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## *Review Article*

# A Review of Biological Foundations of Anger

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**Abstract**
Anger, happiness, sadness, fear, surprise, and disgust are the six fundamental emotions that people can experience. Anger is a strong feeling of annoyance, displeasure, or hostility. It is a blaming emotion that is aimed against individuals, and it frequently leads to violent actions. However, anger serves survival purposes and is embedded in humans. While anger is typically viewed as a psychological or social phenomenon, it also has a biological basis. This literature review focuses on anger and its underlying biological foundations. The biological basis of anger can be explained through the activation of the amygdala, which plays a crucial role in emotional processing. Additionally, studies have shown that anger is associated with decreased activity in the prefrontal cortex. When a person becomes angry, this region of the brain is less active, leading to impulsive behaviors and decreased rational thinking. This explains why individuals often engage in aggressive or violent behaviors when angry. Understanding the biological basis of anger can help us better manage and control this emotion. By recognizing the physiological changes that occur when we become angry, we can take steps to calm ourselves down and develop healthier coping mechanisms.

**Keywords:** Emotions, Anger, Amygdala, Prefrontal cortex, Biological basis

## Introduction

Emotions can range from basic ones like happiness, sadness, anger, fear, and disgust, to more complex ones like love, jealousy, guilt, and pride. There are only six of these fundamental emotions people experience. They are anger, happiness, disgust, surprise, sadness, and fear [1]. The primary purpose of emotional expression is to indicate behavioral intent [2].

Anger is a strong emotional state characterized by an uneasy, uncooperative reaction to anything that one feels is provocative, hurtful, or dangerous [3]. According to estimates, 7.81% of people in the general population have experienced anger at some point in their lives [4]. Men are far more likely than women to experience anger [4]. Certain demographic groups, such as widows, individuals who are separated, divorced, never married, and those who are unemployed, exhibit significantly elevated probabilities of experiencing anger [4]. The psychology behind anger is frequently a response to and detour from internal sorrow. Any human being can instantly alter when they are angry [5]. People with high levels of anger may experience several triggers for their anger and hostility. Anger related issues in people could be a sign of trauma, adversity, turbulent social connections, or even mental illness [6]. Anger often subsides after 10 to 15 minutes for most people [7]. Trembling, grinding teeth, clenched fists are some common physical signs shown by angry people. When a person sense that they have

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been treated unfairly, assaulted, or when experiencing difficulties that prevent them from accomplishing personal goals, they often feel angry [8]. Social rejection, frustration, provocation, feelings of retaliation and social stress also lead to aggression. Researchers discovered a link between anger and impulsivity and links between anger and behaviors such as drinking alcohol, smoking, skipping breakfast, getting less sleep, feeling less positive, feeling more depressive, and using a mobile phone for long periods of time [9]. Anger increases the likelihood of unsafe driving habits. These reckless actions can make accidents more likely [10]. Anger development is linked to sleep deprivation. As sleep deprivation and mental health have been linked, it is possible to speculate that sleep deprivation and anger irritability, aggression, and short temper could be related [9]. Several recent studies have shown that the COVID-19 pandemic related social isolation and restrictions trigger anger and aggressive behaviors [11]. Someone acts unlawfully because they are enraged for no apparent reason. A person who is angry typically exhibits nervousness and a tendency towards verbal or physical aggressiveness. Yelling at others, screaming, and hurting others or themselves are frequently used when someone is angry. However, alternative approaches such as adopting conflict resolution, removing oneself from the situation, or employing relaxation techniques, may be less combative [12].

Anger as a high attribute harms relationships and contributes to domestic violence. Childhood trauma stemming from this can play a significant role in the development of psychopathic traits such as anger [13]. High levels of anger is linked on a physiological level to neurobiological and endocrine reactions, like increased hormones and increased cardiovascular activity which may increase blood pressure and risk of cardiovascular diseases [14]. Treatment of anger is vital because problems with anger management have adverse implications. Inability to manage anger leads to poor mental health and maladaptive decisions. The correlation between anger and suicide was also shown to be stronger specially in younger people [11]. All the emotions that humans feel is controlled by the brain and so is anger. The amygdala, insular cortex, and periaqueductal grey which is a midbrain region have all been strongly associated with emotions [8]. The brain signals an emotion to the rest of the body like an internal alarm system. According to researchers amygdala, frontal cortical areas, hypothalamus, periaqueductal grey region are the areas of brain which are linked to outbursts of anger [11]. So, the brain is the main biological foundation of anger. As such, the aim of this review is to comprehensively understand the brain structures and mechanisms underlying anger.

