Review Article

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Journal of Neurology and Neuroscience
ISSN 2171-6625

2019
Vol.10 No.4:302

DOI: 10.36648/2171-6625.10.4.302

Physiological Correlates of Arousal: A Meta-analytic Review

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Citation: Beri D, Reddy KJ (2019) Physiological Correlates of Arousal: A Meta-analytic Review. J Neurol Neurosci Vol.10 No.4:302

Abstract

Background: This paper reviews the physiological correlates of arousal to develop a comprehensive and collective understanding of the physiological correlates of arousal that occurs at different levels, such as emotion, sexual, sleep, mood, cognitive dissonance, and temperament.

Objective: Main objective of this review was to have a clear understanding of the various physiological correlates that are associated with arousal.

Method: Research articles and books were searched on journals using the keywords 'physiological correlates of emotional arousal', 'physiological correlates of arousal-sleep', 'physiological correlates of sexual arousal'.

Results and Conclusion: Results from the review indicated that there are numerous correlates of physiological arousal which are based on changes in bodily mechanisms, such as variations in breathing rate, cardiovascular systems, and changes in functioning in certain brain areas.

Keywords: Physiological arousal; Emotional arousal; Sexual arousal; Sleep arousal; Temperament; Brain areas; Cardiovascular system; Breathing rate

Received: July 30, 2019; **Accepted:** August 20, 2019; **Published:** August 26, 2019

Introduction

Arousal is defined as the state of awakening of sense organs up to the point where sensation and perception can take place. There is an activation of various mechanisms, such as reticulate activating system which increases wakefulness, functioning of autonomic nervous system as well as endocrine system. The functioning of these mechanisms also increases ability to respond more quickly and higher alertness. The physiological aspect of arousal looks at how wakefulness is achieved through arousal. Research points towards the functioning of ascending reticulate system which consists of a number of neurotransmitters (acetylcholine, norepinephrine, dopamine, histamine, and serotonin). All these neurotransmitters play a crucial role in the arousal activity. There are numerous correlations of arousal which are related to emotional, sexual, mood, sleep, and temperament.

Emotional arousal is linked to the activity of the autonomic nervous system. A major physiological correlate of emotional arousal is piloerection [1]. Piloerection is defined a physically stimulated response towards a cold stimulus. According to Campbell, piloerection in humans occurs in response to cold temperature as a result of thermoregulatory processes that our ancestors used in the course of evolution. Piloerection in humans also occurs because it is associated with a thrilling event. Some of the other sources of piloerection among humans include music, movie scenes, and books. Musical effect of piloerection has been most commonly researched with maximum attention given to the overall structure of music such as kind of instrument used and solo voice [1]. Another research finding in the area of effect of music on piloerection suggests that music that is emotionally arousing produces an effective piloerection.

Most of the studies on physiological correlates of emotions have focused on the functioning of autonomic nervous system and changes in speech signals. Other studies have focused on two dimensional views of physiological correlates of emotions. These are: valence and arousal. The basic difference between the two dimensions are based on being negative or positive (for valence) and being calm or excited (for arousal) [2]. Physiological studies based on these two dimensions are highly valid as they correspond to the two dimensions. Techniques used in these physiological studies are skin conductance level (SCL), electromyogram (EMG), and heart rate (HR) [2].

Physiological correlates have also been found for emotion suppression. Emotional suppression, which downplays the activity

of emotional arousal, has been found to be linked to abnormal behavior and lower ability to have an emotional experience. Emotional suppression results because of more prevalence of suppressed thoughts as well as arousal of sympathetic system [3].

Physiological correlates of arousal have also been assessed for cognitive dissonance. Physiological arousal is associated with cognitive dissonance [4]. These associations and correlations of physiological arousal and cognitive dissonance are based on Skin Conductance Response (SCR) and increased heart rate. According to Cooper & Fazio, physiological correlate of arousal in cognitive dissonance involves a negative state when the arousal is based on individual's self-critical behavior [5]. Thus, a clear correlation exists between physiological arousal and cognitive dissonance.

In the area of sexual orientation, physiological correlates have also been assessed. Physiological studies have shown there are differences in the patterns of sexual arousal among both men and women. Physiological measures have shown that women tend to experience arousal in response to sexually stimulating stimuli such as those depicting men. These measures have been assessed using fMRI studies as well as pupil dilation [6]. Baumeister provided explanations about the differences in the physiological arousal among men and women. According to him, women's sexual attitudes are influenced greatly by social and cultural factors as opposed to men. Also, men tend to show higher consistency in sexual behavior as compared to women [6]. Physiological correlates of sexual arousal have also been assessed for bisexual as well as homosexual women. Sexual arousal of bisexual women is found to be higher than heterosexual and homosexual women. They are also considered to be more aware of their sexual arousal patterns [6]. Neurological assessments such as fMRIs measures the brain activity by assessing the ratio of oxygenated and deoxygenated blood.

Physiological correlates of arousal in insomnia have also been reported [7]. Insomnia is a sleep disorder that is primarily caused by disturbed sleep quality, prolonged awakening, and inconsistency in sleep patterns. Insomnia involves disrupted functioning of day to day activities, loss of energy and impairment of various cognitive processes such as decision making and memory [8]. Physiological correlates point to the role of genetic, emotional, behavioral as well as cognitive factors. These correlates are influenced by various other social factors such as stressful life events and excessive tension which contribute to sleep deprivation. Some of the polysomnography (PSG) and EEG studies have also shown the physiological and neural correlates in insomnia. PSG analyses have shown increased durations of wakefulness after sleep among patients with insomnia which contribute to the disorder. The analyses also included measuring breathing rate as well leg movements of patients with insomnia. EEG analyses points to the finding that there is increased arousal frequency among patients with insomnia as compared to normal people. High activity is seen in beta and gamma waves among patients with insomnia.

Mood and affect are other areas where physiological correlates have been assessed for arousal. Mood arousal has been positively correlated with functioning of various bodily functions. Nutrition and intense physical activity have also been associated with mood arousal [9]. In a study conducted by Snyder et al., they found variations in diastolic blood pressure readings based on mood arousal, when a list of positive and negative lists was presented to the participants [10]. Some of the studies also found increase in heart rate and the functioning of autonomic nervous system.

Biological models based on temperament in the context of physiological arousal have been constructed to study the effect of emotional arousal on personality and temperament. According to Eysenck, personality dimensions of introversion-extraversion and neuroticism-stability are affected by the arousal of reticulate and autonomic systems. Introverts are found to have higher activity in their ascending reticulate activating system. Because of this activity, introverts are able to experience minimum level of arousal and thus, are satisfied with the mild stimulation as opposed to extroverts. Neurotics are regarded having greater reactivity in the autonomic nervous system, indicating higher sympathetic arousal, thereby projecting more intense emotions.

Eysenck's theory focuses on the cortical and autonomic systems' functioning which result in the arousal. However, the physiological analysis of arousal in temperament involves a set of multidimensional processes. In case of emotional arousal, extroverts are considered to have more reactive medial brain functioning. Therefore, they are highly reactive to rewards and punishment/non-punishment situations along with behaviors underlining impulsivity. Introverts on the other hand, have a higher functioning septal-hippocampal region of the brain which involves greater behavior inhibitions and project behavior characterized more by anxiety. Although there are number of physiological correlates of arousal, but the temperament model emphasizes two major types of reactivity. First type involves central reactivity and the second type is peripheral reactivity types of arousal.

Physiological correlates of autonomic cardiovascular arousal have also been assessed. Cardiovascular responses are produced by an integrated functioning of sympathetic and parasympathetic nervous system of the autonomic nervous system. Animal experiments have also shown various components of the autonomic system and provide a clearer understanding of the relationship between cortical and sub-cortical centres under cardiovascular functioning. Variation in heart rate and blood pressure are also known to occur due to the electrical stimulation of different brain regions which play a major role in attention, memory, and motivation. Also, those regions which control limb movements, such as motor cortex and cerebellum [11].

Some studies also point to damage in the orbitofrontal and anterior cingulate cortex which might reduce arousal to emotional stimuli. Changes in these brain regions might also influence decision making and behavior in social situations. fMRI and PET studies have shown the effect of physical activities like cycling and other handgrip exercises to be influential in the arousal of cardiovascular system [11].

Literature Review

Numerous researches have been done to understand the physiological correlates of arousal. Arousal occurs in different mechanisms and across different bodily functions. Some of these mechanisms and bodily functions include emotional arousal, sleep arousal, sexual arousal, mood and affect arousal, and cardiovascular functioning. Therefore, most research studies based on physiological correlates of arousal were searched using the keywords 'physiological correlates of emotional arousal', 'physiological correlates of arousal- sleep', 'physiological correlates of arousal- sleep', 'physiological correlates of mood arousal'.

Journals that were used to search for research articles based on these keywords were: Research gate, Pubmed, Nature reviews, Elsevier, Journal of physiology, Psychometry society, Frontiers in psychology, Google scholar, Society for judgement and decision making, and scientific reports. Research studies based on neurophysiological and neuropsychological assessments such as Electroencephalogram (EEG), Functional Magnetic Resonance Imaging (fMRI), and Positron Emission Tomography (PET) [12]. Case studies and biological models based on physiological correlates were also searched and different areas of physiological arousal, such as flow and happiness were explored in this context. These were searched using keywords 'biological models based on physiological correlates of arousal', 'case studies on physiological correlates of arousal'. Journals used for finding information on these areas were Jstor, Sage journal, and Journal of personality and social psychology.

