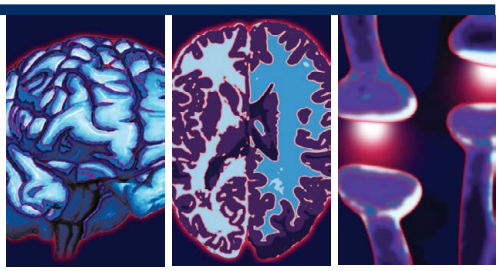
Review



The insane woman-mental disorders and female life history-a Darwinian approach

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ABSTRACT

Gender based differences in the prevalence rate of mental disorders are described since ancient times. In particular a strong association between female reproductive events such as sexual maturity, pregnancy, postpartum period or menopause and mental illness was described and mainly used to describe the female sex as the weak and emotionally instable one. In this review mental disorders associated with specific stages of female life history are analyzed and interpreted from the viewpoint of evolutionary medicine. In particular the association between female adolescence and eating disorders, reproductive phase and postpartum depression and depression during post menopause are focused on using an evolutionary approach. From that viewpoint mental disorders associated with female life history events seem to be adaptive to some degree, but mental disorders may also be interpreted as a result of the mismatch between recent life circumstances and the environment in which our ancestors evolved.

Keywords

Eating disorders, Postpartum depression, Depression, Female life history, Evolutionary medicine

Introduction

Mental disorders are among the most important health problems at the beginning 21^{rst} century [1,2]. According to the Global Burden of Disease (GBD) study published in 2007 mental disorders account for more than 25% of all health loss due to disability. This is more than eight times more than coronary heart disease and more than twenty times more than even cancer [3]. A systematic review of 174 studies published between 1980 and 2013 indicated that about 17.6% of adults experienced a common mental disorder within the past 12 months and 29.2% across their lifetime [4]. Mental disorders are found worldwide, although there is evidence of some regional variation, which may be due to cultural factors but also due to the fact that nationally representative data for incidence of mental disorders were sparse across most of the world [5]. Beside regional differences, mental disorder prevalence vary characteristically according to gender [6,7]. Although gender differences in rates of overall mental disorders, including rare disorders such as schizophrenia and bipolar disorders, are negligible, women suffer more frequently from mood disorders such as depression, anxiety and somatic complaints [8]. On the other hand the lifetime prevalence rate of substance abuse such as alcohol dependence is more than twice as high in men compared to women and men are more than three times as likely to be diagnosed with antisocial personality disorders [8]. Mental disorders reduce not only health related quality of life of affected persons; it represents also an economic and social challenge for societies. In an interview with the Guardian" at September 12th 2005, Lord Richard Layard, an emeritus professor in economics and Downing Street advisor pointed out that "Mental health

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is now our biggest social problem-bigger than unemployment and bigger than poverty" [9]. Consequently understanding the etiology and identifying risk factors of mental disorders remain a substantial ongoing challenge for psychiatric epidemiology. Beside genetic factors, ontogenetic influences and environmental stress factors, the application of evolutionary theory in order to understand causes and expression of mental disorders was introduced about 25 years ago [10]. Although a large number of evolutionary psychiatric texts have been published during the last two decades [11-21], an evolutionary perspective of mental disorders remain largely ignored by mainstream psychiatry and the medical community [22]. Recently however the concept of evolutionary or Darwinian medicine has been included in some medical curricula [23,24] and consequently this evolutionary approach to diseases may gain in importance in future, although Darwinian medicine does not offer treatments but explanations. In the present review mental disorders associated with female life history patterns are discussed from viewpoint of Evolutionary medicine.