## Materials and Methods

A comprehensive literature search was conducted to identify studies, articles, and books on the biological basis of anger written by researchers, psychologists, and neuroscientists. The literature search was conducted using electronic databases such as PubMed, PsycINFO, and Google Scholar. The search terms used included "anger," "biological basis of anger," "neurobiology of anger," "brain mechanisms of anger," and "physiological correlates of anger." The review process involved steps to ensure the inclusion of relevant and high-quality research. Initially, a preliminary search was conducted using the identified search terms to gather a broad range of articles related to the biological basis of anger. Duplicate articles were then removed, and the remaining articles were screened based on their titles and abstracts. After the initial screening, the full-text articles were examined for eligibility. Inclusion criteria included articles that specifically focused on the biological basis of anger, studies that investigated physiological correlates of anger, and articles that provided comprehensive reviews on the topic. Articles that did not meet these criteria were excluded from the review. The selected articles were then critically appraised to assess their quality and relevance. The quality of the included studies was evaluated based on the research design, sample size, data collection methods, and statistical analysis. Studies with methodological limitations or inadequate sample sizes were excluded from further analysis.

Results from the selected studies were synthesized and organized into themes and subthemes. Common findings and patterns across the studies were identified and summarized. The review also highlighted gaps in the current literature and suggested directions for future research. As this review does not involve human participants or data collection, ethical approval was not required. All data used in this review were obtained from publicly available sources and published research articles, ensuring the anonymity and confidentiality of any individuals involved in the original studies.

**Results**

Anger manifests itself in different ways, thus studies on the brain roots of anger concentrate on figuring out how anger is produced in addition to determining how often and to what extent it occurs. Animal research has focused more on anger as a behavior than on the subjective emotion of anger for obvious reasons. Research on decorticated cats demonstrated the importance of the hypothalamus in the expression of “sham rage.” Seventy years later, studies primarily conducted on rats revealed that all vertebrates possess a fundamental neurological foundation for anger. This foundation, in addition to the hypothalamus, includes the amygdala and periaqueductal gray [12]. These brain areas are thought to play a crucial part in the quick identification and reaction to threats in environment as well as the production of rage and the spread of violence that precede the fight or flight response. To look for angry brain in people advanced studies have included non-invasive brain mapping technologies including positron emission tomography (PET) and functional magnetic resonance imaging (fMRI) [12]. Earlier research focused on patients with brain injuries or neuroimaging paradigms that only indirectly assessed anger, making it challenging to pinpoint the neurological bases of anger. More recent research examined how the brain reacts to furious faces and which brain areas are engaged when angry memories are remembered. According to two recent meta-analyses, the medial prefrontal cortex (mPFC), ventromedial prefrontal cortex , anterior cingulate cortex (ACC), posterior cingulate cortex, prefrontal cortex (PFC), and thalamus were some of the most noticeable brain areas to be activated when angry [7]. According to studies using fMRI on healthy volunteers, the amygdala, thalamus, orbitofrontal cortex, ACC, middle cingulate cortex, ventrolateral prefrontal cortex (PFC), dorsolateral prefrontal cortex (DLPFC), and mPFC were found to play a significant role in anger and aggression [15]. Numerous studies have revealed increased amygdala activity during the processing of violent facial signals, and the hippocampus and thalamus of domestic batterers showed neuronal hyperresponsivity to such stimuli. The lateral OFC, which is relevant for choosing rule-driven while suppressing instinctive stimulus-response associations, plays a significant role in the adjustment of behavior whereas the ventrolateral PFC is engaged in inhibitory motor regulation. Together with the ACC, the DLPFC reflects decision-making processes about the effects of one's own behavior, assessing wrongdoings, engaging self-regulatory cognitions, and regaining emotional equilibrium following conflictual encounters with others [15]. Researchers anticipate finding evidence at a structural level, namely changes in the concentration of grey matter, for trait anger, which is thought to be a stable individual propensity. Researchers hypothesized that changes in grey matter within a network of brain region is responsible for perception and emotional processing, including paralimbic and temporal areas. This is because trait anger involves perceiving environmental signals as hostile. The posterior cingulate cortex and temporal regions, which are similarly linked to the certainty that characterizes anger, are expected to be involved in the conceptualization of life events because of trait anger. The initial induction of anger-related ideas such as the unfairness of the scenario may be due to the right anterior fusiform gyrus, which is important for associative semantic information. In those with high trait anger levels, these temporal regions may be the basis of a connection between perceptions, memories, and emotion that is characterized by increased grey matter concentration. The hostile interpretations of environmental stimuli connected to trait anger may also be caused by this increased density of gray matter. The posterior cingulate has previously been linked to high certainty, and many meta-analyses have shown that this region is also involved in both life events that elicit rage and anger perception. Negative emotions like wrath and disgust have been linked to the cerebellum, and it is especially important for emotional control when goal-directed behavior is required in social settings. According to a recent meta-analysis, the cerebellum is also engaged in the aggressive and perceptual pathways that are connected to anger [16]. Researchers revealed that anterior paralimbic areas experience higher normalized regional cerebral blood flow during the angry condition compared to the neutral condition [17]. These localized increases in cerebral blood flow were observed in the right anterior cingulate cortex, the bilateral anterior temporal poles, and the left orbitofrontal cortex[17]. After a brain injury, anger does appear to be a particular concern for victims. It may result in erratic behavior that is potentially hostile and damaging[18]. As such, this literature review identified amygdala, prefrontal cortex, and pituitary gland as the primary organs, assisted by other brain structures, involved in inciting anger in humans.