Results

Results from all the research studies and research articles indicated the different physiological correlations of arousal. While going through the literature, some of the common physiological correlates of arousal were based on different aspects, such as those involving emotional arousal, sleep, sexual arousal, mood and affect arousal, as well as temperament. Many of the research studies involved the use of scales and neurological assessments such as Electroencephalogram (EEG), Functional Magnetic Resonance Imaging (fMRI), and Positron Emission Tomography (PET).

Studies that assessed the physiological correlates of emotional arousal involved the use of audio tracks, in which a number of auditory stimuli were presented to the participants and the level of arousal such as piloerection, cardiovascular activity, and breathing rates were measured. Other studies focused upon the emotional facial recognition which occurs as a result of arousal. In these studies, participants are shown a series of facial expressions which evoke a certain emotion, such as fearfulness, and participants are required to identify the emotion projected by each expression. Participants' Heart Rate Variability (HRV) was then measured. Results of all these studies showed that when certain emotions are evoked, there are significant changes in their physiological mechanisms. Studies that assessed emotional suppression revealed that with the suppression of emotions, lower cardiovascular activation was associated [13].

Studies that were based on physiological correlates of sexual arousal showed that greater activity is seen in lateral occipital cortex when participants are exposed to exotic stimuli. Activity is also seen in the posterior cingulate cortex and fusiform cortex, which involves the perception of face and body. There was higher arousal within the genital system as well. Studies assessing the physiological correlates of arousal that influence temperament found that arousal is positively correlated with the functioning of central and autonomic functioning. Emotions associated with the temperament, such as sadness and relief were correlated with functioning of the central system. On the other hand, emotions such as fear and discomfort were correlated with autonomic system.

Studies assessing the physiological correlates of arousal during sleep showed increased stress levels due to the heightened physiological arousal during the non-rapid eye movement sleep cycle in insomnia. EEG analyses and Electrocardiogram (EKG) measures showed increased levels of perceived stress, with higher readings on the beta band. Therefore, higher stress was found to be positively correlated with physiological arousal among patients with insomnia.

Studies that assessed the physiological correlation of arousal in cognition dissonance showed changes in heart rate as well skin conductance response as well as change of preference due to changes in the striatum activity when the dissonance occurs while performing the task [14]. These studies involved the use of self-report measures and tools like cards.

Discussion

The main objective of this paper was to review the physiological correlations of arousal. With the advancement of science and technology in recent times, it has become possible to study and measure the underlying physiological mechanisms of various behaviors. From a scientific perspective, human behavior is usually influenced by a number of bodily reactions that are controlled by the genetic factors, role of neurotransmitters, and role of hormones. Arousal is considered to be a state of awakening which stimulates an organism to perform actions and process information. It is one of the defining features of 'fight and flight response'. Arousal is essential as it increases the ability to respond as well increases the alertness. Therefore, this paper discusses the physiological correlations of arousal that occurs in different forms, such as emotional arousal, sexual arousal, sleep arousal, mood arousal and cognitive arousal.

Numerous research studies and books were searched on various journals and data and evidence of the bulk of work done in analyzing the physiological correlates of arousal were collected to understanding the common mechanism behind it. From the various research studies, theories and articles, it was seen that with arousal, a number of bodily mechanisms are influenced. There is a heightened ability to respond to the stimuli, there is change in breathing rate which increases with prolonged arousal.

There are also changes in heart rate and cardiovascular systems. These mechanisms are measured through neurophysiological assessments such as Electroencephalogram (EEG), Electrocardiogram (EKG), Positron Emission Tomography (PET) and Functional Magnetic Resonance Imaging (FMRI).

Physiological arousal also affects the temperament. Biological models based on temperament and personality have shown correlations of physiological arousal with the functioning of autonomic and central nervous systems which determine an individual's response towards stimuli. On sexual arousal, stimulation of certain brain areas such as occipital cortex and fusiform cortex observed among heterosexual and homosexual females. However, a contradictory finding was provided by Brotto L and Yule M. They studied the physiological arousal of asexual women, in which they viewed erotic and sexually arousing images. Results indicated that women experienced physiological arousal which was assessed through vaginal amplitude impulse [15].

Conclusion

This meta-analytic review paper provides a comprehensive understanding of the physiological correlations of arousal which was assessed on various levels, such as emotional arousal, sexual arousal, mood arousal, sleep arousal, as well as temperament. Research studies done on these areas and books comprising of theoretical foundations of these arousals were collected and analysed. The physiological correlates of arousal are measured on numerous neurophysiological assessment mechanisms, such as EEG, EKG, PET scan and fMRI. Results of these reviews indicated that the physiological correlates of arousal are related to changes in the functioning of body mechanisms such as cardiovascular systems, breathing and heart rate, nervous system and reaction to various types of stimuli. It also involves changes in the functioning of certain brain areas and influences temperament as well.

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