The concept of evolutionary or Darwinian medicine

Evolutionary theory is above all associated with the name of Charles Darwin (1809-1882), who introduced the terms biological evolution, natural and sexual selection in science, but also considered evolutionary explanations for behavior and disease more than 150 years ago [25,26]. During the twentieth century evolutionary theory became an unquestionable part of natural science and consequently Theodosius Dobzhansky declared that "*Nothing in biology makes sense except in the light of evolution*" [27]. Since about 25 years an evolutionary approach is increasingly used to explain and to understand various medical conditions and eventually to allow a better understanding of current health care issues [28-31]. The concept of Darwinian or better evolutionary medicine in a recent sense was formalized in the early 1990ties most notably by the evolutionary biologists George C. Williams and psychiatrist Randolph Nesse [32], at least three main monographs have initiated evolutionary medicine [33-35]. To clarify how evolutionary theory can be used in medical science the different levels of causality in evolutionary biology have to be considered. Evolutionary theory makes a clear distinction between proximate or physiological and ultimate or evolutionary explanations of biological phenomena [36] Proximate factors are devoted to illuminate the *how* of human functioning based on the sum of all the biological processes such as genetic, epigenetic or physiological factors. Ultimate explanations, in contrast, try to answer the question *why* considering an evolutionary viewpoint and try to understand the contribution of a trait to the reproductive fitness of an organism in its natural environment. [22,37].

Disease itself was not the central target of evolutionary explanations, but Williams and Nesse tried to understand why natural selection has left the human body so vulnerable to diseases [32]. Consequently the focus of evolutionary medicine lays not on the disease but on the susceptibility to diseases. Evolutionary explanations for the vulnerabilities that make humans susceptible to disease are design trade-offs that offer an advantage overall, but leave us vulnerable to diseases such as genes that cause pathologies but give a net fitness advantage. On the other hand there are constraints, that is, limits on what natural selection can do because of its stochastic nature. Other possibilities are accidents that cause disease that are too rare to shape defenses. Furthermore evolved defenses may be interpreted as defects or diseases today. Somatic examples are fever, cough, vomiting diarrhea but also adverse emotions such as anxiety or sadness [17]. Of particular importance is the mismatch hypothesis. According to this idea there are novel environmental factors that change faster than our bodies evolve. Consequently a mismatch between our recent environmental conditions and the environment in which our ancestors evolved may result in various pathological conditions today [38,39]. The best example of this point of view are so called diseases of civilization or Western diseases comprising mainly metabolic and cardiovascular disturbances such as diabetes, obesity, hypertensions and arteriosclerosis [40]. According to the mismatch hypothesis *Homo sapiens* is adapted to a high mobile lifestyle and frequent food shortages and therefore to a very efficient energy storage. This adaptation to hunger and malnutrition does not work in an environment of food abundance and reduced physical activity levels [41,42]. During the last 20 years after Williams and Nesses initial publication [32] the concept and applications of Evolutionary medicine experienced their own evolution and was critically discussed in a

large number of publications [30]. Today the aim of evolutionary medicine is to investigate evolutionary causes of vulnerability to disease, malfunctions and design failures but also the investigation of the history of diseases in order to understand how changing living conditions but also processes of modernization and acculturation influenced health and disease. Consequently evolutionary medicine tries to explain diseases in terms of adaptation to environment. During the last years evolutionary medicine has increasingly focused on certain mental disorders. The so called Darwinian or evolutionary psychiatry have provided numerous new insights [12-14,19,21,43,44]. Nevertheless the evolutionary interpretation of mental disorders is still considered controversial [15-20,40,45-52].

Recently a framework for the evolutionary analysis of mental disorders based on a special conception of life history theory was presented by Del Guidice [53] and critically discussed [37,54-57]. Life history theory is a branch of evolutionary biology focusing on the way organisms allocate time and energy to growth and reproduction. The fundamental assumption of life history theory is that trade-off exists between energy expended on growth and factors influencing survival on the one hand and reproduction on the other hand. Each species has evolved specific life cycles which enhance reproductive success [58] Specific traits of human life history are an exceptionally long life span, an extended period of juvenile dependence, late reproductive maturity, a low number of offspring, cooperative breeding, all mothering i.e. support of reproduction, female menopause and long post reproductive span [59]. Female *Homo sapiens* life history is characterized in particular by a limited reproductive span of about 30 to 40 years and an extended postreproductive period [60,61]. The beginning and the end of reproductive span is additionally characterized by a high frequency of ovulatory cycles which reduce potentially reproductive span even more [62-64]. These different stages of life history may be associated with distinct mental disorders.

Mental disorders across female life span

The focus of this review is the analysis of mental disorders across female reproductive span from an evolutionary viewpoint. The assumption of a specific relationship between female reproductive function and mental disorders is nothing new.

