

## Cognitive Neural Mechanisms of Restrictive Eating and Food Craving in Chinese

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### Abstract

In an era of material abundance, how to resist food cravings elicited by cues of palatable foods and maintain health through dietary restriction has become a significant topic of public concern. In recent years, domestic scholars have constructed a Chinese food picture database to investigate the cognitive neural mechanisms underlying restrictive eating and the differential brain mechanisms between successful and unsuccessful restrictive dieters; they have also conducted cognitive neural research on trait food craving and Chinese-characteristic spicy food craving. These efforts have advanced the theoretical development of eating behavior research and provided crucial support for health interventions in obesity, eating disorders, and related conditions.

### Full Text

#### Preamble

In modern societies where delicious food is abundant, restrained eating and food craving have become widespread phenomena closely linked to physical and mental health, potentially leading to eating disorders, obesity, and other health concerns that have garnered significant attention in the international psychological community. This specially commissioned article introduces the neuro-cognitive mechanisms underlying restrained eating and food craving in Chinese populations, synthesizing research on the cognitive and neural manifestations of these behaviors within Chinese cultural contexts. The article provides a meaningful discussion of the study populations, methodologies, innovations, and advances in this field, and on this basis, offers perspectives on future research directions and applications. Professor Chen Hong and her team have long been engaged in research on body image and eating behaviors, achieving a series of important findings on restrained eating and food craving in Chinese populations and advancing this research area internationally.

## Neuro-Cognitive Mechanisms of Restrained Eating and Food Craving in Chinese Populations

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### Abstract

In an era of material abundance, how to resist food cravings triggered by palatable food cues while maintaining restrained eating for health has become a topic of significant public concern. In recent years, to understand the reasons behind successful dieting, domestic scholars have established Chinese food image databases, investigated the neuro-cognitive mechanisms of restrained eating, and examined differences in brain mechanisms between successful and unsuccessful restrained eaters. Additionally, research has been conducted on trait food craving and spicy food craving—a phenomenon with distinctive Chinese characteristics. These investigations not only advance theoretical developments in eating behavior research but also provide crucial support for health interventions targeting obesity and eating disorders.

**Keywords:** restrained eating, successful restrained eaters, unsuccessful restrained eaters, food craving, spicy food craving

China has a profound culinary tradition, as reflected in the ancient proverb “food is the paramount necessity of the people,” which underscores the cultural significance of eating. Eating behavior is intimately connected to everyone’s daily life, and scientific dietary practices play a crucial role in physical and mental health. With social progress and development, delicious food has become ubiquitous, while simultaneously, demands for ideal body image and health have intensified. On one hand, in modern affluent societies, food is both palatable and readily accessible, making individuals susceptible to food cravings triggered by appetizing cues. On the other hand, primarily among young women, many have adopted restrained eating practices to manage health and maintain a slim physique. In contemporary Chinese society, both food craving and restrained eating are prevalent phenomena closely linked to health outcomes. For instance, food craving may lead to binge eating and obesity (Zhou et al., 2019), while restrained eating can trigger anorexia or paradoxically result in “disinhibited eating” —consuming even more food than usual (Wang & Chen, 2019; Schaumberg et al., 2016). Therefore, investigating the neuro-cognitive mechanisms of food craving and restrained eating in Chinese populations holds significant theoretical and practical value. Although research on these topics originated in the West, dietary behaviors are substantially influenced by regional and cultural factors, making Western conclusions and food stimuli potentially unsuitable for Chinese populations. The establishment of the Chinese Food Image Database has provided methodological support for studying eating behaviors in China

(Kong et al., 2015). In recent years, domestic scholars have conducted a series of studies examining the cognitive characteristics and neural mechanisms of restrained eating in Chinese populations, while simultaneously investigating the neural basis of general food craving and region-specific spicy food craving. These achievements have not only systematically explored the neuro-cognitive mechanisms of eating behaviors within Chinese cultural contexts but have also advanced this research field internationally.

## 2 Restrained Eating

Restrained eating (RE) refers to the tendency to restrict food intake for weight loss or weight maintenance, typically manifested through consumption of low-calorie foods, liquid diets, and intermittent fasting (Polivy et al., 2020). While some studies suggest that restrained eating can achieve the goal of reducing food intake and body weight, numerous findings indicate that restrained eaters (REs) fail to maintain long-term dietary control and may even consume more high-calorie foods than non-restrained eaters (NREs), a phenomenon known as disinhibited eating or counter-regulation (Zhang et al., 2019). Researchers continue to debate whether restrained eating exerts positive or reverse effects on food intake, though most neuro-cognitive evidence currently supports the counter-regulation hypothesis. Additionally, restrained eaters can be categorized into two subtypes: successful restrained eaters who demonstrate effective dietary control, and unsuccessful restrained eaters who exhibit disinhibited eating patterns.

