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Review Article

The Biochemical Factors and Mechanisms of Human Emotions and the Biochemistry of Belief

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Abstract

Feeling is a fundamental aspect of behavioral, social-psychological, and neurobiological sciences, encompassing a range of experiences adapted subjectively by humans. Emotion forms the center of everyday human experiences. Behavior, physiological arousal, cognitive appraisal, motor expression, and subjective experiences are considered critical components in studying emotions or feelings. Beliefs integrate external and personal reflections for their behavior. The relational beliefs are developed instantaneously by associating with those of the same or similar ideologies.

In contrast, language forms the basis of conceptualizing more complex beliefs, based on extensive participation in ritual acts and narratives. Awareness and consciousness are stimuli of human biochemistry. Beliefs help in decision-making and pave the way for moral judgment. Beliefs influence factors directly or indirectly involved in psychopathology. Feelings also evaluate an individual's beliefs, and express the power of self-reliance. This paper describes the neural network of emotions, feelings, beliefs, and perceptions, which appear diverse on the surface.

Keywords: *Basis of Fear; Cognitive Appraisal; Mechanism of Love; Moral Judgment; Neural Network; Role of Beliefs; Semantic Memory*

Abbreviations

APA: American Psychological Association; CNS: Central Nervous System; EEG: Electroencephalogram; LDA: Linear Discriminant Analysis; fMRI: Functional Magnetic Resonance Imaging; MVPA: Multi-Voxel Pattern Analysis; NMDA: N-Methyl-D-Aspartate; RCT: Randomized Controlled Trial; RWE: Real-World Evidence; SVM: Support Vector Machine; ToM: Theory-of-Mind

Introduction

Foundation

The human mind consists of various mental states at every wakeful moment of life. Emotions include fear, anger, love, disgust, empathy, kindness, perceptions (such as color and sound), and cognition (such as planning the future), retrieving a memory from the past, concentrating on performing a task, and creating a multitasking capacity.

Researchers have categorized these emotions and mental states into distinctive categories [1]. For example:

- Wahlen., *et al*. (1998) attempted to identify the neural pathway and the basis of fear [2].
- Wicker., *et al*. (2003) examined the emotion of disgust [3].
- Barterls., *et al*. (2000) explored the mechanism of love [4].
- Northoff., *et al*. (2004) described the structure of the cortical midline and self-love [5].
- Rugg., *et al*. (2002) revealed evidence of episodic memory by functional neuroimaging [6].
- Grossman., *et al*. (2002) similarly described semantic memory [7].
- D'Esposito., *et al*. (1998) provided functional magnetic resonance imaging (fMRI) evidence of aspects of spatial and non-spatial working memory [8].

The role and components of belief

Belief is considered a principle of an individual's life that guides them to explore the meaning of life. Beliefs act as an internal command to the brain to represent and understand what is happening around them. Beliefs originate from what, where, and how humans hear and comprehends and integrates conversations and events.

Knowledge, events, past experiences, and visualization construct beliefs that an individual considers as reality and truth [9]. Armstrong., *et al*. (1973) and Helm., *et al*. (1999) raised the fundamental question of devising methods for a of the relationship of knowledge and belief [10,11].

Freud., *et al*. (1928) regarded belief a neuronal obsession that is negatively interpreted as a sign of weakness [12]. Therefore, Hills., *et al*. (2004) described belief as a religious phenomenon construed as deviant or unneeded, or labeled as a pathological condition in psychology [13].

Emotions' effects

Emotions influence higher-order cognitive functions, such as decision-making, planning, attention, and the distribution of muscle power into tasks. Feeling, thinking, and believing decision-making, each other—this concept is supported by Craig (2002) and Paulus and Stein (2006). These researchers delineated the interoceptive and physiological manifestation of emotions, creating a relationship between behavior and affect [14,15].

Discussion

Overview: emotions versus feelings

The American Psychological Association (APA) defines emotions as "a complex reaction pattern, involving experiential, behavioral and physiological elements" [16]. Individuals deal with situations and issues by feeling particular emotions, such as love and hate. Emotional feeling is a phase of neurobiological activity with a critical interaction between emotion and cognition. Emotions play a crucial role in evolving an individual's consciousness and mental processing. There are different types of emotions—such as love, hate, kindness, anger, empathy, and despair—that correspond to various levels of consciousness [17].