■ Female reproductive function and mental disorders-a historical perspective

Since ancient times a strong association between female sex, female reproduction and mental illness or insanity was postulated. The first mental disorder attributable to women and for which an accurate description exist since the second millennium BC is without any doubt hysteria. Hysteria was mentioned in the Kahun Papyrus (1900 BC) and the Eber Papyrus (1600 BC) in ancient Egypt but also in ancient Greece [65]. Hippocrates (5th century BC) introduced the term hysteria named after the uterus (from the Greek ὑστέρα "*hystera*" = uterus) because he believed that the cause of this mood disorder lies in the movement of the uterus "*hysteron*". Hysteria was thought to be caused by a wandering womb or uterus and consequently the Greek physicians tried to cure hysteria by fumigation of the vagina to lure the uterus back into proper position. Hysteria as a typical female mental disorder was focused on by Roman physicians too. Aulus Cornelius Celsus (1rst century BC) provided an accurate clinical description of hysteria, but also by Claudius Galen (2nd century AD) mentioned hysteria and Soranus (2nd century AD) finally revolutionized hysterical cures [65]. The association between female reproductive organs but also female reproductive function and mental diseases dominated medical research through middle ages and renaissance up to modern age [65].

Since the 18th and 19th century, women outnumbered men in diagnosis of madness. For example in the Edinburgh infirmary 98% of hysteria cases were women in the late eighteenth century. Charcot who has been described as heralding the epidemic of hysteria in the late 19th century treated 90 male hysterics while in the same time approximately 900 women were diagnosed [66]. Thomas Laycock described hysteria as a woman´s natural state (1840). Increasingly female reproductive function was thought to promote female mental problems and cause female insanity by many psychiatrists, psychologists and antifeminists during 19th and early 20th century. Otto Weininger in 1903 declared that "hysteria is the organic crisis of the organic mendacity of women". The still most dubious fame in this respect goes to the German psychiatrist Paul Julius Möbius who published "On the physiological idiocy of women". According to these authors mental illness in women was increasingly seen as a result of female reproductive function. This connection between

female reproductive function and mental illness was used as an argument against political or feministic demands such as admission of women to universities or women´s right to vote. In 1869 James Mac Grigor Allan held a lecture concerning menstruation at the London Anthropological society. He stated: "At such times women are unfit for any great mental and physical labor. They suffer under a languor and depression which disqualify them for thought or action and render it extremely doubtful how they can be considered responsible beings, while the crisis lasts. Much of the inconsequent conduct of women, their petulance, caprice and irritability may be traced directly to this cause. It is not improbable that instances of feminine cruelty (which startle us as so inconsistent with the normal gentleness of the sex) are attributable to menstrual excitement caused by this periodical illness…."

Additionally a new view of female personality and mental illness emerged in the 19th century: women were perceived as passive, weak highly vulnerable to stress in particular during menstruation, pregnancy, postpartum and after menopause. In 1851 two women were found innocent of murder charges because they were found to have acted with temporary insanity as a consequence of suppression of menstruation or problems with their uterus [67,68].

Cesare Lombroso one of the fathers of criminology and criminological anthropology stated that most female criminals were menstruating at the time of crime. At the same time Richard von Krafft-Ebbing, a leading psychiatrist of this time, demanded that the courts should give special consideration to women whose menstrual problems or pregnancies are complicated by emotional influences beyond their control. Women were increasingly seen as victims of their reproductive function, in particular menstruation, childbearing, postpartum period and menopause which lead to deviant behavior or mental illness [67].

■ Mental disorders associated with female life history events

Although the theories of Weininger, Möbius or Lombroso are clearly obsolete today, some mental disorders are associated with particular stages of female life history. The prevalence of one of the most common mood disorders, depression, increases with reproductive developmental events such as puberty, pregnancy, postpartum phase, peri- and post menopause [69-71]. From a proximate viewpoint this observation suggests that sex hormones associated with female reproduction play a key role in depression [72]. Furthermore irregular cycles, late menarche and being in the first year post menarche were found to be differentially associated with depression, obsessive-compulsive disorder and eating disorders among high school girls [73]. Early menopause on the other hand is also associated with increased prevalence of depression [69].