### 2.1 Counter-Regulation in Restrained Eaters

Restrained eaters (REs) typically face a conflict between two competing goals: enjoying palatable food and controlling body weight, often disregarding their dieting or weight-loss objectives when confronted with appetizing foods. Neuroimaging studies have revealed that REs exhibit weaker activation in brain regions associated with inhibitory control and stronger activation in reward-related regions. These findings provide a neuro-cognitive explanation for the counter-regulatory effects of restrained eating—why most dieters are prone to disinhibited eating, or “eating even more.”

#### 2.1.1 The Conflict Between Enjoying Food and Controlling Weight

The goal conflict model of eating posits that dieters face two contradictory objectives: enjoying palatable food and controlling body weight (Stroebe et al., 2013). In modern societies saturated with food-related information, REs are more likely to activate the goal of enjoying food while inhibiting the goal of weight control, leading to disinhibited eating and unhealthy dietary behaviors. When confronted with these conflicting goals, REs demonstrate greater attentional bias toward food enjoyment and weaker inhibitory control capabilities. The goal conflict model has received support from both behavioral and neural evidence. Behaviorally, to directly examine inhibitory control under conditions

of conflict between food enjoyment and weight control goals, our research employed an innovative picture-word interference paradigm that simultaneously presented food and body shape information to create a direct goal conflict. Results showed that young female REs exhibited longer reaction times and higher error rates in food-information conflict conditions compared to body-shape conflict conditions. This indicates that, relative to body shape information, restrained eating women show stronger preference for food information, suggesting automated processing of food cues with minimal involvement of inhibitory control (Chen et al., 2019). At the neural level, event-related potential (ERP) studies have also demonstrated direct associations between inhibitory control and eating behavior in REs. For instance, in a food go/no-go task, REs showed diminished inhibitory control under food exposure conditions. Compared to non-restrained eaters, REs displayed smaller no-go N2a amplitudes in frontal and frontocentral regions related to food processing. Additionally, REs showed significantly increased no-go P3 amplitudes following food exposure, whereas unsuccessful restrained eaters (UREs) showed no such difference (Zhou et al., 2018). N2 and P3 are commonly used indicators in inhibitory control research. Specifically, N2a is associated with inhibitory control (Pires et al., 2014), suggesting reduced inhibitory control over food information in REs. Meanwhile, P3 is related to processing intensity (Chen et al., 2018), and its increased amplitude following food exposure indicates that REs must allocate more attentional resources to inhibit food-related information.

These studies provide behavioral and physiological support for the goal conflict model of eating and advance research on inhibitory control in REs. For example, methodological innovations in experimental paradigms have enabled direct comparisons of cognitive control performance under conflicting goals of food enjoyment versus weight control (Chen et al., 2019), while ERP technology has identified potential neural markers of diminished inhibitory control in REs (Zhou et al., 2018). Together, these findings offer evidence for understanding why many restrained eaters exhibit disinhibited eating behaviors.

**2.1.2 Reward and Control Brain Regions** Behavioral and ERP studies examining the conflict between food enjoyment and weight control have primarily supported the goal conflict model from the perspective of inhibitory control. However, due to limitations in experimental paradigms and measurement indices, these studies could not directly investigate whether and how food information triggers hedonic goals in REs. Neuroimaging research, by examining brain region activation, has not only further corroborated diminished inhibitory control in REs but has also uncovered evidence of enhanced food reward value and altered reward-related brain regions, offering a novel explanatory perspective on the counter-regulatory effects of restrained eating.

Most neuroimaging studies on restrained eating have employed functional magnetic resonance imaging (fMRI) to investigate brain activity during task performance. Overall, compared to non-restrained eaters (NREs), REs show stronger

neural activation in reward-related regions (e.g., insula and orbitofrontal cortex [OFC]) and reduced activation in inhibitory control regions (e.g., dorsolateral prefrontal cortex [dlPFC] and anterior cingulate cortex [ACC]) (Wang et al., 2016). For example, in an oddball task involving food and neutral information, REs responded more quickly to high-calorie food images than NREs, showing enhanced activation in reward (insula, OFC), attention (superior frontal gyrus), and visual processing (superior temporal gyrus) regions, but decreased activation in inhibitory control regions (ACC). REs exhibited the longest reaction times for low-calorie foods, with significantly stronger activation in attention and visual processing regions compared to NREs under low-calorie versus neutral picture conditions (Wang et al., 2016). These findings indicate that although REs are highly sensitive to food information generally, they show attentional bias toward high-calorie foods while allocating more attentional resources to low-calorie foods. Furthermore, since impulse control requires cognitive resources and represents an important behavioral correlate of weight control and weight fluctuations (Weygandt et al., 2015), the influence of brain regions related to impulse control on REs' eating behavior should not be overlooked.

