the Middle Ages, supernatural causes continued to dominate the interpretation of disease, and sickness in general was thought due to the devil’s influence. If accused of witchcraft, (using the devil’s influence willingly for their own personal gain), people could be tortured and executed [6]. When reviewing illustrations of demonic possessions and exorcism, Charcot and Maudsley likened the depictions to their patients suffering from functional neurological disorders [7]. Janet had suggested that patients suffering from functional symptoms may have equally been praised as saints just as well as demoniacs, given their distortions in sensation and perception [8].

In the 18th century, Father Johann Gassner, who himself suffered from nervous illness, claimed to have cured himself by rites of exorcism and attracted much attention. He was later opposed by a physician, Franz Mesmer, who claimed to use curative techniques instead through a universal life force, “animal magnetism”. Mesmer described the ability to heal symptoms by means of relieving blockages of these life forces. Initially, this included having the patient swallow iron fillings and using magnets, while later he adopted grandiose gestures and poses to help patients while abandoning the magnets, instead relying only on his own inherent powers. He was the source of much controversy and the medical community (with the assistance of Benjamin Franklin’s placebo-controlled trial) denounced his practice and beliefs, referring to it as sourced from delusion or imagination [9]. There are accounts, nevertheless, of him being able to temporarily reverse blindness in a piano player through his practice of such animal magnetism. The successful therapeutic interventions were thought also to be chiefly related to temporary improvement of functional neurological disorders via hypnotism and suggestion, empowered by the strong therapeutic alliance he formed with his patients [10].

FND caused by reproductive organs

Texts as old as the 1900 BC Egyptian Kahun Medical Papyrus offer references to a collection of otherwise unexplained symptoms which are attributed to uterine dysfunction. For example, the pain of “a woman whose eyes are aching till she cannot see, on top of aches in her neck” is suggested to be caused by “discharges of the womb in her eyes” [11]. As such, some scholars have suggested this be perhaps the first recorded description of FND, referencing the wandering womb found in other ancient texts as a suggestion of a hysterical etiology [12]. At the same time, given the significant degradation of the texts, this claim of uterine etiology of functional symptoms has been challenged [13].

The term “hysteria” owes its origin to ancient Greek philosophers and physicians, with its root meaning associated with the womb or uterus. In Plato’s *Timaeus* he references the animalistic desires for procreation inherent in men and women, commenting that if the womb lies infertile for too long, it shall become angry,

Table 1
Broad categorization of main themes seen within the history of functional neurological disorders.

	Proposed etiology	Proposed pathogenic mechanisms	Therapeutic interventions	Mechanism for therapeutic intervention
Supernatural	God or gods, demons, ghosts	Patients are punished for their actions through divine or demonic retribution	Prayer, temple sleep, punishment	Either appease the offended divine entity or pray to another to receive blessing and relief
Reproductive organs (hysteria)	Uterus (or testes/ semen for male patients)	The displaced uterus interferes with other organ functioning	Various perfumes, suppositories, dietary supplements, or marriage and conception	An attempt to return the uterus to its normal position or appease the sexual organ through procreation
Conversion and dissociation	Traumatic experiences	Painful affect and memories are repressed and converted into symptoms	Psychodynamic psychotherapy or psychoanalysis	Processing painful memories and affects alleviates symptoms
Cognitive and neurocircuitry models	Cognitive biases towards bodily symptoms	Predictive biases, increased limbic-motor network connectivity, altered prefrontal systems	Behavioral, cognitive, and/or mindfulness-based therapies; TMS	Cognitive re-appraisal of somatic symptoms; decrease in avoided activities; alter brain networks directly

thus wandering about the body causing blockages and a variety of illnesses [14]. The Hippocratic *Corpus* included a collection of medical texts under the name of Hippocrates of Cos from the fifth and fourth centuries B.C. [15]. The uterus was described to move in various directions internally, impinging on organs and consequently leading to a number of symptoms depending on its final resting place. For example, movement towards the head produced suffocation and a sense of heaviness in the head; alternatively, movement towards the heart also provoked suffocation, restlessness, and convulsion. Depending on the proposed movement, other symptoms included vomiting, pain, orthopnea, speech loss, dullness of vision, numbness, clenching of the teeth, coughing, leg contraction, amenorrhea, or sterility. The treatments varied based on the assumed location of the uterus, and could include many assorted combinations of hot water baths or fomentation, various foods, herbs, oils, or animal products, fumigation with fragrant substances, emetics, or suppositories [16].