In this review eating disorders mainly associated with female adolescence, postpartum depression, as well as depression during post menopause and old age are focused on and discussed from the viewpoint of evolutionary medicine.

■ Adolescence and eating disorders

The life history stage of adolescence marks the metamorphosis of the child into the adult. It starts with the onset of puberty and ends with the completion of the growth spurt, the attainment of adult stature height and the achievement of reproductive maturity [74]. Consequently adolescence is the entry in female reproductive life. Adolescence however is also a sensible phase of life when body image and body image dissatisfaction gain in importance [75]. In Industrialized countries an increasing number of adolescent girls are extremely concerned with their body weight and body shape [76]. Although only few of them suffer from a pathological eating disorder fulfilling all diagnostic criterions to DSM-IV [77] disturbances in eating behavior are increasingly common among female adolescents. Consequently eating disorders such as Anorexia nervosa or bulimia nervosa are among the most common mental disorders of adolescent girls and young females in First World countries and in case of Anorexia nervosa an increase in the incidence among 15 to 19 year old girls was observed over the past decades [78]. This trend and the mainly discussed the proximate causes of these disorders i.e. interacting psychological, social and biological factors [79] led to the assumption that Anorexia nervosa is mainly caused be environmental factors typical of postmodern Industrialized countries. Anorexia nervosa however, was described as early as 17th century. Eating disorders among female adolescents were already reported in the 19th century and interpreted in the framework of hysteria at that time. Today it is estimated that 10% of school-aged adolescent girls show partial anorectic or bulimic symptoms [80], but much more adolescent girls are worried about the

body weight, diet frequently and step on scale very often. But why adolescent girls strive for thinness? And why eating disorders or restricted eating behavior affects much more girls than adolescent boys? In a recent study carried among 677 Viennese adolescents aging between 10 and 18 years significant gender differences in body image, eating behavior and dieting could be observed. Body image, in particular the subjective description of weight status, differed significantly between boys and girls. Although overweight and obesity were rare among boys and girls of this sample more than 50% of girls during late adolescence, i.e. 15 to 18 years described themselves as overweight. This was true of less than 20% of the boys only. Regarding weight controlling practices it turned out, that significantly more girls than boys tried to reduce their body weight by dieting and stepped more often on a scale to control their body weight [81].

The association between extensive dieting and the stage of reproductive maturity seems paradox because the physiological consequence of intensive dieting and a longtime negative energy balance lead in prepubertal girls to a delay of sexual maturation and during later adolescence to a marked reduction of ovulatory cycles, anovulation and as worst case to secondary amenorrhoea. Extremely dieting girls reduce in this way their reproductive capability dramatically. Consequently eating disorders during adolescence reduce reproductive capability and in this way reproductive fitness. From an evolutionary viewpoint eating disorders are clearly maladaptive. During the last 30 years various evolutionary interpretations of the phenomenon eating disorders have been published. Voland et al. [82] pointed out the kin selection hypothesis interpreting restricted eating behavior and resulting anovulation as a helper at the nest phenomenon. Guisinger [83] introduced the "flee from famine hypothesis". He suggests that anorectic symptoms, including restricted food intake are manifestations of adaptive mechanisms to the conditions of famine that in our past facilitated migration from the famine in the depleted environment to a better one. But the key feature of restricted eating behavior or manifest eating disorders is reduced reproductive capability. This idea was first pointed out by Wasser and Barash [84], who introduced the reproductive suppression hypothesis in the early 1980ties. According to this idea human females can optimize their life time reproductive success by suppressing reproduction when future conditions for survival of the offspring are likely to be sufficiently better. Our ancestors did clearly not live in the Garden of Eden, and food shortages were a common experience. Gestation and lactation however are energetically costly and a too low fat amount would increase complications during pregnancy and increase the risk of pregnancy loss and neonatal mortality. For our ancestors the reduction of fertility potential during times of food shortage was clearly a positive adaptation. Adolescent girls in contemporary First world countries suffer extremely seldom from food shortages despite the refuse to eat enough or diet intensively. But extreme dieting postpone adolescent development and in recent First world countries sexual maturation takes place extremely early in comparison to former times but also in comparison to contemporary traditional societies. During the last 170 years age at menarche had decreased significantly from about 16.2 years in 1840 to about 12.2 years in 2000 [85]. Furthermore the period of frequent ovulatory cycles in first years after menarche had decrease markedly. Additionally first sexual intercourse occurs earlier. Early reproduction however, which is now physiologically possible, is not social desired in our postmodern society. Modern living condition in an affluent society have led to an increase of reproductive span, the society however does not support this biological change. Restricted eating behavior therefore may be interpreted as a strategy to postpone sexual maturation and enhance reproductive success through delaying reproduction until social circumstances increase the potential reproductive success.