Our research using a chocolate delay discounting task to examine the neural correlates of impulsive behavior in female REs found enhanced activation in the striatum and dlPFC. Moreover, right striatum activation positively correlated with the reward system, while left dlPFC activation positively correlated with striatum activation, suggesting that the impulsive brain region (striatum) in REs serves as a complement to food reward regions (Dong et al., 2015). Therefore, during food-related tasks, REs' brain activation patterns are characterized by enhanced reward region activation and reduced inhibitory control region activation. Additionally, activation in attention, visual, and impulse-related regions indicates that food information exerts stronger and less suppressible attraction for REs.

Resting-state functional magnetic resonance imaging (rs-fMRI) measures spontaneous BOLD signal activity in the brain when no explicit task is being performed (Stopyra et al., 2019). Our series of studies have found that even in the absence of food cues, REs show stronger activation in reward and attention regions and reduced spontaneous activity in inhibitory control regions. First, researchers (Dong et al., 2014) used regional homogeneity (ReHo) analysis and found that REs displayed greater ReHo activation in regions associated with reward (OFC), attention (lingual gyrus, cuneus, inferior parietal lobule), and body perception functions (paracentral lobule, anterior insula). Second, researchers (Dong et al., 2015) employing ReHo analysis found that young female REs exhibited increased activation in food reward regions (OFC/ventromedial prefrontal cortex [vmPFC]) and decreased spontaneous activity in inhibitory control regions (dlPFC). Third, researchers (Chen et al., 2016) used voxel-mirrored homotopic connectivity (VMHC) to examine inter-hemispheric interactions and assess functional coordination between inhibitory control and reward systems in REs. Compared to unsuccessful restrained eaters (UREs), female REs showed reduced VMHC in the dlPFC and altered functional connectivity between the right pre-

frontal cortex and ACC. This reduced inter-hemispheric functional connectivity in inhibitory control regions and altered connectivity in reward-related regions may help explain why REs cannot control hedonic goals and engage in eating behaviors, exhibiting higher levels of binge eating symptoms. These rs-fMRI results demonstrate that spontaneous neural activity in reward-inhibition brain circuits is altered in restrained eaters, with the activation patterns observed in task-based fMRI studies persisting even without food-related stimulation.

Moreover, structural brain changes represent another important potential neural mechanism for understanding restrained eating and its counter-regulatory effects. Several studies have examined relationships between eating behaviors and brain structural changes, primarily manifesting as greater gray matter volume (GMV) in reward regions and lower GMV in inhibitory control regions. For example, using the Three-Factor Eating Questionnaire, disinhibited eating was found to negatively correlate with GMV in the left middle frontal gyrus, while restrained eating negatively correlated with GMV in the putamen but positively correlated with GMV in the dlPFC (Yao et al., 2016) and right precuneus (Song et al., 2019). Additionally, using the Restraint Eating Scale, higher RE levels were found to positively correlate with GMV in the OFC and left insula but negatively correlate with GMV in bilateral posterior cingulate cortex (Su et al., 2017). These results suggest that structural brain changes associated with restrained eating and disinhibited eating may contribute to reduced inhibitory control function and increased food sensitivity.

In summary, task-based, resting-state, and structural fMRI findings further support altered neuro-cognitive mechanisms in REs. Consistent with behavioral and ERP results, fMRI studies have also identified reduced activation and gray matter volume in inhibitory control regions among REs. Additionally, neuroimaging results have revealed enhanced activation and increased gray matter volume in reward regions. Collectively, these neuroimaging studies underscore how REs amplify the reward value of food cues while diminishing inhibitory control capacity, thereby increasing the risk of disregarding weight control goals and engaging in disinhibited eating in food-rich environments.

