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Neurotransmitters' Activity and Pharmacotherapies: From Decision Making Process to Juridical Implications

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ABSTRACT

Neurotransmitters' activity, pharmacotherapies, pathological status and the possible interactions between them might influence the neural functions of the brain regions involved in the decision making process. Therefore, we should consider that under certain circumstances, the decision making ability and eventually the behavior might be affected if the individual is for example either under the influence of pharmakons or suffering from neurological disorders. Thus, during legal trials implicating this individual, such approach may have an impact on the juridical decisions or verdicts, especially if it is supported by experts' opinions on related fields such as pharmacology, toxicology, psychiatry and neuropsychology.

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1. INTRODUCTION

Since humans are trying to establish juridical systems to regulate and govern their social and economic daily lives, experts in different fields are investigating human decision making process, human behaviors, in addition of the implications such concepts' analyses can have on both legislation and application of different laws and regulations. Based on neural descriptions, these concepts were linked with neural activities and pathways within the brain. Indeed, pharmacotoxicological and neuropathophysiological advances are providing more details about how cerebral activities may influence the decision making especially under certain therapeutical or medical circumstances. Herein, we exemplify possible correlation between the brain's activities and some juridical aspects within the contexts of the neuroeconomics, pharmacotoxicology and the individuals' psycho-psychiatric status.

The "decision making process" we are describing herein explains the possible individual cases of persons who may suffer from cerebral diseases or be under the influence of exogenous active compounds (including drugs), rather than the processes that may be described at an industrial or at an institutional level such as the healthcare organizations [1] or the establishment of strategies to reach certain development goals (see P.G. Sow and V. Vinekar (2012) [2] as an example), fixed by local; national, regional or international organizations, which mainly depend upon a group decision rather than an individual decision. The descriptive approach of this paper is multidisciplinary and involves neuroscience, pharmacology; toxicology, psychiatry and psychology .This approach starts form scientific illustrations of the decision making process-related factors to reach legal implications and juridical conclusions.

2. ILLUSTRATIVE EXAMPLES OF IMPLICATED NEURAL PATHWAYS

Divers studies have reported some neurotransmitters as interfering with the decision making process and other behavior-related cerebral functions. Among those neurotransmitters; serotonin and dopamine play major roles within different brain structures such as striatum and amygdala. Indeed, a relationship between dopamine activity and striatum activation [3],[4], and also a link between serotonin (5-hydroxytryptamine or 5-HT) and amygdala activation [5]-[7] have been shown through several researches using imaging and genetic studies. Domapaminergic system neurons found in divers brain regions, including substantia nigra and the locus coeruleus [8], mediates its effects via two dopaminergic receptors' families that are classified on the basis of molecular biological data [9]. These families are D1-like family with two (D1 and D5) receptors and D2-like family with three (D2, D3 and D4) receptors respectively [10],[11]. Domapaminergic activity has been implicated in divers phenomena that might strongly influence both the decision making process and the behavior. Such phenomena, mediated by dopamine, include emotional behavior [10], wellbeing feelings and stress reduction [12]. In addition, reward computation and reward prediction errors involve mesolimbic dopaminergic neurons [13],[14]. On the other hand, harm avoidance and aversive behavior have been linked to serotonin neurons [15].

Importantly, behavioral economics researches, employing an imaging genetics strategy have brought out a novel neural explanation of the decision making processes [16]. This study has investigated the roles that both dopamine and serotonin play in mediating striatal and amygdala responses during decision making processes. It has also shown the possible neurotransmission's pathways and concluded that in decision making under risk, opponency between dopamine and serotonin is involved. Importantly, the results have also shown enhanced striatal activation and increased amygdala activation suggesting that serotonergic inhibition may lead to a striatal activation of the dopaminergic neurotransmission. This confirms the hypothesis of serotonin linked to dopamine in an "opponent partnership" that has been described by previous publication [17],[18] . Furthermore, complementary studies' data about decision making look coherent with this hypothesis and the functions of the two brain structures (striatum and amygdala) are coherent with this concept. In fact, striatum, that receives afferent input from midbrain dopaminergic neurons, has been pointed as playing a role in decision making under risk [19]-[21]. In addition, within the central nervous system dopamine represents the most ubiquitous catecholamine neurotransmitter [22]. Moreover, amygdala is involved in divers decision-related processes [23] and it was reported that dopamine controls a variety of functions including locomotion, cognition, emotion, food intake and endocrine regulation [22] which further our understanding of the decision making process.

As a larger approach, we should consider the network (Figure 1.) that describes divers potential interactions between pharmakons, cerebral diseases and the influences they might have on the neural functions via changing the neurotransmission functions. Following this line of thoughts, drugs used for treatment may influence the cerebral neurofunctions and the prognosis of some brain diseases as well; in addition, diseases may have an impact on drugs efficacy.

