

The neurobiology of pleasure, reward processes, addiction and their health implications

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Abstract

Modern science begins to understand pleasure as a potential component of salutogenesis. Thereby, pleasure is described as a state or feeling of happiness and satisfaction resulting from an experience that one enjoys. We examine the neurobiological factors underlying reward processes and pleasure phenomena. Further, health implications related to pleasurable activities are analyzed. With regard to possible negative effects of pleasure, we focus on addiction and motivational toxicity. Pleasure can serve cognition, productivity and health, but simultaneously promotes addiction and other negative behaviors, i.e., motivational toxicity. It is a complex neurobiological phenomenon, relying on reward circuitry or limbic activity. These processes involve dopaminergic signaling. Moreover, endorphin and endogenous morphinergic mechanisms may play a role. Natural rewarding activities are necessary for survival and appetitive motivation, usually governing beneficial biological behaviors like eating, sex and reproduction. Social contacts can further facilitate the positive effects exerted by pleasurable experiences. However, artificial stimulants can be detrimental, since flexibility and normal control of behavior are deteriorated. Additionally, addictive drugs are capable of directly acting on reward pathways. Thus, the concrete outcome of pleasant experiences may be a question of dose. Moderate pleasurable experiences are able to enhance biological flexibility and health. Hence, pleasure can be a resistance resource or may serve salutogenesis. Natural rewards are mediated by sensory organ stimulation, thereby exhibiting a potential association with complementary medical approaches. Trust and belief can be part of a self-healing potential connected with rewarding stimuli. Further, the placebo response physiologically resembles pleasure phenomena, since both involve brain's reward circuitry stimulation and subjective feelings of well-being. Pleasurable activities can stimulate personal growth and may help to induce healthy behavioral changes, including stress management. However, more research is needed to better understand the nature, neurobiology and maybe dangerous aspects of pleasure. Also, a possible involvement of endogenous morphinergic signaling has to be studied further.

Introduction

Medicine is typically interested in disease-promoting factors and ways to cure. However, health-enhancing factors are becoming more popular, and the concept of salutogenesis and its association with self-care is of growing importance [1,2]. This may be due to money shortage in the health care system – in relation to its demands – and the rapidly increasing interest in preventive medicine and disease avoidance.

For neuroscientists, the brain most often is related to neural disorders and disease mechanisms – which are of interest, undoubtedly. But much could also be learned by studying the brain in relation to health. The brain has processes and salutogenic functions that contribute to health by enabling one's experiences in life to benefit one's health (Figure 1) [3]. Science has ever neglected positive sensations and mind states like satisfaction and contentment, solely focusing upon pathogenetic processes. For example, a vast number of publications on depression and mental disorders exist, but only a few describe possible mechanisms underlying feelings of joy and bliss.

What makes one feel good instead of bad? What are possible resources within the brain that medicine may want to use? May pleasure possibly be a concept that is available for each individual to protect from disease or serve health processes? Besides feeling good, what are the biological implications of pleasurable sensations, and what are the risks of pleasure-seeking behavior, i.e., addiction? May pleasure, at last, facilitate survival and early death likewise?

With this work we try to examine the neurobiology of pleasure and shed some light on implicated risks, health consequences and molecular mechanisms in connection with the pleasure phenomenon.

Reward and motivation

Research has identified a biological mechanism mediating behavior motivated by events commonly associated with pleasure. This mechanism is called 'reward'. It is usually governing normal behavior through pleasurable experiences [4]. Pleasure, however, describes a 'state or feeling of happiness or satisfaction resulting from an experience that one enjoys' [5]. Pleasure is a subjective phenomenon, i.e., subjective quality. Hence, an intimate association between reward and pleasure exists [4,6]. In neurobiology, pleasure is a competence or function of the reward and motivation circuitries that are imbedded in the central nervous system (CNS). Anatomically, these reward pathways are particularly linked to the brain's limbic system. The underlying physiology, however, is complex and morphological correlates are still a matter of thorough research.

Motivation may be divided into two categories – appetitive and aversive motivation. Appetitive motivation concerns behavior directed towards goals that are normally associated with positive hedonic, i.e., pleasurable, processes (food, recreational drugs, sex

etc.). In contrast, aversive motivation involves getting away from hedonically unpleasant conditions [4]. Consequently, two fundamental forces rule motivation: pleasure and pain. It has been suggested that pleasure may be associated with *beneception*, events that facilitate survival and thus 'benefit' the organism or species from an evolutionary biology perspective [7]. Pain, on the other hand, is associated with *nociception*. This latter term basically describes conditions that may have undesirable biological consequences for an organism [4,7]. However, the illustrated division of pleasure and pain in reference to their possible biological functions and outcome should not lead to an incorrect understanding, since both conditions – in specific situations – may have the capacity to serve survival and 'amusement' likewise. Thus, pain and pleasure potentially merge into another. With regard to specialized brain compartments involved in motivational processes, the physiological substrate for appetitive or aversive motivation (as for reward and avoidance) primarily lies within the limbic system [8–12].

The common idea that the limbic system is solely concerned with feelings and emotion is at best a half-truth, but there certainly exists a connection which is relevant to the pleasure phenomenon [13]. Yet, the limbic system is made up of the limbic lobe and certain additional structures (Figure 2) [14]. The limbic lobe surrounds the corpus callosum and consists of the cingulate gyrus and the parahippocampal gyrus. The hippocampus, which is in the floor of the temporal horn of the lateral ventricle and is closely linked to memory processing, is also included in the limbic lobe [14]. Additional structures incorporated in the limbic system are the dentate gyrus, amygdala, hypothalamus (especially the mammillary bodies), septal area (in the basal forebrain) and thalamus (anterior and some other nuclei). Functionally, the 'hippocampal formation' consists of the hippocampus, the dentate gyrus and most of the parahippocampal gyrus [13].

Neurobiologists have long known that the euphoria induced by drugs of abuse, sex or other things we enjoy arises because all these factors ultimately boost the activity of the brain's pleasure and reward systems. These are made up of complex circuits of nerve cells or neurons that evolved to make us feel flush after eating or sex – things we need to do to survive and pass along our genes [15,16]. Reward pathways are evolutionarily ancient, like limbic structures. Limbic and reward systems share common mechanisms and morphological structures. In fact, integral CNS components involved in reward and motivational processes are of limbic origin [14]. For example, prefrontal or orbitofrontal cortices, cingulate gyrus, amygdala, hippocampus and nucleus accumbens participate in the reward physiology [8]. Thus – pleasure, limbic system and reward circuitry seem to be biologically interconnected. Memories of the pleasure of wellness, i.e., 'remembered wellness', are accessible to this circuitry through hippocampal mechanisms [14]. Further, belief affects mesocortical-mesolimbic appraisal of a pleasurable