## 2.2 Cognitive-Neural Performance Differences Between Successful and Unsuccessful Restrained Eaters

Although most REs fail to maintain long-term dieting and may even exhibit disinhibited eating, some REs can consistently achieve their goal of reduced caloric intake. Consequently, researchers have classified REs into subtypes based on behavioral performance: successful restrained eaters (SREs) and unsuccessful restrained eaters (UREs) (Polivy et al., 2020). According to the goal conflict model, UREs typically satisfy their goal of enjoying food by undermining their weight control objective, resulting in disinhibited eating behaviors. In contrast, SREs prioritize weight control goals, enabling them to reduce caloric intake and maintain weight even in food-rich environments (Keller & Siegrist, 2014).

Cognitive-neural differences between successful and unsuccessful restrained eaters primarily manifest in attentional bias and conflict control, which researchers have investigated through behavioral, eye-tracking, electrophysiological, and neuroimaging approaches. First, regarding attentional bias, significant differences exist between SREs and UREs, demonstrating a robust “energy effect” in food information processing—UREs show greater attentional preference for high-calorie foods than SREs. For example, eye-tracking studies on attentional bias toward food information have found that SREs exhibit early attentional vigilance followed by overall avoidance of high-calorie foods, whereas UREs show early vigilance, avoidance, and overall sustained attention toward high-calorie foods, indicating greater attention to high-calorie food cues among UREs (Zhang et al., 2016).

Second, concerning conflict inhibition, researchers propose that because UREs allocate substantial attentional resources to palatable food information, they experience less conflict between the goals of enjoying food and controlling weight during food choice tasks compared to SREs. Several eye-tracking, ERP, and neuroimaging studies have examined conflict control differences between UREs and SREs. For instance, eye-tracking research comparing reaction times and gaze shift indices during food selection found that UREs responded faster and made fewer gaze shifts than SREs, indicating reduced conflict experience (Zhang et al., 2019). The neural basis of these cognitive conflict differences has been supported by rs-fMRI and ERP evidence. Specifically, UREs showed reduced ReHo in inhibitory control regions (inferior parietal lobule), decreased activation in conflict monitoring regions (anterior cingulate cortex), and weaker connectivity between conflict monitoring and inhibitory control regions (particularly the frontoparietal network) compared to SREs (Zhang et al., 2020). ERP studies have also supported differential conflict monitoring and inhibitory control between successful and unsuccessful restrained eaters, demonstrating larger no-go N2a amplitudes in SREs than UREs during a food go/no-go task (Liu et al., 2020).

Furthermore, we have investigated the impact of negative emotion on conflict control in UREs and SREs. In a food go/no-go task, both SREs and UREs exhibited larger N2a amplitudes under negative versus neutral emotional states, suggesting that negative emotions may disrupt conflict monitoring and inhibitory control abilities. However, only SREs showed significantly reduced no-go P3 amplitudes under negative emotional conditions, indicating that SREs may enhance their inhibitory control over food, enabling them to suppress eating desires triggered by external food cues even when experiencing negative emotions. In contrast, UREs cannot suppress appetite under such conditions (Liu et al., 2020). Thus, negative emotion influences conflict control differently in successful versus unsuccessful restrained eaters, revealing distinct inhibitory control capacities.

Therefore, cognitive-neural performance differences between successful and unsuccessful restrained eaters may explain the success or failure of their dieting

efforts. Specifically, UREs demonstrate greater attentional preference for high-calorie foods and weaker conflict monitoring and inhibitory control abilities compared to SREs, as evidenced by both behavioral and neural indices. Additionally, negative emotion emerges as a critical factor interfering with dieting success.

### 3 Food Craving

Food craving is defined as an intense desire to consume a specific food or food type, an experience that nearly everyone has encountered in one form or another (Kober & Mell, 2015). Although relatively benign compared to cravings for harmful substances such as alcohol, food craving can nonetheless impact health by predicting binge eating behaviors and weight changes (Kober & Boswell, 2018). Beyond general food craving, international researchers have begun investigating cravings for specific foods, primarily focusing on sweet food craving (Meule & Hormes, 2015) and carbohydrate craving (Ma et al., 2017). In Chinese culinary culture, spicy food constitutes a major category, and “spicy food preference” represents a widespread regional phenomenon. Consequently, domestic researchers have started exploring the behavioral manifestations and neuro-cognitive mechanisms of spicy food craving.

#### 3.1 Cognitive-Neural Research on Food Craving

Based on its relationship with temporary physiological needs (e.g., hunger), food craving can be distinguished as either state or trait. Psychological research typically examines the cognitive performance associated with trait food craving. The Food Cravings Questionnaire-Trait (FCQ-t), which includes items such as “I feel like I have food on my mind all the time” and “Sometimes eating makes everything seem perfect,” measures trait-level reflections of general food craving across behavioral, cognitive, and physiological dimensions (Hormes & Meule, 2016).