The ancient Greeks also understood that men could suffer from similar symptoms as described in those attributed to the movement of the uterus, despite having no such organ to hold responsible. There was a continued theme of sexual organ dysfunction, with Galen of Pergamon explaining that these functional symptoms could possibly occur secondary to sperm retention [12]. Both men and women and their respective organs of reproduction were felt to have the potential to lead individuals to behave without reason as animalistic desire overcame good sense.

FND as a nervous illness: Charcot and colleagues

Many astute physicians made insightful claims regarding patients with functional symptoms over the centuries and deserve mention. In time, critique of witchcraft and supernatural etiologies began to arise, such as from sixteenth century physicians Henry Cornelius Agrippa and Paracelsus (though they were denounced or jailed). English physician Edward Jorden also claimed that symptoms thought to be functional in nature were not of supernatural decree but rather due to mental illness. Burton and Sydenham in the 17th century believed hysteria to be related to hypochondria and melancholy. Sydenham referred to the condition as a “Proteus” due to the heterogeneity and capacity for the symptoms to change and fluctuate [8]. Raulin supported Sydenham and maintained that the illness can affect both men and women. Whytt and Cullen in the 18th century hypothesized hysteria was a dysfunction of the nervous system.

In the latter half of the 19th century ideas surrounding functional neurological disorders began to shift, with interest growing within the neurologic community to explain these perplexing symptoms. Neurologists increasingly attempted to conceptualize disorders in more detail than had previously been described [17]. Though for centuries there appeared to be numerous physicians who recognized functional symptoms originating in the mind or brain, during this period, the connection to the uterus became more firmly discouraged and the disorder was conceptualized as a neurological or mental illness. This was once more emphasized by the acknowledgment of men, who obviously had no uterus, also suffered from functional symptoms. Pierre Briquet, a neurologist of Paris, observed hundreds of patients with functional symptoms over a ten-year course, allowing him the ability to recognize the association of the symptoms with painful emotion. He also commented upon epidemiological commonalities within this patient population, including female gender, youth, low socioeconomic status, suggestibility, family history of similar presentations, and situational stressors. His suggested treatments included alleviating the stressors and improving family situations, electrical stimulation, opiates, education, good nutrition, and/or marriage [18,19]

John Russel Reynolds, a neurologist of London, also discussed either morbid emotions or thoughts having the ability to mimic neurological symptoms, which were also accompanied often by a general fatigue or disability, and may be comorbid with other medical illnesses [19].

Jean-Martin Charcot, one of the most distinguished physicians of his time and considered a founder of modern neurology, took interest in functional symptoms during his appointment at the Salpêtrière Hospital in Paris. He spent a great deal of time recognizing patterns which could discern functional symptoms from other neurological disorders. Many of these diagnostic strategies are still in use today, such as splitting of the midline in somatosensory complaints [17]. Other techniques, have since been abandoned however, such as the attempt to use magnets to shift sensory abnormalities to the contralateral limb for further diagnostic specificity [12]. Though controversial within the medical community, Charcot used hypnotism as an additional diagnostic measure, finding patients with functional symptoms to be particularly susceptible to hypnotic suggestion. Hypnotism would allow for relief of symptoms in such a way that would be incompatible with many of the neurological disorders which those functional symptoms mimicked. Charcot believed a patient's expectation bias could also predispose functional symptoms to develop after a minor injury or trauma to the affected body part, which he referred to as autosuggestion [17]. Autosuggestion also was considered to account for the seemingly spontaneous initial onset or periodic recurrences of the disorder. Though there was acknowledgment that at some level the patient's own ideas about their illness propagated symptoms, he distinguished patients suffering from functional symptoms apart from intentional simulation of symptoms [17]. Similar to his conceptualization of other neurological disorders, Charcot believed that individuals with functional symptoms suffered from a hereditary predisposition of their illness. Though he acknowledged that certain stressors, such as psychological factors, could provoke symptom onset, he believed that only those with inherited predisposition could develop the disorder [17]. Consistent with his understanding of neurological illness, he believed that some neuroanatomically defined lesion could explain functional symptoms (for example, at the site of the contralateral motor cortex for functional motor symptoms).