Feelings can also be defined as a subjective experience, emerging from perceptions, events, central nervous system (CNS) functioning (both internal and external), and the physiological state in and around interpersonal and environmental circumstances [17,18].

Enacted experiences create meaning, arising from social interactions, recalling a particular behavior, remembering any activity through the kinesthetic, and visceral and sensual systems—which are further fed into the feelings manifested in the social scenarios (such as appraisals, arousals, physical actions, hedonistic behaviors, and motives [18]. Figure 1 presents social feelings that adapt to social functioning and facilitate interaction.

Figure 1: *Social feelings that impact the general nature of well-being.*
Note: Neurotransmiters (above) refer to levels and expression of neurotransmitters

Dissimilarities between feelings and emotions

Recent advances in research techniques have revealed various distinctions between feelings and emotions. Feelings are considered a component of collective and collaborative emotional responses. For example, fear is a spectrum of cognitive reactions that define defensive behavior. Emotions are more complex cognitive reactions, and semantically filtered [19]. Anecdotal evidence supports the hypothesis that feelings can guide caution or confirm cognition in and around social settings, such as an individual having a 'feeling' that the atmosphere makes him or her feel uncomfortable, or something does not 'feel right' [18].

Evolutionary neural mechanisms that control emotions are distributed in the brainstem, paralimbic, limbic, and neocortical regions. Descending connections allow for increased coordination and flexibility of the emotional response, culminating in a patterned activity in the peripheral and autonomic nervous systems [20]. Ascending connections influence the cortical pathway, allowing perceptual and cognitive processing that adapts to the prevailing emotional state [20].

The perception of feelings in response to emotions is a specific function of cortical sensory fields activated by signals generated in the CNS, or input generated in the peripheral nervous system [20].

The emotions coordinating brain structures' functioning

The emotional brain structures consist of the cortical, subcortical, and limbic regions. A conglomerate is collectively referred to as the corticolimbic system, including the lateral and medial prefrontal cortices, anterior cingulate, and subcortical structures (the amygdala, basal ganglia, and hippocampus) [21].

The amygdala region forms the core structure of the emotional brain construct. It presents the most robust connections to the prefrontal cortex—the ventral aspect of the anterior cingulate and posterior orbitofrontal cortex, specifically [22].

The amygdala, in turn, communicates with a vast network in the cortical and subcortical regions, such as the striatum, hippocampus, basal forebrain, nucleus accumbens, and sensory part of the cortices [23]. Öhman and Mineka (2001) highlighted this feature of the amygdala when sensing fear and threats [24].

The role of the endocrine systems and hormones

Foundationally, hormones are proteins, peptides, and steroids secreted by the endocrine glands, affecting brain activity and playing an essential role as neurotransmitters and neuromodulators (control the release of neurotransmitters by increasing or decreasing pleasure or pain sensations). Regardless of the structure's location and secretion, nearly all hormones are involved in feelings and emotions. Hormones help achieve self-regulation of emotions.

Multiple chemical reactions continuously occur in the brain, altering humans' emotions and behavior—influencing the thinking process and cognition. Hormones affect emotions and mood patterns (Table 1). In short, according to Butnariu and Sarac (2019), hormones stimulate the manifestation of emotions, such as love or hate [25].

Hormones	Role in cognitive functions, emotions, and mood patterns
Acetylcholine	Increases learning ability
Dopamine	Supports decision-making, explores novelty, and coordinates movements. It also stimulates pleasure sensations and desires—labeled the 'happy hormone'
Adrenaline	Provides the extra energy required by the body to cope with critical or urgent situations, and dangerous or extraordinary circumstnaces
Noradrenaline	Helps in memorizing long-term projects
Serotonin	Provides relief and calmness, and helps maintain and attain patience by limiting the perception of frustration and aggression
Cortisol	Acts similarly to adrenaline, being released in stressful scenarios
Oxytocin	Factorial in social interactions by encouraging trust, positive feelings, empathy, and generosity. Labeled the 'love hormone' as it plays a vital role in mother-child relationships, lactation, and familiarity

Table 1: *Hormones and their role in cognitive functions, emotions, and mood patterns.*

From embryo through pregnancy

A dramatic adaptation in behavior is observed in adult mammals from the transition period of pregnancy to postpartum. A plethora of neurochemicals, neurotransmitters, steroid hormones, and neuropeptides are extruded during this period, regulatiing maternal physiology and arousing caregiving behavior, emotions, mood, and cognition [26].

A study by Hoekzema., *et al*. (2017) revealed that substantial changes occurs in brain structure—with significant reductions in gray matter volume in the regions of social interactions—in first-time (primiparous) mothers and fathers; and presented a similarity with the theory-of-mind (ToM) network [27].

The change in gray matter volume further alters conscience measures and postpartum maternal attachment. The data also evidenced long-lasting changes in women's brains after pregnancy [27].

fMRI and electroencephalogram (EEG) are non-invasive neuroimaging techniques used as real-time applications to study neurofeedback loops and training. fMRI is a closed-loop brain-computer interface that explores self-regulation of the anguish and tenderness category of complex emotional states [28].

Linear discriminant analysis (LDA)—that forms the basis of support vector machines (SVMs) and LDA algorithms—significantly improved the multi-voxel pattern analysis (MVPA) approach to multivariate analysis [29]. However, the high cost of scanning, signal delay, and comparatively uncomfortable imaging settings are unfavorable. Conversely, EEG provides a higher resolution of temporal origin and directly measures information processing. Moreover, EEG and machine-learning tools can distinguish complex emotional states, using specific data from the emotion-elicitation paradigm [28].

The nature, biology, and biochemistry of beliefs

Convictions or mental acceptance that holds the true nature of an idea in an individual's mind are generally defined as beliefs. The ability of the brain to create a pattern and intent based on the religious and superstitious natures presents a true meaning in the mind [30].

The senses have a higher brain potential to capture outer and inner perceptions, which help to cognize customs or faiths better. These perceptions are constructed in a generalized way, established into a belief, and stored in memory—thus depicting the stimuli of trusted information as the source [9].

Beliefs form a mental scaffolding that helps assess the environment, interpret, define, or provide distinct explanations for new observations—thus, self-constructing a new meaning of existence [30].

Belief, considered a religious phenomenon in psychology, is understood as the subject of an attitude or state towards someone or something. The process of believing is related to perception [31].

Le Poidevin and McBeath (1993) described a model of the 'physiological process of believing' and its integration with the notion of time and process [32]. Moreover, they also presented an open-ended question, positing whether belief can easily be reduced to a measurement level of time.

Extensive brain circuits involve anatomical structures of the medial and lateral frontal cortex. The dorsolateral prefrontal cortex region helps in decision-making processes [31]. Dopaminergic activation in the midbrain is observed via fMRI for belief systems. The false belief state or delusions are characterized by hyperdopaminergic states associated with drug-induced psychosis and idiopathy [33].

Beliefs' expression

Beliefs are generally communicated in narratives that are socially transmitted in communities. Narratives construct meaning and create a relationship with the history of any society or community or social group, influences an individual's mental state. With continuous repetitions, socially practiced rituals stimulate the attribution of personal meaning. This thinking and subsequent behavior become predictable with a state of mind, such as hope or fear [34]. Nevertheless, experience, personality, and attitudes are personal aspects of the individual reflected in any belief system. It tends to change according to encounters [35].

Beliefs are classified into three sets based on field, content, political, and religious identities (Table 2) [36].

Type of beliefs	Description
Empirical beliefs	Empirical beliefs are instantaneous, object-based, i.e., developed at first and external to the awareness. For example, an object is perceived and valued from experience. Although these beliefs are established outside of consciousness, individuals become aware by assessing personal relevance.
Relational beliefs	Relation beliefs are instantaneous, events-based, i.e., isolated objects are observed in the form of grouped items—a process known as 'clumping'. Individuals who can interact with each other are easier to engage; thus, the brain can quickly develop interpersonal trust. Reciprocal interactions result in reward signals in the striatum region.
Conceptual beliefs	Conceptual beliefs are language-bound narratives, i.e., labeling and processing an abstract construct regarding unique events, such as music and fairy tales. Conceptual beliefs are formed gradually, over time, such as ecological, cultural, social, political, and religious identities—acquired and maintained over time.