Cognitively, individuals with high food craving demonstrate stronger automatic approach tendencies toward food compared to those with low craving (Brockmeyer et al., 2015). Food craving and trait impulsivity jointly influence inhibitory control over food information (Meule & Kubler, 2014), and exposure to food cues can weaken inhibitory control abilities in food cravers (Jones et al., 2018).

Nevertheless, the neural mechanisms of food craving remain poorly understood. Substantial evidence indicates that food and drug rewards share similar neural substrates (Noori et al., 2016). fMRI studies on general substance craving have found that specific activation in the hippocampus, insula, and caudate nucleus is associated with intense craving. Building on this foundation, a recent resting-state fMRI study investigated spontaneous neural activity in brain regions related to food craving. In young, healthy women, ReHo analysis was used to assess temporal synchronization of spontaneous brain activity, revealing pos-

itive correlations between food craving and ReHo activation in regions involved in emotional memory (parahippocampal gyrus) and visual attention processing (fusiform gyrus) (Chen et al., 2017). The fusiform gyrus, which is involved in processing visual food attributes, showed increased activation consistent with the central role of visual food cues in everyday food craving. Meanwhile, the parahippocampal gyrus participates in hedonic learning and incentive memory encoding, and its increased activation suggests that individuals with high trait craving may experience greater eating enjoyment, automatic responses to food cues, and more frequent recall of palatable foods. More frequent recollection of previously tasted foods may strengthen emotional memories and facilitate encoding of delicious food memories.

Therefore, trait food craving may be encoded by memory circuits with enhanced spontaneous activity in the parahippocampal gyrus, such that reinforced hedonic memories may override weight control goals with intense desires for palatable foods. These results align with previous substance craving research, indicating certain similarities across different craving subtypes.

### 3.2 Cognitive-Neural Research on Spicy Food Craving

Previous neuroimaging research on specific food cravings has focused primarily on sweet food craving, with studies demonstrating differential responses to sweet foods in the OFC, ACC, and ventral striatum between chocolate cravers and non-cravers (Rolls & McCabe, 2007). Unlike the widespread preference for other palatable foods (e.g., sweets), attitudes toward spicy food span a broad spectrum—from craving to aversion (Tepper et al., 2004), suggesting that the cognitive-neural profile of spicy food cravers should differ from other specific food craving populations. Furthermore, while most food cravings negatively impact health (e.g., excessive sweet consumption leads to obesity and related complications), capsaicin—the active component in spicy foods—offers various pharmacological benefits, including increased energy expenditure (Ludy & Mattes, 2011), antibacterial activity, and modulation of gut microbiota (Qin et al., 2014), and is associated with reduced mortality from cancer, ischemic heart disease, and respiratory diseases (Lv et al., 2015). Meanwhile, spicy food consumption is substantial in China, particularly in southwestern regions where “spicy food preference” is widespread, with consumption rates rising—over 30% of adults consume spicy food daily (Sun et al., 2014). Therefore, studying spicy food craving can not only deepen our understanding of the mechanisms underlying food craving but also contribute to public health improvement.

To investigate the neuro-cognitive mechanisms of spicy food craving in Chinese populations, we developed a culturally appropriate Spicy Food Craving Questionnaire (Zhou, 2018) and conducted a series of studies on its neural mechanisms. First, an fMRI study using a food cue reactivity task preliminarily explored behavioral responses and neural circuits in spicy food cravers. Behaviorally, spicy food cravers responded faster to spicy foods than non-cravers. Neuroimaging results revealed that when exposed to both chili-containing and

non-chili foods, spicy food cravers showed greater activation than non-cravers in brain regions associated with food and addictive substance cue reactivity, specifically enhanced activation in reward (e.g., insula, putamen), inhibitory control (e.g., ACC), and visual attention (e.g., inferior parietal lobule, lingual gyrus, precuneus, fusiform gyrus) regions. Moreover, in spicy food cravers, beta value changes in these regions (e.g., insula, putamen, ACC, precuneus) positively correlated with subjective spicy food craving, while beta value changes in the right inferior parietal lobule correlated with spicy food consumption frequency (Zhou et al., 2019). On one hand, these findings align with general food craving research (Geilebter et al., 2016), supporting the role of dorsal striatum, ACC, and insula as neural substrates of food craving from the perspective of spicy food craving. They are also consistent with the automatic behavioral tendency explanation of food craving (Brockmeyer et al., 2015), suggesting enhanced automatic behavioral tendencies toward spicy food cues. On the other hand, results regarding inhibitory control in spicy food cravers reveal characteristics distinct from other substance craving populations. Although feeling out of control represents a shared feature of food and substance craving (Goldstein, 2018), spicy food cravers show diminished inhibitory control specifically in response to spicy food cues without exhibiting this uncontrolled cognitive-neural pattern toward general cues.