Many functional patients at the Salpêtrière shared similar symptoms amongst one another, which led to the idea that there was a uniform presentation of the disorder. Charcot described functional seizures, of which he referred to as *la grande hystérie*. This consisted of four distinct phases which were variably present: epileptoid, violent movements, *attitudes passionnelles*, and delirium [20]. Retrospectively this led to the consideration that patients shared the physicians' expectation bias, which influenced symptom expression, or even led to accusation that some patients were fraudulently performing what was expected of them to the great audiences of Charcot's famous Tuesday clinic lectures [12,21]. Alternatively, a mass hysteria phenomenon, restricted to the patients within that section of the hospital, may have also explained the homogeneity in symptom expression.

Hypnosis became more popular, not only as a diagnostic method but also as a treatment for functional symptoms. Hippolyte Bernheim and Ambroise-Auguste Liébaux of the Nancy School believed the hypnotist's influence was psychological in nature, relying heavily on suggestion during a vulnerable state of sleepiness, rather than a transfer of any substance between practitioner and patient [12].

Alfred Binet and Pierre Janet shared the view that the dissociation of consciousness under conditions of significant psychological stress within functional states was similar to that of hypnotic states. Janet was a psychologist who focused on the psychological or mental aspects of patients with FND. Contrary to Charcot who

invested great time observing the specific phenomenology of the disorder, Janet viewed the study of such a variable range of symptomatic expression within the population too burdensome to realistically draw any meaningful conclusions from. He categorized the various functional convulsive episodes, contractures, paralyses, amnesias, vision and speech problems, and double personalities as sharing similar etiology despite their vastly different phenotypic presentations [8]. Janet recognized that in addition to suggestion, other psychological phenomenon such as strong emotions, preoccupation, and reveries would amplify symptoms, and could be modified depending on the context [8]. He appreciated the idea of automatic behavior that was precipitated by fixed ideas occurring below the level of consciousness [12].

Psychoanalytic theory and treatments of FND

At the turn of the 20th century, the study of the brain and mind began to fraction into two distinct disciplines: neurology and psychiatry, respectively. Patients presenting with functional symptoms had previously seen but one doctor, though now there were two potential treaters. As time progressed, treatment fell within the domain of psychoanalysts, while the descendants of Charcot continued to focus on those neurological disorders with clearer neuropathological association [22].

Sigmund Freud, an Austrian neurologist, initially studying neuropathology, was encouraged by Charcot to pursue an understanding of the hysterical phenomena. In 1895, Freud and Josef Breuer published *Studies in Hysteria* which included a theoretical introduction proposing a psychological mechanism for functional disorders, and included a case series [23].

Freud and Breuer attempted to understand potential inciting factors for functional symptoms. Although at times there was a clear correlation between a traumatic event leading to symptom formation, other times patients reported no clear cause despite obtaining a thorough history. They too used hypnosis as a diagnostic tool, discovering additional history of painful events not previously mentioned by the patient. If these dissociated events were then processed by talking about them, symptoms could remit. However, they realized that pure intellectual recitation of a traumatic event was insufficient to yield symptom resolution – it must be accompanied by the appropriate emotional reaction. They thus reasoned that a disconnect between memory and affect was a significant contributing factor within functional symptom etiology, hence the famous expression developed, “the hysteric suffers mostly from reminiscences.” [23] The patient may have not appropriately reacted to the original psychic trauma for any number of reasons, such as not being able to due to social setting, the affect being so overwhelming that it caused an autonomic surge such as a freezing or dissociative state, or even consciously inhibiting it from memory.

Freud and Breuer attempted to explain the wide variety of symptoms, which were broadly organized into “conversion” symptoms (including somatization) or “dissociative” symptoms (with altered level of consciousness), though often with significant overlap. It appeared that at times the form the symptoms took was merely coincidental, often having to do with the situation that was associated with the experience of the original painful affect. They gave an example of a significant stressor that originated during dinner, and while the affect was ignored or repressed, symptoms persisted through expression of significant nausea and vomiting.