Table 2: *Classification of beliefs.*

The neural center of beliefs is likely to be the cerebral cortex. The parietal cortex region plays a role in representing complex conceptual beliefs [36]. This role has also been validated by electrophysiological recordings [37]. Neuroimaging has revealed various signals from multisensory neurons located in the posterior intraparietal sulcus regions—that act as a source of causal interference processing for empirical and relational beliefs [38,39].

Coordination within the brain is necessary to stabilizebeliefs in responding to environmental or external stimuli. Neural circuits and brain regions, such as the frontal lobes, play a crucial role in establishing beliefs and morphing them into emotions and feelings [38,39].

The prefrontal cortex releases subcortical information that is integrated with mental state constructs. The amygdala and hippocampus, together with the N-methyl-D-aspartate (NMDA) receptor, are also involved in processing belief development and thinking [38,39].

When a new stimulus appears to challenge existing beliefs, distress occurs, continuing to intensify by enhanced dopamine release [9]. Young and Saxe (2008) revealed the involvement of the medial prefrontal cortex in belief valence processing by two components: encoding beliefs and integrating them with other relevant and supported features (of the outcome) or action to achieve or in applying moral judgment. This processing involves the precuneus and right temporoparietal junction [40].

The Bayesian model of control

The Bayesian ideal model of inhibitory control with a shared computational network describes two sections of computational elements that seem to be modulated by emotion: 1) probabilistic computations explaining beliefs with the respective frequencies of events and actions; and 2) valuation computations explaining cost or value associated with the potential actions and outcomes [39–41].

The inhibitory control framework of this model explains the role of effect in aspects of cognition, such as action, beliefs, value, and choice. Computational analysis has revealed that emotion can affect inhibitory behavior through certain biases, such as prior expectations of beliefs based on past events, the comparison of action and result, and the value of action outcome. Thus, emotional memories (stored in the brain) based on prior experiences significantly influence cognitive beliefs that might interfere with an individual's goal [41].

Bias-rendering of feelings and beliefs

To feel is to believe as an individual's past experiences prompt that individual to be biased in forming beliefs. According to Ford and Gross (2018) and Dolan (2002), logic suggests that life experiences drive conclusions and decisions based on cognitive constructions lead people to believe in such constructs and conclusions [41,42].

Human emotional memory houses an enormous amount of data, construed to predict outcomes, and assist in similar future encounters. The human brain stores past experiences, comparing them with current situations [42].

Kim (2018) posited that most psychopathological treatments are based on non-accommodated and non-standardized literature and anecdotal evidence, requiring more randomized controlled trials (RCTs) and supportive real-world evidence (RWE) studies [43].

Conclusion

Emotional episodes are transient, critical to survival, and strongly influence various cognitive processes, such as attention, perception, decision-making, and memory [42]. Every emotion triggers a vast hormonal network of secretions [25]. Religious belief is a unique human experience (trait), considering a supernatural agent or relating to cosmological constructs, such as 'heaven' and 'hell'.

Inherent computations in the neural network are probably the driving force for the phylogenetic expansion of the human brain. Cognition and feeling are separated, based on experience, and influenced by the emotional state of feelings that may not be truly justified. Nevertheless, feelings can sway humans to fashion a supporting rationale. Neurotransmitters are the 'code' that the brain uses to communicate and exchange continuous information [9]. However, beliefs and their dramatic influence on feelings and emotions remain a medical mystery, yet to be decoded.

Understanding better the biochemical factors and mechanisms of human emotions and the biochemistry of belief will have an inestimable impact on enhancing positive human interactions, social stability, and treating those patients hampered by aberrant beliefs and behavior.

Conflict of Interest Statement

The authors declare that this paper was written without any commercial or financial relationship that could be construed as a potential conflict of interest.

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