#### 4 Summary and Outlook

This article has summarized research on the neuro-cognitive mechanisms of restrained eating and food craving within Chinese cultural contexts. In recent years, domestic researchers have made cutting-edge and in-depth contributions to understanding the psychological mechanisms of eating behaviors. As health issues and risks associated with dieting and binge eating become increasingly prominent in contemporary Chinese society, future research must explore the neuro-cognitive manifestations of restrained eating and food craving from more comprehensive perspectives and develop effective intervention strategies to mitigate unhealthy dieting and binge eating behaviors.

First, both domestic and international studies have found that restrained eaters tend to eat more than intended—that is, they exhibit disinhibited eating. Chinese scholars have expanded the neuro-cognitive evidence for this counter-regulatory effect within Chinese cultural contexts. Specifically, based on the goal conflict model of enjoying food versus controlling weight, research has identified weakened conflict control abilities in restrained eaters and documented alterations in reward-inhibition brain circuits through neuroimaging studies. Future research should investigate populations beyond healthy adolescents and adults, such as individuals with eating disorders including anorexia and binge eating disorder, particularly children in critical developmental stages.

Second, by distinguishing subtypes of restrained eaters—successful versus unsuccessful—domestic researchers have identified that the key to dieting success lies in changes in inhibitory control and associated brain regions. Therefore, based

on cognitive-neural performance differences between successful and unsuccessful restrained eaters, future studies can develop and test more effective intervention protocols for eating behaviors to serve public physical and mental health.

Third, food cravers exhibit automatic approach tendencies toward food and weaker inhibitory control over food cues. Brain activation patterns in food cravers show similarities with those observed in substance craving research. However, compared to more harmful substance cravings (e.g., smoking, alcohol, drugs), food craving poses relatively minor health risks. Consequently, future research should more specifically identify and differentiate the similarities and differences between food craving and other substance cravings.

Fourth, “spicy food preference” represents a distinctive feature of Chinese culinary culture, particularly in southwestern regions. Current research indicates that spicy food cravers show diminished inhibitory control and altered brain regions only in response to spicy food cues, while maintaining intact inhibitory control toward other cues. However, research on spicy food craving in Chinese populations is still emerging, and these findings require further empirical support. Future studies should conduct cross-regional and cross-cultural investigations.

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## References

王邵睿, 陈红. (2019). 为何越减越肥? ——限制性饮食者过度进食的心理机制及影响因素, *心理科学进展*, 27(2), 322-328.

王健美, 刘永, 周一舟, 张露露, 尹明, 陈红. (2020). 辣食渴求者抑制控制能力的行为和 ERP 研究. *心理科学*, 43(01), 150-157.

张雪萌, 陈红, 高笑, 江沂芯, 周一舟. (2016). 成功与失败限制性饮食者对食物信息加工的能量效应: 注意偏向的眼动研究. *心理科学*, 39(4), 956-963.

周一舟. (2018). “辣食渴求者”线索反应的生理及神经机制. 博士论文, 西南大学.

Brockmeyer, T., Hahn, C., Reetz, C., Schmidt, U., & Friederich, H. C. (2015). Approach bias and cue reactivity towards food in people with high versus low levels of food craving. *Appetite*, 95, 197-202.

Chen, S., Jackson, T., Dong, D., Zhuang, Q., & Chen, H. (2019). Effects of palatable food versus thin figure conflicts on responses of young dieting women. *Frontiers in Psychology*, 10.