## Discussion

### *Amygdala*

Amygdala is an almond shaped structure which is situated just above the hypothalamus [8]. There are two amygdalae in each lobe of the brain. The amygdala is a crucial component of our nervous system and is made up of many nerves that link to different regions of the brain, including the visual cortex and neocortex [8]. If enough emotional charge is created by the incoming information, the amygdala can override the cortex and transmit information to the limbic system, causing the person to respond by using the lower part of the brain. The specific function of the amygdala in processing threat-related cues, in particular anger and fear, is well known. It has therefore been claimed to be heavily engaged in the pathways regulating aggressiveness [19]. In several functional neuroimaging investigations using overtly and covertly presented face stimuli, the amygdala has consistently been linked to the appropriate processing of emotional facial expressions. Additionally, injury to the amygdala has been linked to particular identification deficiencies of emotional expressions associated with threat [20]. Individuals with amygdala lesions would perform worse on the fear-to-anger scale [21]. In one study, a patient with amygdala lesion consistently recognized faces as afraid regardless of the level of facial anger, whereas the other patient's response curve was equivalent to that of controls but was more variable. This was discovered when the morphing of frightening to furious expressions was explored. It should be particularly challenging to perform on fear/anger emotion mixes if amygdala damage makes it impossible to distinguish between the two emotions [21]. During the anger prime condition, amygdala activity was a reliable indicator of anger discrimination. The right amygdala activity showed an inverse relationship with the right inferior frontal gyrus activity only when unconscious emotional reactions were triggered by subtle, intense angry faces. This occurred while participants were categorizing facial expressions based on cognitive processes. The masked faces displaying extreme fury may unintentionally stimulate the right amygdala, but not the target faces expressing moderate anger [17]. The amygdala was shown to be activated during the anger. Additionally, during the anger prime condition, amygdala activity was a predictor of anger discrimination. These findings show a disparity between the processes of covert detection of external emotional stimuli, such as facial expressions, and covert discrimination of those stimuli, and they also imply that the amygdala is likely engaged in the former but not necessarily the latter process [17]. Also, the hormone testosterone controls aggressiveness primarily via modulating the vasopressin receptors in the amygdala and other subcortical locations, such as the hypothalamus. The PFC may play a significant part in the overt perception of an emotional stimuli and the amygdala is responsible for the unconscious discrimination or detection of the stimulus [22]. Recent research suggests that the amygdala and right ventral PFC can modulate one another in instances when emotional reactions are unconsciously triggered. The degree to which internal emotions impact present cognitive judgment may also depend on the functional balance of the amygdala and right ventral PFC [22].