Furthermore, brain modifications due to active compounds and cerebral disorders might result in a neurochemical modifications that may influence the decision making process, and eventual behavior-related neuro-aspects, but only if the neurochemical modifications involve neurotransmitters or neural pathways that are either directly implicated in the decision making process or are involved in mechanisms that indirectly influence the decision making process (such as psycho-psychiatric status).

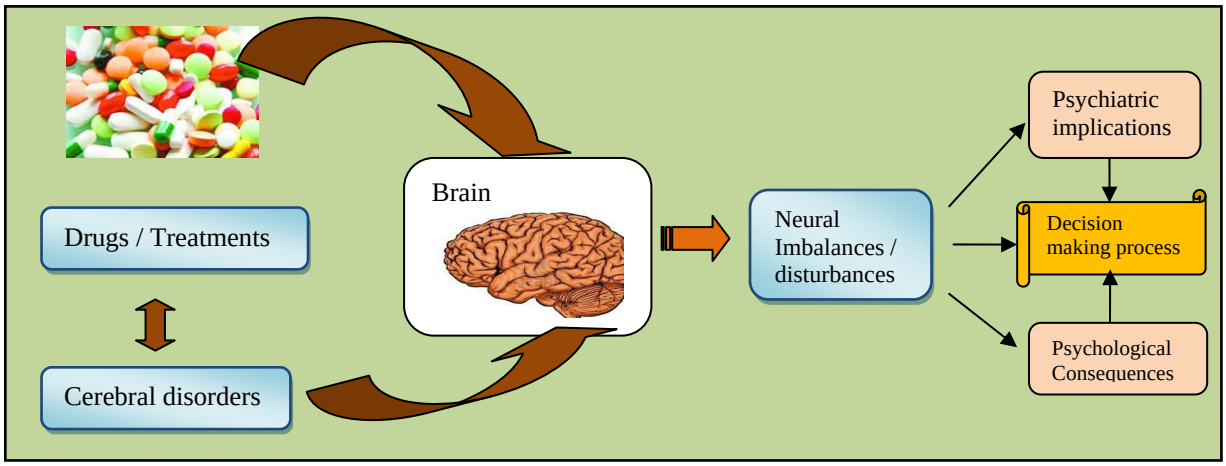

Figure1. Possible interactions between pharmakons, cerebral dysfunctions, neurotransmitters' activity and the decision making process.

3. IMPLICATIONS AND PERSPECTIVES

Both dopaminergic and serotonergic pathways, within striatum and amygdala respectively, are involved in the decision making processes. Therefore, for decision making process, we may suggest possible influences of drugs (agonists or antagonists) that interact with either the two corresponding receptors (dopaminergic and serotonergic), the related mechanisms or eventually other receptors that can influence the decision making, processes especially if we take into consideration both the divers factors that may influence the neuroreceptors' functions (for examples, refer to [24]) and the fact that the central nervous system constitutes complex networks within which different neurotransmitters are constantly interacting and leading to divers outcomes in form of behaviors, psychological status and physical implications. Therefore, we should consider, in case of legal investigations, for example while judging individuals accused of crime to decide whether they are guilty or innocent, and this if the accused were, at the time of committing the crime, under such drugs influences or if they suffered from cerebral imbalances or neurological disorders that can influence the pathways linked to decision making mechanisms. Furthermore, some cerebral neuroreceptors' expressions may depend upon the age [25].

In addition, the population (adolescents or adults) to which belong the accused constitutes also another element (which is physiological) that should be juridically considered, especially that the use of drugs among some population constitutes a factor that increases the criminality rate which might be explained, in some cases, by the potential impact some compounds including psychostimulants drugs and different other substances like amphetamine can have on the brain and thus, lead to cerebral neurochemical modifications and behavioral changes [26]. Thus, under particular conditions, the decision making ability and the capability to evaluate and distinguish between what is considered "good "or "bad" by the society, and "allowed" or "forbidden" by the low remain an interesting area that needs further investigations, mainly within the context of the related juridical implications, because the behavioral consequences such factors have. These concepts are supported by the divers findings indicating how neuroreceptors are implicated in numerous neuropsychological phenomena such as cognitive or emotional behavior [27],[28], feelings of wellbeing [29] and stress reduction [30].

Starting from the striatum and amygdala functions, described as illustrative examples, extrapolations from these concepts can lead to a wider overview of the possible interactions of the physiological, pathological and therapeutical neuro-cerebral aspects with the human behavior and the decision making process, especially if supported by further studies to describe other neurotransmitters and drugs that may influence the decision making-related phenomena. To reach such goals, factors such as the possible linkage between mental health and psychosocial stressors [31] and the interactions of the different neurotransmitteurs within the "psychiatric neural networks" [32] should be considered as well. Taken together and combined with other references, the above described data might results into a "redefinition" of concepts including "The Free Decision" and "The Volunteer Action". However, experts' opinions and descriptions of the related factors should be taken as references within any legal or juridical context.

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