Freud continued to elaborate upon his models of symptom formation, attempting to understand why some individuals would develop functional symptoms following a painful event and others would not [24]. He hypothesized that in addition to the traumatic

experience in adulthood, symptom emergence also depended on the disposition of the individual. This involved both their experiences in early childhood as well as hereditary constitution. Patients appeared to have capacity to regress to earlier ways of being (or alternatively may have never psychologically progressed beyond an early developmental phase). He considered symptom formation to be a substitute or compromise for patients to obtain otherwise inaccessible, and therefore frustrated, needs. The symptoms may allow, for example, a patient to be in a sick role and taken care of, or otherwise excused from some responsibility. Freud stated “In some way, the symptom repeats this early infantile kind of satisfaction, distorted by the censorship arising from the conflict, turned as a rule to a feeling of suffering, and mingled with elements of the precipitating cause of the illness [24].”

As the field of psychoanalysis and psychoanalytic theory evolved, study turned to an attempt to describe personality types that seemed more vulnerable to development of functional symptoms. Fritz Wittels in 1930 first described the hysterical personality as associated with strong dependent features. Hysterical (now currently “histrionic”) personality developed into an independent pathology without diagnostic requirement of functional symptoms. It is recognized that development of functional symptoms is not limited or unique to this personality subtype, and can be found amidst various personality styles, such as infantile, dependent, or masochistic [25].

Modern psychodynamic psychotherapy approaches functional symptoms depending on a number of both patient and therapist factors. General practice includes assisting the patient to construct a personal narrative that often includes recognition of the developmental effects of childhood trauma, managing potential regression, as well as fostering a greater awareness of ongoing psychic conflicts with increased capacity to accept and grieve painful affect. The primary goal is not amelioration of bodily symptoms (though this may be a beneficial byproduct), but rather understanding their symptoms’ symbolic representation, defensive purpose, and their impact on relationships and functioning [26].

The Great War and Shell Shock

The horrific catastrophes and collective trauma brought about by the Great War led many otherwise healthy soldiers to suffer from a condition referred to as *shell shock*. This umbrella term encapsulated a range of psychosomatic reactions to the intense artillery bombardments, which could range from symptoms now considered acute stress reactions to FND. In the absence of any physical symptoms, debates initially ensued as to whether these disorders were physical (including theories of concussive blasts), psychological, or malingering with intent to escape war duties [27]. Charles Myers, a British psychologist, described cases of soldiers recovering from traumatic experiences of being targeted by artillery fire. He recognized their symptoms as remarkably similar to hysteria, noting cases such as vision loss or decreased acuity, visual sensitivity (being overwhelmed by electric lightbulbs), leg weakness, tremulousness, general convulsive movements, or muscle spasms, all unexplained by any physical injury. He felt these symptoms were manifested as a means to maintain dissociation from the traumatic event [28].

WHR Rivers, an English neurologist and psychiatrist, wrote that these symptoms of war were the result of the soldiers’ natural attempt to avoid and repress distressing affects and memories of war experiences, compounded by the physical strains of wartime trench life [29]. Advice given to the patient from friends, family, and even physicians initially, often colluded with the patients’ avoidance tactics, encouraging them to banish all thoughts of the war from their minds, which was of course impossible [29]. Rivers

instead suggested that the painful memories should be attempted to "...make them into tolerable, if not even pleasant, companions instead of evil influences which forced themselves upon the mind..." though he admitted some experiences were too irredeemably disgusting or horrible to find any positive reframe [29]. Doctors questioned why some and not others were affected, and considered familial predispositions of neurosis or psychosomatic tendency, or character traits developed from earlier formative experiences [27].

Re-emergence of neurobiological theories of FND

Functional symptoms continued under the label of hysteria, predominantly treated by the psychoanalytic community, through the first half of the 20th century. The first edition of the Diagnostic and Statistical Manual for Mental Disorders by the American Psychiatric Association differentiated psychosomatic disorders, termed *psychophysiologic autonomic and visceral disorders* (including "neurasthenia" in which the predominant complaint is fatigue), from conversion reactions in a few ways. According to this older description, "psychosomatic disorders" involved organs innervated by the autonomic nervous system rather than involving voluntary control or perception, had physiological rather than symbolic etiology, and its expression did not alleviate anxiety.

The diagnosis came under greater scrutiny with Eliot Slater's 1965 publication in which he followed a cohort of patients diagnosed with hysteria who were later found to have a number of organic pathologies (though sometimes pathologies were discovered many years later, thus it is not clear if the original symptoms were functional or related to emergence of later disease). He criticized the lack of clear positive diagnostic findings and raised concern that when no clear etiology could be found for symptoms which seemed mysterious, physicians reverted to labeling it a functional illness by default. To the extreme, he argued against its existence entirely, harshly stating "the diagnosis of 'hysteria' is a disguise for ignorance and a fertile source of clinical error" [30]. The paper had a profound impact on medical practice despite its significant flaws. It was later corrected that around the time of Slater's paper misdiagnosis rates of FND was around 15%, and in modern practice the number has further dropped to 4% (similar now to other neurological or psychiatric disorders) [31,32].

The nosological revolution in psychiatry during the 1980's abandoned the term hysteria and instead divided it into a variety of symptomatic descriptions, which included somatoform disorder, body dysmorphic disorder, dissociative disorders, and conversion disorder. One purpose of this division was an attempt to pin down the protean condition into more rigorous and concrete descriptions (in contrast to Janet's warning against this). As further editions of the Diagnostic and Statistical Manual of Mental Disorders were published, less emphasis was placed on etiology and theory. Currently, in the DSM-5, the need for any association with a traumatic event or stressor was removed as a diagnostic criterion for FND and the diagnosis relies mainly on whether clinical findings are or are not compatible with recognized neurological conditions [33].

Though long separated, the fields of neurology and psychiatry began once more to converge within functional neurological disorders as functional imaging led to the identification of possible biomarkers for the disease. In a way, the association of FND to neurocircuit dysfunction offers a means of legitimizing the diagnosis and decreasing stigma towards the illness. Harkening back to Charcot's assumptions of an underlying functional lesion, modern neurobiological theories support alterations in motor circuitry, increased limbic-motor network connectivity, and alterations in prefrontal systems thought to be involved in emotion regulation and cognitive control [34]. These neurobiological conceptualiza-

tions are complimentary rather than contradictory to the previously described psychological models. Brain circuit models may not argue for specific etiology but demonstrate a potential neurobiological mechanism of action for symptom expression and/or development.

Attention and expectation biases have long been appreciated in models of functional disorders, both in terms of precipitating and perpetuating factors. The prediction or anticipation of symptoms through Bayesian inference has been one theorized mechanism for functional symptoms, with these predictive processes superseding sensory input, and leading to a perception of symptoms as involuntary [35].

An interesting recent turn of events has led us back to the field's previous fascination with magnets and electricity, now via the electrical field conducted by transcranial magnetic stimulation. A better understanding of an underlying neurocircuitry dysfunction in FND will hopefully offer a more precise mechanism of action for TMS in this disorder. Historically, although electrical treatments (such as general faradization) have generated theories of complex biological interactions to explain treatment response for functional symptoms, they have ultimately each been replaced by models of placebo [36]. Understanding psychological factors that mediate any possible benefits, such as suggestibility, will need to be considered as we learn more about this potential treatment modality.

Comparison and overlap of theories

For thousands of years we have contemplated and proposed different explanations for functional neurological symptoms. Though described as protean in nature, clinical presentations even across history have shared remarkable similarities (reference Table 2), such as Epizelus's blindness during the Battle of Marathon and soldiers' vision loss from shell shock in the Great War, each demonstrating a dramatic reaction to wartime trauma. Though divine intervention plays little role in current etiological hypotheses, there are other recurring patterns arising, receding, and returning often disguised in new terminology.

A common theme, especially as an explanation amongst earlier curative techniques, has been the power of suggestion or placebo. The Temples of Aesculapius, for example, likely were of great benefit to patients, though cessation of symptoms would likely be considered predominantly mediated by a combination of anticipation of cure, suggestion, and the general atmosphere of shared belief [4]. Mesmer's animal magnetism, hypnosis, ovarian compression [21], and electric treatments all likely heavily relied on a similar mechanism. The suggestibility of FND patients has been supported by recent meta-analysis, offering potential for diagnostic value [37]. To what degree each of the curative techniques through the years relied on suggestibility is challenging to quantify, though it continues to be a powerful force that persists in today's clinical practice.

Though the concept of a reproductive system cause for functional symptoms has long fallen out of favor, the conflict derived between animalistic desires and opposing societal obligation has persisted in recurrent themes. One may consider the restless womb or seminal fluid referenced in the ancient Greek dialogues as representative of more instinctual drives (psychoanalytic theory) or primitive subcortical and limbic survival circuitry (neurobiological concepts). These inherent urges and behavioral patterns, including the referenced reproductive drive, can often become obstructed by law or social etiquette. Whereas psychosocially this could be conceptualized as individuals needing to manage instinctual urges in order to peacefully coexist in modern society, in parallel fashion it could be formulated as higher order prefrontal

Table 2
Historical themes have explanations that share overlap over the centuries. The pathological models generally had multiple convening contributions to explain the onset and perpetuation of functional symptoms.

Pathological mechanism	Historical and contemporary theories and their shared themes
Attention or predictive biases	This has been a consistent component of most theories since Charcot's "autosuggestion", Janet's "fixed ideas", Freud and Breuer's explanation of specific expression of symptom formation, and modern cognitive theories using Bayesian inference. Behavioral based distraction techniques target interruption of attention biases.
Dissociation	Hypnosis shares significant overlap with dissociative phenomenon and was used as treatment of functional symptoms. Janet conceptualized FND symptoms as a result of splitting of consciousness. Freud and Breuer theorized that overwhelmingly painful affect or traumatic memories were dissociated from consciousness. Both World War I shell shock and Epizelus of Marathon shared themes of bodily expression after trauma. Neurocircuit models demonstrate increased connection between limbic and motor symptoms, potentially generating symptoms and bypassing neocortical structures. Mindfulness psychotherapies in FND attempt to bring emotions into conscious awareness to prevent their bodily expression.
Avoidance	To a degree, dissociation is an avoidant mechanism in the setting of significant threat. Freud and Breuer also recognized secondary gain from the assumed sick role invoked by functional symptoms, including gaining care and compassion from friends or family, while avoiding other stress inducing responsibility, which further reinforced the symptoms. Cognitive behavioral theories recognize symptoms as behaviors that have a function, which is often avoidance of some perceived threat. Biological theories recognize increased autonomic activity in FND patients, mobilizing bodily resources to escape.
Placebo or suggestibility	Every potential theory offers a role for suggestibility, ranging from divine intervention through temple sleep to Mesmer's animal spirits to modern psychotherapies, though it is difficult to ascertain to what extent. The placebo effect has crossover also with predictive biases, as the expectation for a cure influences perceptive abilities

cortices managing long-term and abstract goals in the setting of automatic lower order responses that must be overridden, such as limbic structures reacting to perceived threat. Because many of these instinctual processes may arise outside of awareness, patients may not always be mindful of their influence. Relaxation techniques as part of psychotherapy for FND illustrates the recognition of a hyperactivated autonomic nervous system, an instinctual response to perceived threat; the diminished autonomic response may lead to reduction in or alleviation of functional symptoms [34,38].

Current psychotherapy trends propose models of functional symptoms that can harmoniously attempt to explain vulnerability, symptom formation, and perpetuation of illness. Grounding and distraction techniques acknowledge the patient's attentional bias leading to amplification of symptoms. This allows opportunity to interrupt autosuggestion, the conceptualization by Charcot of the self-fulfilling symptom generation by means of anticipation. Disruption of one's expectation bias and focus upon symptoms can itself be sufficient to alleviate them. These concepts also parallel modern mechanistic conceptualizations of FND as failures of inference, inspired by Janet and his writings on patients' fixed ideas influencing the generation of symptoms. These fixed ideas includes false predictive beliefs that modulate attention towards sensory or motor movements as well as incorrect deductions that such perceptions are symptoms [35].

Because patients frequently have limited acknowledgment of potential triggers of symptom provocation, manualized therapies such as cognitive behavioral therapy (CBT) encourage patients to track symptoms and other contextual factors in order to gain greater understanding of those situations that create vulnerability towards symptom expression. The importance of situational stressors as precipitants for the disorder has been long acknowledged, although their presence and acknowledgment may not be obvious at the time of diagnosis. As noted by Freud and Breuer in the past, patients frequently have a curious lack of conscious awareness regarding stressful events that precede their symptoms, and more recent studies have once again identified this linkage [39]. This may have been most obviously seen within shell shock in response to the tragedies of the Great War. On the other hand, the lack of identifiable precipitating events can signal other, long-term predisposing factors as having a more influential role in the development of a functional syndrome. In such cases of unidentifiable precipitants, cognitive mechanisms that developed over time may represent a more fitting explanation for how symptoms may have originated.

Historically, there has been continued emphasis on the importance of an environment free of stressors as an ideal climate for healing, again harkening back to the ancient temples of Aesculapius. This temporary reprieve may encourage a sick-role, however, and generally does not have carry over effect once the patient returns to their regular environment, such as that of Franz Mesmer's pianist, as her return to home correlated to her return of symptoms.

Still today it is not uncommon for patients to disavow the diagnosis of FND in favor of another medical illness. To some degree this can be attributed to the persistent stigma of psychiatric or mental health diagnoses, though this is likely more complex and multifactorial. After all, many patients often already have comorbid psychiatric diagnoses that they do not refute, and therefore additional factors must be considered. Although a circular explanation to some extent, expectation bias that contributes to symptom origin can be powerful enough to invalidate any suggested contribution from affective or psychological factors. Similar to Freud and Breuer's theory of symptoms playing an essential role in protecting against an uncomfortable affect, current research also supports viewing functional symptoms in the context of avoidance and escape mechanisms [39]. Resistance to the diagnosis also serves as a means of continuing to utilize this mechanism of avoidance to decrease painful affect, as unexpected insight may be overwhelming and rejected.

Table 2 summarizes how different explanatory mechanisms in FND (predictive bias, dissociation, avoidance, suggestibility) have repeated themselves over time with updated terminology and understanding.

For comparison, we may consider a patient suffering from functional seizures in 19th century Paris and the same patient's experience in a contemporary clinic. For the former, the patient is sent to the Salpetriere, given Professor Charcot's expertise in the subject. They are placed in a ward with many other patients that also suffer from functional seizures and/or epilepsy. Diagnosis is made based on carefully extracted history, observation, and hypnotic suggestion to induce an event, perhaps even within the amphitheater during a Tuesday lecture. Treatment consists of hypnosis to induce new behavior and cease psychic automatism, or possibly ovarian compression to cease seizure episodes, though patients could continue to reside in the asylum indefinitely [21,40]. The same patient, a century and a half later, may be sent by their outpatient neurologist, who suspects diagnosis of functional seizures after a careful history, organizes admission to an epilepsy monitoring unit. Diagnosis is made with a team including

a neurologist and psychiatrist, and the patient is discharged to outpatient follow-up. Treatment consists of ongoing check-in with neurology and psychiatry, as well as starting either psychodynamic psychotherapy, mindfulness based therapy, or cognitive behavioral therapy [41].

Summary

Although functional neurological disorders are still often referred to as poorly understood, we do have hundreds of years of clinical observations in which this illness has been carefully scrutinized, with repeated themes observed. It is clear that discerning the precise etiology of FND is a complicated matter. Though terminologies have been rebranded, there is also a surprising consistency within conceptualizations of FND since the 19th century and even in some theories from earlier times. In many ways, despite rotating terminology and fractioning of nosology, *plus ça change, plus c'est la même chose*.

Through time there appears a fluctuating course as to what degree the public or medical field assign the patient's control or responsibility over their functional symptoms. As the pendulum swings towards either extreme, patients are faced with either harsh judgment over what they feel is beyond their volition, or alternatively are helpless bystanders destined to invalidism. We attempt our best to appreciate the wisdom of past clinical acumen with the blessing of hindsight, dispose that which did not stand the test of time, and recycle the components that served to promote understanding and healing. Functional neurological symptoms have been explained through many lenses, from external punishment due to some aberrant behavior to neurocircuitry dysfunction. Patients with FND can have complex histories, the clinical phenotypes are heterogenous, but likely all the discussed theories offer helpful perspectives to aid in our treatment of those suffering from the disorder.

Ethical statement

The authors Geoffrey Raynor MD and Gaston Baslet MD confirm compliance with all relevant ethical regulations in this submission of the article "A historical review of functional neurological disorder and comparison to contemporary models" to Epilepsy and Behavior Reports.

Declaration of Competing Interest

Gaston Baslet has received honoraria for continuing medical education lectures on functional neurological disorder and royalties from Oxford University Press. The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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