***Prefrontal Cortex (PFC)***

The prefrontal cortex is the brain's front part. When Amygdala is handling the emotion, PFC gives the judgement. PFC is crucial for many social cognitive processes, such as perspective-taking and the control of emotions like aggressiveness. When seeing angry or nervous facial expressions, imaging studies on face perception have shown that the lateral ventral prefrontal regions become more active [23]. Researchers have shown that activity in the left PFC is linked to approach motivation or positive affect, whereas activity in the right prefrontal cortex is linked to withdrawal motivation or negative affect. Although it is a negative emotion, anger causes the left PFC to become more active and the right prefrontal cortex to become less active as anger is an approach related emotion. PFC and the DLPFC subdivisions are responsible for initiation of anger related behaviors. The VMPFC subdivision plays a key role in controlling anger and reduction. When damage happen to this PFC that person cannot control their anger [24]. There are at least two different regions of mPFC that are engaged in aggressiveness and its regulation, according to imaging studies on social interaction and emotional control. When controlling emotions cognitively, the dorsal medial prefrontal cortex has been seen to be activated [23]. In particular, researchers discovered that a combination of strong executive control-related DLPFC activity and relatively low threat-related amygdala activity protected people from the link between childhood suffering and later characteristic anger [25].

***Pituitary gland***

Pituitary gland is a pea-shaped structure [26]. The pituitary gland releases chemical messengers like hormones. When the brain recognizes a threat or harm, millions of nerve fibers in the brain produce hormones that travel to every organ in the body. Adrenaline and noradrenaline are hormones that are emitted by the body when a person is angry. The body utilizes chemical messengers from them to regulate blood pressure and heart rate [8]. These adrenaline and noradrenaline prepare the body for flight or fight responses when in an angry or aggressive situation. The hypothalamus gives signals to pituitary gland by discharging corticotropin releasing hormone. Then the pituitary gland sends signals to adrenal glands which are located on kidneys by releasing adrenocorticotropic hormone (ACTH). Upon stimulation by ACTH adrenal gland release stress hormones like cortisol, adrenaline, and noradrenaline. Too much cortisol is released in people with high trait anger levels. Too much cortisol leads to loss of neurons in PFC and hippocampus. Loss of neurons in PFC prevents it from using best judgement. That is why people do not make and should not make any decisions or plan the future when in an angry situation. Loss of neurons in hippocampus weakens short term memory and prevents forming new memories properly. That is why people do not remember anything they say in a high angry level situation and do not remember what to say. Stress hormones have a significant impact on every stage of cancer development and progression. According to a research, high cortisol inhibits the activity of natural killer cells, allowing cancer cells to survive in body. Furthermore, stress hormone production might impair DNA repair pathways, resulting in the growth of cancer [27]. Immunoglobin positive cells were severely downregulated by cortisol release, and it was discovered that as a result lymphocytes were adversely impacted. Additionally, the process of producing new lymphocytes was negatively impacted. As a result, the patient's condition is greatly impacted, and the body's immunity is weakened. The stress hormone cortisol, which provides the body energy waves, is released when someone is angry. However, excessive cortisol can have several harmful impacts on the body, including a blood glucose imbalance that can impair thyroid function and reduce bone density. The immune system is also impacted by this hormone imbalance [27]. Numerous experts claim that abnormal uterine bleeding has a considerable detrimental effect on a woman's quality of life and that persistent menstruation problems are linked to aggressive behavior, fear, wrath, like emotions [28]. This abnormal bleeding occurs due to abnormalities in sex hormones which are release by pituitary gland. In contexts where dominance, power, and control over the social situation are goals, some research suggests that induced anger is correlated with increases in testosterone. Other studies have shown that high levels of testosterone increase vigilance to angry facial expressions. These effects may all help people decide whether to approach or avoid signals of control and also increase aggressive behaviors [29].

## Conclusion

In conclusion, anger is a complex emotion that has a strong biological basis. It involves a series of physiological changes in the body. The amygdala, pituitary gland, and prefrontal cortex are mainly involved in anger. Among these the amygdala is the main brain region involved with anger. When amygdala is activated in an angry environment it activates hypothalamus to send signals to pituitary gland and release stress hormones. Stress hormones can activate anger emotion. Damage or abnormalities in these areas lead to abnormal behaviors related to anger. These biological responses are evolutionary adaptations that have helped humans survive and protect themselves in threatening situations. Though there are situations in which anger is appropriate, it is crucial to learn how to identify and control it in a healthy way to avoid negative outcomes that could affect ourselves or others.

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