Chen, S., Dong, D., Jackson, T., Su, Y., & Chen, H. (2016). Altered frontal inter-hemispheric resting state functional connectivity is associated with bulimic

- symptoms among restrained eaters. *Neuropsychologia*, 81, 222-228.
- Chen, S., Dong, D., Jackson, T., Zhuang, Q., & Chen, H. (2017). Trait-based food-cravings are encoded by regional homogeneity in the parahippocampal gyrus. *Appetite*, 114, 155-160.
- Chen, S., Jia, Y., Woltering, S. (2018). Neural differences of inhibitory control between adolescents with obesity and their peers, *International Journal of Obesity*, 42 (10), 1753.
- Claus, E. D., Blaine, S. K., Filbey, F. M., Mayer, A. R., & Hutchison, K. E. (2013). Association between nicotine dependence severity, BOLD response smoking cues, functional connectivity. *Neuropsychopharmacology*, 38(12), 2363-2372.
- Dong, D., Jackson, T., Wang, Y., & Chen, H. (2015). Spontaneous regional brain activity links restrained eating to later weight gain among young women. *Biological Psychology*, 109, 176-183.
- Dong, D., Lei, X., Jackson, T., Wang, Y., Su, Y., & Chen, H. (2014). Altered regional homogeneity and efficient response inhibition in restrained eaters. *Neuroscience*, 266, 116-126.
- Geliebter, A., Benson, L., Pantazatos, S. P., Hirsch, J., & Carnell, S. (2016). Greater anterior cingulate activation and connectivity in response to visual and auditory high-calorie food cues in binge eating: Preliminary findings. *Appetite*, 96, 195-202.
- Goldstein, R. (2018). 9. Cue-induced incubation of craving in human cocaine addiction: Modulation by reappraisal? *Biological Psychiatry*, 83(9), S3-S4.
- Hormes, J. M., & Meule, A. (2016). Psychometric properties of the English Food Cravings Questionnaire-Trait-reduced (FCQ-Tr). *Eating Behaviors*, 20, 34-38.
- Jones, A., Robinson, E., Duckworth, J., Kersbergen, I., Clarke, N., & Field, M. (2018). The effects of exposure to appetitive cues on inhibitory control: A meta-analytic investigation. *Appetite*, 128, 271-282.
- Keller, C., & Siegrist, M. (2014). Successful and unsuccessful restrained eating. Does dispositional self-control matter? *Appetite*, 74, 101-106.
- Kober, H., & Boswell, R. G. (2018). Potential psychological & neural mechanisms in binge eating disorder: Implications for treatment. *Clinical Psychology Review*, 60, 32-44.
- Kober, H., & Mell, M. M. (2015). Neural mechanisms underlying craving and the regulation of craving. *The Wiley Handbook on the Cognitive Neuroscience of Addiction*, 195-218.
- Kong F., Zhang Y., Chen H. (2015). Inhibition ability of food cues between successful and unsuccessful restrained eaters: A two-choice oddball task. *PLoS*

ONE, 10(4), 741-752.

Liu, Y., Zhang, L., Jackson, T., Wang, J., Yang, R., & Chen, H. (2020). Effects of negative mood state on event-related potentials of restrained eating subgroups during an inhibitory control task. *Behavioural Brain Research*, 112249.

Ludy, M. J., & Mattes, R. D. (2011). The effects of hedonically acceptable red pepper doses on thermogenesis and appetite. *Physiology & Behavior*, 102(3-4), 251-258.

Lv, J., Qi, L., Yu, C., Yang, L., Guo, Y., Chen, Y., et al. (2015). Consumption of spicy foods and total and cause specific mortality: Population based cohort study. *The British Medical Journal*, 351, h3942.

Ma, Y., Ratnasabapathy, R., & Gardiner, J. (2017). Carbohydrate craving: Not everything is sweet. *Current Opinion in Clinical Nutrition and Metabolic Care*, 20(4), 261.

Meule, A., & Hormes, J. M. (2015). Chocolate versions of the Food Cravings Questionnaires. Associations with chocolate exposure-induced salivary flow and ad libitum chocolate consumption. *Appetite*, 91, 256-265.

Meule, A., & Kubler, A. (2014). Double trouble. Trait food craving and impulsivity interactively predict food-cue affected behavioral inhibition. *Appetite*, 79, 174-182.

Noori, H. R., Linan, A. C., & Spanagel, R. (2016). Largely overlapping neuronal substrates of reactivity to drug, gambling, food and sexual cues: A comprehensive meta-analysis. *European Neuropsychopharmacology*, 26(9), 1419-1430.

Pires, L., Leitão, J., Guerrini, C., Simões, M.R. (2014). Event-related brain potentials in the study of inhibition: Cognitive control, source localization and age-related modulations, *Neuropsychological Review*, 24 (4), 461-490.

Polivy, J., Herman, C. P., & Mills, J. S. (2020). What is restrained eating and how do we identify it? *Appetite*, 155, 104785.

Qin, N., Yang, F., Li, A., Prifti, E., Chen, Y., Shao, L., et al. (2014). Alterations of the human gut microbiome in liver cirrhosis. *Nature*, 513(7516), 59-64.

Rolls, E. T., & McCabe, C. (2007). Enhanced affective brain representations of chocolate in cravers vs. non-cravers. *European Journal of Neuroscience*, 26(4), 1067-1076.

Song, S., Zhang, Y., Qiu, J., Li, X., & Chen, H. (2019). Brain structures associated with eating behaviors in normal-weight young females. *Neuropsychologia*, 133, 107171.

Stroebe, W., Van Koningsbruggen, G. M., Papies, E. K., & Aarts, H. (2013). Why most dieters fail but some succeed: A goal conflict model of eating behavior. *Psychological Review*, 120(1), 110.

Stopyra, M. A., Simon, J. J., Skunde, M., Walther, S., Bendszus, M., Herzog, W., & Friederich, H. C. (2019). Altered functional connectivity in binge eating disorder and bulimia nervosa: A resting-state fmri study. *Brain and Behavior*, e01207.

Su, Y., Jackson, T., Wei, D., Qiu, J., & Chen, H. (2017). Regional gray matter volume is associated with restrained eating in healthy Chinese young adults: Evidence from voxel-based morphometry. *Frontiers in Psychology*, 8, 2307.

Sun, D., Lv, J., Chen, W., Li, S., Guo, Y., Bian, Z., et al. (2014). Spicy food consumption is associated with adiposity measures among half a million Chinese people: The China kadoorie biobank study. *BMC Public Health*, 14(1), 1293.

Sutherland, M. T., McHugh, M. J., Pariyadath, V., & Stein, E. A. (2012). Resting state functional connectivity in addiction: Lessons learned and a road ahead. *NeuroImage*, 62(4), 2281-2295.

Tepper, B. J., Keller, K. L., & Ullrich, N. V. (2004). Genetic variation in taste and preferences for bitter and pungent foods: Implications for chronic disease risk (pp. 60-74). *Challenges in Taste Chemistry and Biology*.

Wang, Y., Dong, D., Jackson, Jie, Du, Zhou, Yang, Hui, Lu, Chen, H. (2016). Neural correlates of restrained eaters' high susceptibility to food cues: An fMRI study. *Neuroscience Letters*. 631, 56-62.

Weygandt, M., Mai, K., Dommès, E., Ritter, K., Leupelt, V., Spranger, J., & Haynes, J. D. (2015). Impulse control in the dorsolateral prefrontal cortex counteracts post-diet weight regain in obesity. *NeuroImage*, 109, 318-327.

Yao, L., Li, W., Dai, Z., and Dong, C. (2016). Eating behavior associated with gray matter volume alternations: A voxel based morphometry study. *Appetite* 96, 572-579.

Zhang, X., Luo, Y., Liu, Y., Yang, C., & Chen, H. (2019). Lack of conflict during food choice is associated with the failure of restrained eating. *Eating behaviors*, 34, 101309.

Zhang, Y., Wang, S., Wei, L., Jackson, T., Gao, X., Xiao, M. Y., Go, G. L., Chen, H. (2020). Resting state differences between successful and unsuccessful restrained eaters. *Brain Imaging and Behavior*, 6.

Zhou, Y., Liu, Y., Du, J., & Chen, H. (2018). Effects of food exposure on food-related inhibitory control in restrained eaters: An ERP study. *Neuroscience Letters*, 672, 130-135.

Zhou, Y., Gao, X., Small, D. M., & Chen, H. (2019). Extreme spicy food cravers displayed increased brain activity in response to pictures of foods containing chili peppers: An fMRI study. *Appetite*, 142, 104379.

### **Neuro-cognitive mechanism of food craving and restrained eating in Chinese**

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**Abstract:** In modern affluent societies, where palatable foods are readily available, resisting the food craving brought by tempting food clues and keeping restrained eating to maintain a healthy body weight has become one of the challenging propositions. In recent years, in order to identify the reasons for the success of dieting, domestic scholars have created a Chinese Food Image Database to investigate the neuro-cognitive mechanism of restrained eating, and examine the differences of brain mechanism between successful and unsuccessful restrained eaters. In particular, based on the neural correlates of food craving, researches on general food craving and spicy food craving with Chinese characteristics has been carried out. Exploring neuro-cognitive mechanisms of restrained eating and food craving can not only promote the theoretical developments of eating behavior research, but also provide important support for health interventions such as obesity and eating disorders.

**Key words:** restrained eating (RE), successful restrained eaters (SREs), unsuccessful restrained eaters (UREs), food craving, spicy craving

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