Neuroanatomy and neurochemistry of pleasure and fear: are they opposite emotions?

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Introduction

We experience a variety of emotions every day, and whereas negative emotions such as fear usually promote avoidance or defensive behavior, pleasure is a positive emotion that encourages exploratory, ingestive, sexual or novel-seeking behavior. Therefore, emotions facilitate adaptive behavior and equilibrium.

There are several neuroanatomical and neurochemical substrates involved in both pleasure and fear, but special attention has been paid on the roles of the amygdala, nucleus accumbens and dopamine as they are all involved in these two emotions that may seem opposite at first sight:

- The amygdala has a critical role in emotional expression as it evaluates the emotional valence of each stimulus, and even if it has mainly been associated with negative emotions such as fear, its role in rewarding-stimuli will also be defined.
- Nucleus accumbens (NAC) is the main part of the ventral striatum, and although it is an essential structure for processing positive emotions such as pleasure, its role in negative emotions such as fear will be discussed next.
- There are diverse chemical neurotransmitters involved in the modulation of emotions, but since dopamine (DA) is one of the most important elements in this regulation 1 aim to define its role in both pleasure and fear.

1. Pleasure

Pleasure itself is generated by a small set of hedonic hotspots that enhance liking reactions through interactions between their specific anatomical site and their particular neurochemical. Distributed system in the brain related to pleasure:

- The main neuroanatomical structure involved in pleasure is nucleus accumbens (NAC), and dopamine neurons from the ventral tegmental area projecting to this structure also play an essential role.
- Dopamine is the main neurochemical related to pleasure through its interaction with NAC, but the role of this structure is also controlled by glutamatergic, serotonergic and noradrenergic afferents from diverse areas of the brain.

Figure 1. Widespread pleasure coding brain networks. Hedonic hotspots are shown in nucleus accumbens, ventral pallidum, and brainstem parabrachial nucleus. Ref (2).

1. Basolateral amygdala (BLA):
   - Lateral (LA) + basal amygdala (BA).

2. Central nucleus of the amygdala (CEA):
   - Laterally (CEL) + medial nucleus (CEm).

3. Intercalated cell masses (ITCs):
   - Lateral (ITC) + medial ITC (mITC).

Diverse biogenic amines such as serotonin and norepinephrine are related to this emotion, but dopamine (DA) is the main neurochemical involved since it is important in the controls of inhibitory circuits and fear responses.

2. Fear

Fear functions as an internal signal to alert the organism to potential danger, and the amygdala is a structure critically important for processing this emotion. It is composed of distinct nuclei:

- Basolateral amygdala (BLA):
  - LA + BA.
- Central nucleus of the amygdala (CEA):
  - CEL + CEm.
- Intercalated cell masses (ITCs):
  - Lateral (ITC) + medial ITC (mITC).

3. Pleasure and fear: common features

Nucleus accumbens is mainly known for its role in pleasure while the amygdala is known for fear processing, but these two neuroanatomical structures are actually involved in both types of emotions.

Dopamine neurons come in multiple types and through their connections with distinct brain networks they modulate fear and pleasure.

Fear and pleasure are not as opposite as it may seem at first sight since they share several features.

Conclusions

- Nucleus accumbens is the main structure involved in causing pleasure, but evidence from anatomical, neurochemical and behavioral studies implicate it also in processing fear.
- Activity in this nucleus allows the assignment of a particular value to a stimulus depending on the distribution (D1R vs. D2R) and location (core vs. shell) of receptors that are activated by a burst of dopamine, and it is thus important for both pleasure and fear.
- The amygdala is particularly important for its role in processing fear memories, but its role in positive emotions such as pleasure has also been described.
- This structure processes the valence of a stimuli and bias behavior in an adaptive manner.
- Important problem studies have just recently began to define amygdala’s circuits that contribute to reward, and these analysis are not as far along for reward as they are for fear.
- In spite of the mixed effects found in several studies, it is clear that dopamine is important for learning and memory in most terminal fields of nigrostriatal, mesolimbic and mesocortical dopaminergic systems.
- It has a role in both fear and pleasure through its interactions with several neuroanatomical structures such as nucleus accumbens and amygdala.

Methodology

In order to do this review the bibliographic research has been focused on the most recent and relevant articles.

- The most used Data Base has been PubMed.
- Amongst the several prestigious journals consulted are Discovery Medicine, Nature, Neuron and Trends in Neurosciences.
- A total of 20 articles have been cited and the number of documents consulted is a bit higher.

References