Neuronal concepts for coordination of thermoafferent information, its central integration and resultant initiation of effector responses

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Cannon (1929) used the regulation of body temperature as an example of a homeostatic system, comprising mechanisms acting simultaneously or in succession to maintain constancy of body temperature, and thus contribute to the homeostasis of the internal environment. Although it was established that sensory information from the skin and core regions contributes to the autonomic thermoregulatory responses of heat production, heat loss and heat retention, the manner in which these were regulated was unclear. The invention of stabilised feedback in electrical engineering (Black, 1934), also termed negative feedback, prompted Cannon’s associate Rosenbleuth, together with Wiener and Bigelow (1943) to introduce the concept of purpose controlled feedback in physiological systems. Their seminal paper lay the foundation for the field of cybernetics, and suggested that negative feedback control could be used to model physiological systems. The mutually inhibiting activity of the hypothalamic thermoregulatory centres was thus modelled as a negative feedback control system, in which the effector responses of heat production and heat loss were initiated in proportion to the displacement of body temperature from a fixed reference value, or set-point. Such rigid control of a quality and quantity of the internal environment are not in line with the concept of homeostasis, which resulted in the development of the adjustable set-point concept. The characteristics of the thermoafferent information and thermoregulatory effector responses have been well documented, but the manner in which the former is integrated centrally to give rise to the latter remains unresolved. The reciprocal cross inhibition theory of thermoafferent information eliminates the need for a set-point, but unlikely represents the manner in which homeostasis is achieved. Human and animal experimental evidence have now confirmed that core temperature is not maintained at a set-point, but rather within a band of core temperatures, the interthreshold zone, bound by the thresholds of sweating and shivering onset, where vasomotor activity predominates. These autonomic responses are activated by thermal factors (core and skin temperature), but can also be modified by nonthermal factors. Regulation of the thermal status of the body relies on both autonomic and behavioural thermoregulatory responses. Whereas conventional engineering control theory suggests that perception drives the latter, the perceptual control theory suggests that behaviour is a means of controlling an organism’s perception. Similar to the core temperature interthreshold zone, a skin temperature thermal comfort zone exists, bound by the thresholds for thermal discomfort. A neuronal model will be presented, incorporating separate, but interacting sensor-to-effector pathways. It will incorporate the contribution of thermal and nonthermal factors to the autonomic and behavioural regulation of body temperature.