

抑郁情绪与超重/肥胖大学生对大脑奖赏功能影响的概述

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收稿日期: 2025年1月6日; 录用日期: 2025年2月17日; 发布日期: 2025年2月28日

摘要

抑郁症和超重/肥胖在现代社会中日益成为影响人类健康的主要问题。已有研究表明, 这两种病症往往共同发生, 并且可能通过改变奖赏系统的功能表现出相似的神经机制。目前, 奖赏系统在这两种病症中的具体作用机制尚未得到充分探讨, 理解奖赏功能失调在抑郁症与超重/肥胖中的作用, 成为揭示二者共病的潜在机制和治疗方法的重要方向。同时, 探索奖赏功能在这两种状态中的变化将对改善抑郁肥胖共病个体存在潜在治疗效果, 因此, 未来治疗策略应聚焦于调节奖赏功能。探究抑郁肥胖的奖赏改变将为奖赏功能干预的临床应用提供重要理论支持。

关键词

抑郁, 肥胖, 奖赏功能

An Overview of the Impact of Depressive Moods and Overweight/Obesity on the Reward Functions in College Students

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Received: Jan. 6th, 2025; accepted: Feb. 17th, 2025; published: Feb. 28th, 2025

Abstract

Depression and overweight/obesity have increasingly become major health issues in modern society. Studies show that these conditions often co-occur and may share similar neurobiological

mechanisms through alterations in the reward system. However, the specific role of the reward system in these conditions has not been fully explored. Understanding the impact of reward dysfunction in depression and obesity is crucial to revealing the underlying mechanisms of their comorbidity and potential treatment strategies. Meanwhile, investigating the alterations in reward function across these two conditions may have potential therapeutic implications for improving outcomes in individuals with depressive-obesity comorbidity. Therefore, future treatment strategies should focus on modulating reward function. Exploring reward-related changes in depressive-obesity comorbidity will provide crucial theoretical support for the clinical application of reward function interventions

Keywords

Depressive, Obesity, Reward Function

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1. 引言

根据《2022 年中国国民心理健康报告》，对近 8 万名大学生的心理健康状况调查显示，抑郁风险的检出率约为 21.48% (方圆, 王路石, 陈祉妍, 2023)。抑郁情绪主要表现为情绪低落, 快感缺失以及注意力分散, 睡眠或食欲不振 (National Institute for Health and Care Excellence, 2023)。抑郁患者不仅具有较高的自杀风险, 还可能导致心血管疾病、阿尔兹海默症、社交功能障碍以及极大的经济负担 (O'Sullivan et al., 2023)。长期的抑郁情绪将带来抑郁症的高发风险。为此, 重点关注具有抑郁情绪的人群很有必要。与此同时, 一项 2020 年的中国大学生肥胖调查研究表明, 19 至 22 岁大学生中, 男性和女性的超重及肥胖率分别为 20.8% 和 7.3% (Chen et al., 2020)。中国居民身体状况的调查和分析表明, 在过去的二十年里, 学生肥胖率呈上升趋势 (Li et al., 2020)。大学生正处于生活方式发生重大改变的人生阶段, 在这一阶段中, 身体活动减少、睡眠时间缩短、压力水平增加以及不健康饮食习惯等共同导致了肥胖的发生 (Telleria-Aramburu & Arroyo-Izaga, 2022)。不仅如此, 大学期间形成的肥胖趋势往往伴随一生, 造成个体长期的健康问题 (Ilić et al., 2024), 寻求有效的干预方法势在必行。令人担忧的是, 抑郁和肥胖往往相互促进, 导致更为复杂的不良后果且带来更差的预后效果。据统计, 抑郁患者发生肥胖的几率高出一般人群 37%, 而肥胖患者发生抑郁的几率高出 18% (Pont et al., 2017)。

快感缺失是抑郁症的核心症状之一, 而肥胖形成的重要特点之一是食物奖赏敏感性异常。有研究表明, 异常的奖赏环路可能是抑郁与超重/肥胖相互作用的重要神经机制 (Manelis et al., 2022)。然而, 目前针对抑郁肥胖共病这一特定人群的有效干预手段仍较为有限 (Cao et al., 2022)。大学生的认知功能较高, 可能对循证治疗更为敏感。因此, 本综述拟整合相关文献, 探索抑郁与超重/肥胖大学生在奖赏加工相关的心理行为与神经机制特点, 为开发抑郁肥胖共病个体新的干预方法提供指导依据。

2. 抑郁、超重/肥胖与奖赏功能的关联

2.1. 大脑奖赏功能概述

大脑奖赏功能是指中枢神经系统通过特定神经回路和神经递质系统对能够带来愉悦感、满足感或强化某种行为的刺激作出反应的能力 (Knutson et al., 2001)。奖赏功能是大脑激励机制的重要组成部分, 它能

够影响情绪、动机和行为决策。在演化生物学理论中, 大脑奖赏功能是人类和动物生存与适应的重要驱动力(Volkow et al., 2012)。奖赏功能的核心机制主要涉及大脑的奖赏回路, 包括中脑边缘多巴胺系统, 其关键区域为腹侧被盖区(VTA)、伏隔核(NAc)和前额叶皮层(PFC)。当个体接触到愉悦刺激(如食物、金钱或社会认可)时, 奖赏回路被激活, 引发一系列神经生化反应, 从而增强个体对该行为的重复动机(Schultz, 2016)。

奖赏功能研究在心理学和精神病学领域具有重要意义。例如, 抑郁患者表现出的奖赏缺失(愉悦感降低), 而成瘾行为则表现为对奖赏的过度敏感或奖赏系统的失调(Russo & Nestler, 2013)。这些现象进一步推动了对奖赏功能的深入探索, 以期开发更有效的干预手段。

2.2. 抑郁症中的奖赏功能异常

快感缺失是抑郁症的诊断标准之一, 也是奖赏功能异常的重要表现。抑郁不仅导致严重的功能障碍, 还会对人际关系产生不良影响(Hames et al., 2013)。大量研究一致发现, 抑郁患者在获取奖励的过程中表现出较低的动机(Mansur et al., 2019)。

多巴胺等神经递质代谢异常很早便被认为是抑郁产生快感缺失的原因。奖赏区域的多巴胺信号减少是快感缺乏在神经生物学上的表现, 奖赏环路的改变是引起快感缺乏的核心机制(Russo & Nestler, 2013)。但近几年来, 更多研究认为抑郁症主要与更复杂的神经调节系统和神经回路有关, 导致神经递质系统的继发性紊乱。有研究显示, 奖赏网络和默认模式网络之间的网络连接中断可能是导致抑郁的神经机制(Ding et al., 2022)。并且, 研究者在抑郁患者的大脑伏隔核(Stanislawski et al. 2021), 前扣带回皮层(ACC), 纹状体(VTA)等奖赏核心区域均发现了奖赏预期激活减少(Admon & Pizzagalli, 2015)。

2.3. 超重/肥胖与奖赏功能异常

超重肥胖人群在奖赏功能改变方面主要表现为对高脂, 高糖饮食的偏好。现有纵向研究证实, 长期对高脂饮食的偏好将调节奖赏处理过程, 从而进一步提升暴饮暴食和体重增加的可能性(Edwin Thanarajah et al., 2023; 高峰等, 2018)。一项有关暴饮暴食个体神经影像的元分析研究显示, 静息态时暴饮暴食个体表现出纹状体多巴胺释放较低, 纹状体、额叶皮层和脑岛的体积发生变化, 额叶纹状体连通性较低; 而在食物预期过程中发现了更高的大脑奖励系统的活动, 更多的无模型强化学习和更多的习惯性行为(Leenaerts et al., 2022)。肥胖个体奖励网络功能连通性的改变很可能导致食物成瘾的增加(Ravichandran et al., 2021)。由于奖赏神经机制的参与, 超重/肥胖人群更难从不健康的行为模式中转变过来。综上所述, 奖赏网络的异常与肥胖的发生发展形成了螺旋式上升的恶性循环。

2.4. 抑郁与肥胖个体的奖赏功能共同特点

迄今为止, 来自行为范式和神经影像学研究的证据提供了一致的证据, 证明抑郁肥胖人群的大脑回路中普遍存在奖励和相关认知功能失调。奖赏环路的改变与重度抑郁症的认知缺陷和抑郁严重程度相关。基于奖励的饮食行为与 BMI 和抑郁症的临床严重程度有关, 特别是脂肪摄入量增加(Rivera-Iñiguez et al., 2022)或更多选择令人愉悦的食物(即甜点和油炸食品)(Privitera et al., 2015)。上述结果与表明甜食或其他高热量食物与抑郁肥胖患者之间存在联系的数据相一致(Dalton et al., 2013; Epel et al., 2014), 即糖和脂肪食物的组合可能会在大脑的奖励系统中产生积极的反馈, 导致情绪状态的增强, 并鼓励暴饮暴食(DiFeliceantonio et al., 2018; 韩艳等, 2017)。简而言之, 奖赏功能改变既是 MDD 的重要神经机制病变, 同时也是参与超重/肥胖人群减肥困难的重要环节。对奖赏功能的改善很可能成为抑郁、肥胖共病个体干预的重要关键。

3. 抑郁与超重/肥胖特异性的大脑奖赏加工

尽管直接探讨抑郁与超重/肥胖在社会奖赏失调方面的研究较少, 但已有证据表明二者之间的交互作

用可能对奖赏功能产生影响。部分研究在奖赏行为表现与奖赏相关脑区发现了抑郁与超重/肥胖之间的交互作用。一项行为研究提出,超重/肥胖显著调节了重度抑郁症与努力获得奖励意愿之间的关联(Mansur et al., 2019)。肥胖遗传负荷将会影响抑郁患者大脑结构和奖励相关脑回路功能改变(Opel et al., 2019)。在超重的抑郁患者中发现了胰岛素抵抗水平越高,静息态大脑奖赏区域功能连接障碍也越高(Singh et al., 2019)。这都说明了抑郁与超重/肥胖的共同作用很可能对奖赏功能产生特异性的影响。

还有大量的研究在大脑功能性成像的帮助下,对抑郁或超重/肥胖人群在不同奖赏任务下大脑奖赏区域功能改变进行了探索。奖赏功能的表现形式多种多样,主要包括食物奖赏、金钱奖赏以及社会奖赏。在不区分人群的情况下,神经影像学研究(包括功能性磁共振成像 MRI, 正电子发射断层扫描 PET, 脑电图 EEG 等)中对奖赏功能好坏进行表征时使用最多的是金钱奖赏任务评分,如 MID 任务(Monetary incentive delay task)。在目前研究中,超重/肥胖人群的研究主要探讨的是食物奖赏异常,而抑郁个体则更多偏向社会奖赏失调。但由于金钱奖赏任务在表现奖赏功能方面的普适性,有部分研究同样用它来表征抑郁症快感缺失的程度(Wang et al., 2021)。当对比金钱奖赏与其他奖赏形式在抑郁个体中的改变时,多数研究没有发现金钱奖赏的异常。有研究探讨了金钱奖赏处理在抑郁与超重/肥胖中的作用,但最终仅发现肥胖与金钱奖赏处理异常之间的关联(Gill et al., 2021)。在仅针对具有抑郁症状人群的社会激励延迟任务与金钱激励延迟任务的研究中,也只发现抑郁组在社会奖赏预期下的奖赏功能异常,而金钱奖赏预期下大脑奖赏功能激活在抑郁组与健康对照组中没有显著差异(Zhang et al., 2022)。超重/肥胖者是否具有较差的社会奖赏体验及功能异常结合目前的研究尚未可知,但社会排斥的增加会导致暴饮暴食的行为,超重/肥胖的个体更容易遭到社会孤立及排斥(Salvy et al., 2011)。综合以上讨论,我们认为食物奖赏与社会奖赏处理的异常是抑郁与超重/肥胖个体在奖赏加工失调的共同表现。

4. 奖赏功能改善对抑郁、肥胖个体干预的探索

认知行为疗法(CBT)可通过改善个体情绪调节策略的方式,使个体的消极情绪下调或积极情绪上调(Denny, 2020)。已有研究表明,积极的情绪调节策略(如认知重评)可以增强奖赏功能,而消极策略(如情绪抑制)可能进一步恶化奖赏异常(Denny, 2020)。情绪调节的改善对抑郁人群来说,有助于减少快感缺失的程度,因而可能在过程中对奖赏功能的失调起到改善作用。一项针对情绪与预期奖赏/损失的研究显示,负面情绪与预期损失时脑岛前部激活有关(Wu et al., 2014)。情绪调节干预对奖赏加工的改善可对抑郁与肥胖个体起到有效干预作用。首先,情绪处理与奖赏加工活动中存在共同的神经变化(Yankouskaya et al., 2022);大脑多个功能均需要情绪调节区域与奖赏加工区域的联合行动;其次,认知重评等干预方式可以从认知层面改变个体奖赏体验解释模式,从而改变个体面对奖赏预期的心理行为(Yang & Li, 2014)。再者,有研究发现,放大积极情绪的治疗方法可增加抑郁焦虑个体在奖励处理、注意力和情绪调节网络中的连通性(Kryza-Lacombe et al., 2021);这表明情绪调节的有效反应可能通过奖赏功能对抑郁个体产生有利影响。在肥胖患者中,基于奖赏调控的干预方法,如行为治疗和认知重构,有助于降低高脂饮食的奖赏效应(Winter et al., 2017)。在抑郁症患者中,利用神经调控技术(如重复经颅磁刺激 rTMS)来改善奖赏网络的功能也取得了一定进展(Xu et al., 2023)。这些研究均为未来针对抑郁与超重/肥胖个体的综合干预提供了重要参考。

Wilson 等人提出,干预方法如果不解决抑郁和肥胖人群在奖赏缺陷潜在途径的神经调控改变,治疗可能几乎没有效果(Wilson et al., 2023)。因此,目前的干预方式均有包含对奖赏功能的改善,而这一特性增加了抑郁肥胖个体干预方式的有效性。若绕开改善奖赏功能这一重要环节,干预方案可能出现有效性不足的情况。因此,围绕奖赏功能开发新的治疗方案可以对抑郁肥胖个体起到不错的预后效果。

5. 结语

抑郁与超重/肥胖的奖赏功能异常共享相似的神经机制,表明两者在病理过程中的相互作用对大学生心理健康和生活方式具有重要影响。本综述结合现有文献,系统分析了抑郁与超重/肥胖个体在奖赏加工中的特异性表现,并探讨了潜在的神经机制和行为特征。此外,通过认知行为疗法和神经调控技术等干预手段,针对性地改善奖赏功能,为解决抑郁和肥胖共病问题提供了新思路。未来研究应进一步探索这一特定人群的奖赏加工特点及其可行的干预策略,从而推动精准心理健康干预的发展,并为大学生群体的健康管理提供理论依据和实践指导。

参考文献

- 方圆,王路石,陈祉妍(2023). 2022 年中国大学生心理健康状况调查报告. 见 傅小兰,张侃,陈雪峰,陈祉妍(编),《中国国民心理健康发展报告(2021~2022)》(pp. 70-99). 社会科学文献出版社.
- 高峰,焦广发,董东(2018). 过度进食肥胖症脑奖赏功能异常与运动治疗:脑功能成像证据. *中国运动医学杂志*, 37(5), 432-439.
- 韩艳,舍英,高笑(2017). 肥胖成因的解释——基于食物奖赏研究的视角. *心理科学进展*, 25(3), 452-462.
- Admon, R., & Pizzagalli, D. A. (2015). Dysfunctional Reward Processing in Depression. *Current Opinion in Psychology*, 4, 114-118. <https://doi.org/10.1016/j.copsyc.2014.12.011>
- Cao, B., Xu, J., Li, R., Teopiz, K. M., McIntyre, R. S., & Chen, H. (2022). Interventions Targeting Comorbid Depression and Overweight/Obesity: A Systematic Review. *Journal of Affective Disorders*, 314, 222-232. <https://doi.org/10.1016/j.jad.2022.07.027>
- Chen, Y., