H

Hypothalamus

Conny W. E. M. Quaedflieg[1,2] and Lars Schwabe[2]
[1]Department of Cognitive Psychology, Institute of Psychology, University of Hamburg, Hamburg, Germany
[2]Faculty of Psychology and Neuroscience, Maastricht University, Maastrich, MD, The Netherlands

Definition

The ventral part of the diencephalon that controls the autonomic nervous system and, via the pituitary gland, major neuroendocrine systems, thereby regulating homeostasis in response to a changing environment.

Introduction

As suggested by its name, the hypothalamus is located below the thalamus, along the walls of the third ventricle just above the brainstem. One of its main roles is to establish and maintain homeostasis in response to a changing environment. The hypothalamus is critical for the regulation of numerous vital functions including body temperature, hunger, thirst, fatigue, circadian rhythms, sleep, sexual activity, parenting, and attachment behaviors (Grossman 1960). Its function in turn is sensitive to environmental signals such as light, olfactory stimuli, or stress. The hypothalamus also coordinates hormonal production and thereby influences functions throughout the body (Kalat 2016).

The Anatomy of the Hypothalamus and Its Connections

In humans, the hypothalamus has only the size of an almond. It consists of about 15 small nuclei that can be subdivided into three zones: a medial zone, a lateral zone, and a periventricular zone. The medial zone contains several magnocellular nuclei and is important for the regulation of motivated eating. A lesion in the medial zone promotes feeding and body weight gain. The lateral zone of the hypothalamus is anatomically less defined. Dysfunction of the neurons in the lateral zone has the opposite effect on eating, it suppresses feeding and drinking via two peptides, melanin-concentrating hormone (MCH) and orexin. The medial forebrain bundle connects both the lateral and medial zones of the hypothalamus to the brainstem, basal forebrain, amygdala, and cerebral cortex. The medial and lateral zones also provide the main input to the periventricular zone, located next to the wall of the third ventricle. The periventricular zone consists of different groups of neurons, one of which forms the suprachiasmatic nucleus (SCN) just above the optic chiasm. The SCN receives retinal innervation and synchronizes the circadian rhythms with the

V. Zeigler-Hill, T.K. Shackelford (eds.), *Encyclopedia of Personality and Individual Differences*,
DOI 10.1007/978-3-319-28099-8_767-1

daily light-dark cycle. Another group of cells in the periventricular zone, neurosecretory cells, link the autonomic nervous system to the neuroendocrine system via the pituitary. The pituitary is connected to the hypothalamus via a stalk that contains axons of neurons and blood vessels. The hypothalamus controls the posterior pituitary via the axons of the magnocellular neurosecretory cells in the periventricular zone. These cells release two neurohormones into the bloodstream, oxytocin, and vasopressin. Furthermore, the hypothalamus controls the anterior pituitary via the blood vessel system in the stalk, called hypothalamo-pituitary portal circulation. The parvocellular neurosecretory cells in the periventricular zone secrete hypophysiotropic hormones that in turn stimulate or inhibit the secretion of pituitary hormones into the general circulation controlling other endocrine glands (Dudás 2013; Kandel et al. 2000).

The Hypothalamus and Stress

Through the autonomic nervous system and the connection with the pituitary, the hypothalamus coordinates our bodily responses to stressful events. Specifically, within seconds following stress exposure, the paraventricular nucleus of the hypothalamus activates two physiological systems. It stimulates the sympathetic branch of the autonomic nervous system (ANS) which triggers the release of adrenaline and noradrenaline from the adrenal medulla. Adrenaline and noradrenaline enhance alertness, arousal, and attention and stimulate various bodily reactions (e.g., increased heart rate, respiration, and blood pressure), thus initiating a "fight-or-flight" response. In addition, the hypothalamus also controls the secretion of the stress hormone cortisol via the hypothalamic-pituitary-adrenal (HPA) axis. This endocrine stress response starts with the secretion of a peptide, corticotrophin-releasing hormone (CRH), by the parvocellular neurosecretory cells of the hypothalamus. CHR travels via the hypothalamo-pituitary portal circulation to the anterior pituitary where it triggers the release of adrenocorticotrophic hormone (ACTH). ACTH enters the bloodstream and stimulates the adrenal cortex to secrete cortisol. In our body, cortisol mobilizes energy reserves and increases metabolism. Moreover, cortisol regulates the basal HPA axis activity via negative feedback on the pituitary gland and hypothalamus. The binding of cortisol to its receptors in the hypothalamus and pituitary inhibits the secretion of CHR and ACTH leading to a reduction in the circulating levels of cortisol (de Kloet et al. 2005; Ulrich-Lai and Herman 2009).

The Hypothalamus and Sexual Hormones

In addition to its major role in the coordination of the stress response, the hypothalamus also controls the secretion of hormones involved in sexual development. The parvocellular neurosecretory cells in the periventricular zone secrete gonadotropin-releasing hormone (GnRH) which triggers the secretion of luteinizing hormone (LH) and follicle-stimulating hormone (FSH) from the anterior pituitary. In males, LH stimulates the testes to produce testosterone. Both FSH and testosterone play a key role in sperm maturation and thus fertility. In females, LH and FSH cause the secretion of estrogens from the ovaries. Cyclic variations in LH and FSH determine the menstrual cycle in females (Bear et al. 2007; Kalat 2016).

Gender Differences in the Hypothalamus

Due to the binding of sex hormones early in life, there are subtle anatomical and physiological differences in the hypothalamus between men and women. For example, the sexually dimorphic nucleus in the anterior hypothalamus is larger in males than in females. On the other hand, parts of the female hypothalamus generate a cyclic pattern of hormone release that has not been seen in the male hypothalamus (Bear et al. 2007; Kalat 2016).

Conclusion

The hypothalamus is a small yet highly complex area of the human brain that coordinates the autonomic and endocrine outflow with our behavioral state and in such is crucial for human survival.

Cross-References

- ▶ Fight-Flight-Freeze System
- ▶ Hormones and Personality
- ▶ Hypothalamic-Pituitary Adrenal Axis
- ▶ Hypothalamic-Pituitary-Gonadal (HPG) Axis
- ▶ Infants' Salivary Cortisol Levels
- ▶ Pathogen-Stress Theory
- ▶ Personality and Stress
- ▶ Post-Traumatic Stress Disorder
- ▶ Transactional Model of Stress and Coping
- ▶ Transactional Stress Theory

References

Bear, M. F., Connors, B. W., & Paradiso, M. A. (2007). *Neuroscience: Exploring the brain*. Philadelphia: Lippincott Williams & Wilkins.

de Kloet, E. R., Joels, M., & Holsboer, F. (2005). Stress and the brain: From adaptation to disease. *Nature Reviews: Neuroscience, 6*, 463–475.

Dudás, B. (2013). *The human hypothalamus: Anatomy, functions and disorders*. Nova Science Publishers, Incorporated.

Grossman, S. P. (1960). Eating or drinking elicited by direct adrenergic or cholinergic stimulation of hypothalamus. *Science, 132*(3422), 301–302.

Kalat, J. W. (2016). *Biological psychology* (12th ed.). Belmont: Cengage.

Kandel, E. R., Schwartz, J. H., & Jessell, T. M. (2000). *Principles of neural science* (4th ed.). New York: McGraw-Hill, Health Professions Division.

Ulrich-Lai, Y. M., & Herman, J. P. (2009). Neural regulation of endocrine and autonomic stress responses. *Nature Reviews: Neuroscience, 10*, 397–409.