■ Reproductive age-postpartum depression

Pregnancy and the postpartum period are associated not only with physical but also profound emotional changes [86,87]. Postpartum period is a particular vulnerable phase in female life cycle. After giving birth women in many cultures are subject to various postnatal rituals. They often follow certain dietary rules and other taboos and are cared for mainly by other women. This period of rest and seclusion usually lasts between 20 and 40 days. In Chinese culture this phase is called "Doing- the-month". During this time the mother will be confined to home and observe ritual practices which are thought to bring the postnatal condition back to a normal state of health. These behaviors should support mothers

and help them to cope with the new situation. Worldwide a significant number of mothers, however, experience a period of depression during postpartum phase. There are several forms of postpartum emotional disorders-from the so called baby or maternity blues which occurs typically for a short period of few days following delivery to postpartum depression which is later more prolonged and serious condition [87-89]. Symptoms include anxiety, guilt, negative maternal attitudes, and poor parenting self-efficacy and can have immediate ill effects on the offspring [87,90-92]. Internationally, the prevalence of postpartum depression is considered to be 10 to 15%, however prevalence rates ranges from almost 0% in Singapore to nearly 57% in Brazil [89]. In western societies approximately 10 to 15% of all mothers are affected by postpartum depression. Similar rates are found for various other societies such as 11.2% among Chinese women, 17% among Japanese women, and 16% for Arab women [93]. Higher rates are found among Indian women in Goa (23%) [89]. The exhaustion of a new mother, due to the demands of labor and the new situation with a new-born baby will often progress to postpartum depression. Negative feelings of a mother towards her newborn child associated with anxiety, feelings of guilt, and the impossibility to care for the newborn child have clearly adverse effects on the child and its chance to stay healthy and survive the critical period of neonatal phase and early infancy. Consequently from an evolutionary viewpoint postpartum depression seems to be maladaptive. Hagen [94,95] however provided an evolutionary interpretation of postpartum depressive disorders. At first we have to consider that rearing a child requires an extremely high maternal investment [96]. Human newborns are quit large at birth however they are extremely helpless in comparison to the social mammals such as non-human primates [57]. This feature is typical of humans and is the result of two counteracting evolutionary trends: bipedy i.e. upright locomotion and encephalization. Bipedy requires a narrow pelvis, which allows the legs to be close together in order to optimize biomechanics of biped locomotion. On the other hand the trend of encephalization resulted in larger brains and consequently larger fetal heads. This antagonistic interaction of bipedalism and encephalization makes childbirth consequently complicated and leads to the birth of premature helpless newborns [57,97]. Bringing up a human infant and child is a very costly experience requiring large amounts of time, resources and energy. In order to cope with these challenges *Homo sapiens* has evolved cooperative breeding and allomothering i.e. help provided by other women or sometimes the father. A lack of support may result in newborn death. Evolutionary theory predicts that a mother neither does automatically invest in every child and that the mother constantly evaluates the fitness costs and benefits of investing in her offspring [98]. Under adverse conditions the mother may defect her care and consider investing in other fitness enhancing behaviors. Hagen hypothesized that a lack of support by the father, poor environmental conditions, problems during pregnancy and birth or indicators that the offspring is unlikely to survive to reproductive age would have an impact of whether or not to invest in the offspring. Postpartum depression may give the mother the tool to defect from raising the child. Hagen called this evolutionary approach to postpartum depression the defection hypothesis [94,95]. The lack of support and adverse environmental conditions seem to be strongly associated with postpartum depression especially in recent times. In former times when large family units live close together family members were able to help the young mother. If insufficient care had been given initially the onset of postnatal depression would have resulted in immediate response. Family or other group members with a wealth of parenting experience would support the young mother. Baby blues or post-partum depression would increase the investment of their social network, by making themselves unable to care for their child. In this sense postpartum depression may be adaptive and fitness enhancing. Today the situation has completely changed only few people were born, raised, works and die in their local communities. The nuclear family and single moms have replaced the extended family and social isolation especially of young mothers is on increase. This situation may increase the prevalence of postpartum depression.

■ Menopause and post menopause

Human menopause is unique in nature and only few social mammals experienced an extended post reproductive phase, which is however not comparable to that of human females [60]. Menopause and extended post reproductive phase might have been favored by natural selection in various ways: menopause ensures that mothers are young enough to have a real chance to survive pregnancy, birth and early childhood of their offspring and ensures that

old oocytes are not fertilized [60]. Additionally post reproductive phase enables women to invest in the grandchildren generation and enhance reproductive fitness in this way [96-99]. Physiologically Menopausal transition is characterized by marked hormonal changes first of all a decline of estrogens and a rise of gonadotropins [60,61]. But menopause is also characterized by marked social and culture dependent changes of life. Furthermore menopausal transition or climacteric is related to an increased prevalence of psychological symptoms, depressive disorders and a loss of quality of life. As early as 1830 one physician notes" There is a predisposition to many diseases, and these are often of a melancholy character" (Joseph Ralph 1830). 1893 the French scientist Regis de Bordeaux used ovarian extract to treat a female patient for menopausal insanity. Even today it is well described that menopausal women often complain a depressive mood and population based studies showed that psychological disorders peaks during menopausal transition. Proximate or physiologically these symptoms are explained by estrogen deficiency, but also social factors may increase depressive symptomatic. In a recent study focusing on the situation of menopausal women with a background of migration in Vienna an extraordinary high prevalence of psychic symptoms, mainly depression was observed [100]. Depression scores were significantly higher among Turkish immigrant women in comparison to Austrian women. The Turkish immigrant women suffered markedly also from cultural isolation and a loss of their extended family.

A special risk factor for depression during post reproductive phase seems to be childlessness and the relationship between parents and offspring [101-103]. Childless post reproductive women experienced significantly higher depression scores than childless men or mothers of comparable age [104]. The increased risk of mental disorders in particular depression during post reproductive phase can be interpreted in a Darwinian sense. According to Watson and Andrews [45] so called social - navigation hypothesis depression is an evolved strategy to cope with unpropitious social circumstances. It signals the need for help and more investment from partners, or the social network [18]. Furthermore the association between reproductive history and depression during post reproductive phase may be interpreted as a result of a mismatch or the dysregulation hypothesis according to Wilson [105]. The recent situation of many posts reproductive may be childless women without a well working social network was completely uncommon in the environment where *Homo sapiens* evolved. At this time older individuals survived only in well working social networks. In the industrialized countries and postmodern societies however, many social networks do not longer exist. Postmodern societies are characterized by increased rates of divorce, single living arrangements, but also voluntary childlessness and the decline of the family as social institution [103]. The increasing number of ageing post reproductive women, who are childless, lonesome and suffer from a lack social support, is completely new in our long evolutionary history. The result of this trend may be a dysregulation according to Wilson [105] and as follows an increased rate of depression which also may be interpreted as an adaptation to this unfavorable living circumstances during post reproductive phase.

Discussion

This short review focused on mental disorders associated with female life history events such as adolescence, postpartum period, and post menopause from a viewpoint quite different from that of clinical medicine. During the last four decades psychiatry has accumulated an enormous base of knowledge and several effective new treatments [17]. The main goal of a clinical approach to mental disorders is to provide an effective treatment, which increase the patient´s the health related quality of life. The evolutionary approach discussed in this review however does not offer any treatment; the main goal is to understand the evolutionary basis of mental disorders. As already pointed out in the introduction section mental disorders are among the most important health problems at the beginning 21rst century. The World Health Organization has estimated that by 2020 major depressive disorders would constitute the second largest component of the burden of disease worldwide [2]. According to Lord Richard Layard we are confronted with an epidemic of mental disorders at the moment [9]. Mental diseases however are clearly not new disorders of the 20th or 21^{rst} century only. Earliest attempts to treat mental illness are evidenced by the discovery of trepanned skulls dating 5000 BC [68]. Early man widely believed that mental illness were the result of supernatural phenomena such as demonic possession or the evil eye.

Trepanations have been carried out in order to allow the demon to get out of the head of the affected person. Trepanations as treatments of mental disorders were performed for thousands of years. Roger of Parma wrote in his Practica Chirurgiae in 1170 "For mania or melancholy a cruciate incision is made in the top of the head and the cranium is penetrated to permit the noxious material to exhale to the outside…" From the 15th century onwards asylums were established in order to accommodate mental ill individuals in Europe however the goal of these institutions was not treatment. Asylums were merely inhumane institutions where mentally ills persons were abandoned by relatives or city authorities. Mental disorders are described throughout human history and throughout different cultures [67].

The evolutionary approach to analyze mental illness - the so called Darwinian psychiatry - tries to find answers on the following question: "Why has natural selection left the body vulnerable to mental disorders?" As pointed out in the introduction section Darwinian psychiatry tries to explain the existence of particular mental disorders as an evolutionary adaptation [15,16,106]. In evolutionary terms there is a selection pressure towards the development of adaptations. Adaptations however, are not endpoints they must confer benefit to individuals and increase their reproductive success [106]. Within the framework of the concepts of evolutionary medicine mental disorders may be interpreted as defenses or results of a mismatch between our recent living conditions and the environment in which our ancestors evolved. The environment in which our ancestors of the genus *Homo* and in particular *Homo sapiens* evolved in Paleolithic times has been called the environment of evolutionary adaptedness (EEA) [107] or more recently the adaptively relevant environment [38,108]. According to these concepts human biology has adapted through the process of natural selection to the environmental conditions during Paleolithic. This view is summarized by the notion that "Human biology is designed for Stone Age conditions" as Williams and Nesse pointed out [32,42]. The adaptively relevant environment was characterized by a foraging subsistence based on hunting and gathering, the use of stone and wooden tools, a highly mobile (nomadic) life style, small multi-aged egalitarian groups consisting of 20 to 30 group members. There was a lack of domesticated animals with the exception of the dog [108]. Ethnographic analyses of the few remaining contemporary forager populations such as the Hadza in Tanzania, the !Kung of Namibia and Botswana, Ache of Paraguay or Efe of central Africa provided information about life style in a foraging economy [109,110]. About 20 000 years ago the process of Neolithic transition started resulting in the emergence of agriculture and a complete change in subsistence economy and life circumstances about 10 000 years ago in the area of the fertile crescent [111]. Domestication of animals and plants allowed the production of a surplus of food. Consequently humans developed semi-permanent settlements and gave up their mobile lifestyle. The production of food allowed a considerable population growth because more people could be supported on the food grown. Neolithic transition changed human lifestyle dramatically [111,112]. This was in start of urbanization-a process still continuing today [113].

99% of our evolutionary histories we have spent as hunter gatherers following a nomadic life style in small groups consisting of 20 to 50 group members. Our recent environment is completely different from that in which our species evolved. An increasing number of people live in urban environments, many of them in so-called mega cities of more than 10 million inhabitants. Recent urban *Homo sapiens* live alone without family members as singles or in small nuclear families in a quite anonymous society. This habitat and these living conditions are completely different from that environment we are adapted for. Loneliness, social isolation, occupational stress may lead to rising rates of burnout syndrome or depressive disorders. Consequently we are faced with a dramatic mismatch between current environment and a human body evolved in the environment of our evolutionary adaptedness [38]. This mismatch between our evolutionary heritage and recent living conditions may enhance the prevalence of mental disorders through our life span. As pointed out eating disorders which mainly result in postponement of sexual development, cycle irregularities, anovulation and amenorrhea may be interpret as a reaction of earlier sexual development according to secular trends [85] and the social refusal of early pregnancies. In this way eating disorders may be interpreted within the framework of the mismatch hypothesis.

The evolutionary basis of depression is still considered controversial [15-20,40, 45-50]. It was hypothesized that low mood may be an

adaptation to circumstances where a life goal cannot be achieved and should be disengaged from [18]. Furthermore it was mentioned that the mechanism activated in depression is one designed to cope with threatening circumstance where flight is impossible [114]. According to Wilson [105] depression may be the result of dysregulation which might occur because the environment of recent *Homo sapiens* is so different from that in which our ancestors evolved. Hagen [94,95] in contrast, interpreted depression as an adaptation by itself. Postpartum depression, for example, is a mechanism by mothers to increase the investment of their partners but also of their social network, by making themselves unable to care for their child [94,95]. This adaptation in case of postpartum depression may be explained by increased investment of the partners and other relatives which may result in increased reproductive success of the depressive women. But is this adaptation model applicable to all kinds of depressive disorders, especially to geriatric depression? Watson and Andrews [45] generalized the adaptation model to all cases of depressive disorders. In their - so called social - navigation hypothesis they characterized depression as an evolved strategy to cope with unpropitious social circumstances [45]. Depression enhances not only the individual fitness it has also the function of social motivation. It signals the need for help and more investment from partners, or the social network. This hypothesis may be applicable to postpartum depression as well as post reproductive depression. It signals the need of help to social networks, this is especially true among new mothers but also childless elderly. On the other hand the association between female life history events and depression may be interpreted as a result of a mismatch or the dysregulation hypothesis according to Wilson [105]. In case of childless post reproductive women the recent situation characterized by being childless without a well working social network was completely uncommon in the environment where *Homo sapiens* evolved. Only few members of social groups survived until post reproductive age and these individuals survived in well working social networks. In many developing countries and traditional societies offspring and close relatives are still recognized as an old age security in an economic and are essential for surviving. In recent postmodern societies however, we are confronted with increased rates of divorce, single living arrangements, but also voluntary childlessness, and the transition to of family systems towards nucleation and the decline of the family as social institution [103,115]. This trend of a growing number of post reproductive people, who are lonesome and suffer from a lack social support, is new in our long evolutionary history. The result of this trend may be a dysregulation according to Wilson [105] and as follows an increased rate of depression which also may be interpreted as an adaptation to this unfavorable living circumstances during old age.

Additionally to the evolutionary approach to mental disorders across female life history we should not forget the cultural dimension. As pointed out above mental disorders have been associated with female reproductive function since ancient times. Although also a great number of males was and is affected by mental disorders, mental disorders have been especially stigmatizing for girls and women. The strong association between reproductive function and mental disorders was clearly related to gender discrimination and misogyny. Typical examples are the statements of Otto Weininger and Paul Julius Möbius who published "On the physiological idiocy of women". A cultural environment which is characterized by a low social status of women increases stigma –discrimination and may increase mental disorders. On the other hand the association between female gender and mental disorders represents a stigmatization and discrimination too. Stigmatization and discrimination however can also be interpreted within the framework of evolutionary theory [116].

Conclusions

What can we conclude from these three examples of psychic disorders through female reproductive life span? Female reproductive life span is limited and energy imbalance and other stress factors may affect female reproductive success negatively. Mental disorders across female reproductive phase have ever existed, and are not the result of menstruation per se as thought by 19th century scientists but distinct mental disorders or what recently is classified as mental disorders may increase life time reproductive success of women. As pointed out female reproduction requires high costs in energy during and after pregnancy and an intensive investment to bring up the offspring to reproductive age. Under less favorable conditions women may not be able to meet these affords. Eating disorders during adolescence or young reproductive age may postpone sexual

development during adolescence or interrupt reproductive capability during young reproductive age. In this way unsafe early teenage pregnancies are avoided, and reproduction is postponed to better conditions. Postpartum depression may enhance reproductive success as mood disorders of the mother may increase social support from relatives or society. Depressive disorders during post reproductive phase may be explained by a mismatch between present social environment of aging people and the adaption to stop reproducing early and invest in existing dependent children, grandchildren or the offspring of genetically related relatives. Voluntary and involuntary childlessness, social isolation and the awareness that reproductive capability has ceased irreversible may enhance depressive disorders during this stage of life. Consequently mental disorders associated with female life history stages may be interpreted in an evolutionary sense.

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