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Cognitive control of metabolism: How cold memories drive whole-body thermoregulation

Jan Mohammad Omar, Yihui Liu*

The Second Affiliated Hospital of Harbin Medical University, Harbin 150081, China

Corresponding author Yihui Liu, E-mail: 502986473@qq.com

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Muñoz Zamora *et al*.'s study[1] is the first to investigate how cognitive processes can directly affect thermoregulation. By combining behavioral conditioning, engram labeling, and neural manipulation techniques, the authors demonstrate that mice are capable of can form and retrieve memories of cold environments. Remarkably, recalling these memories induces metabolic responses typically associated with actual cold exposure. This work represents a significant advancement in our understanding of brain, body interactions, particularly in how learned experiences can modulate fundamental homeostatic processes. The findings have broad implications across multiple fields of neuroscience and physiology.

1 Memory systems and homeostasis

The finding that hippocampal engrams can store and retrieve temperature-related information challenges the traditional view that memory systems primarily support cognition and emotion. This suggests that memory circuits may play a more integral role in basic physiological regulation than previously recognized[2]. The identification of cold-responsive engrams in both the hippocampus and hypothalamus points to a distributed memory system for physiological states, potentially extending other homeostatic processes.

2 Interactions between cognition and metabolism

The observation that recalling cold memories can trigger brown adipose tissue (BAT) thermogenesis in the absence of actual cold exposure reveals a novel pathway through which the brain can regulate metabolism. This finding may help explain why psychological factors have been shown to influence metabolic rate in human studies[3]. The work provides a mechanistic framework for understanding how learned associations and expectations can directly affect energy expenditure.

3 Evolutionary perspectives and clinical implications

From an evolutionary standpoint, the ability to encode contextual memories and anticipate thermal challenges would offer a significant survival advantage. The plasticity of the hippocampal, hypothalamic network suggests that the presence of an integrated system for predictive homeostasis, in which past experiences modulate current physiological responses[4]. This may represent a general principle by which the brain uses environmental history to optimize energy balance.

The study's clinical implications are equally compelling. If similar mechanisms operate in humans, cognitive-behavioral strategies could be developed to modulate metabolic rate in individuals with obesity or metabolic syndrome[5]. Furthermore, the findings raise important questions about how chronic stress or traumatic memories might dysregulate metabolic processes in comparable ways.

4 Future research directions

This groundbreaking study opens several promising avenues for further investigation:

(1) Translational applications: Exploring whether similar cognitive–metabolic interactions exist in models of obesity could inform novel treatment strategies for metabolic disorders[3]. Human studies using virtual reality-based conditioning paradigms could help validate the translatability of these findings across species[5].

(2) Circuit-level investigations: Examining the potential role of the amygdala could reveal how emotional valence shapes the encoding and recall of cold-associated memories[4]. Investigating the gut–brain axis may also uncover additional pathways through which cognition influences metabolic regulation[6].

(3) Molecular Mechanisms: Epigenetic profiling of engram cells could identify molecular markers of cold memory storage and link them to downstream metabolic adaptations[7]. Single-cell RNA sequencing of activated neuronal populations may reveal how different neuronal subtypes respond to cold memory retrieval.

Muñoz Zamora *et al*.[1] have provided critical insights into how cognitive processes influence metabolism. By demonstrating that the recollection of cold experiences can elicit thermoregulatory responses through hippocampal, hypothalamic circuits, this study redefines our understanding of brain–body integration. Continued research in this direction may uncover the neural circuits and molecular pathways that mediate this connection, offering new therapeutic avenues for metabolic disorders.

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Research ethics

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Informed consent

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Author contributions

Omar J M drafted the manuscript. Liu Y H edited and reviewed the manuscript.

Use of large language models, AI and machine learning tools

No Generative AI was used in the preparation of this manuscript.

Conflict of interest

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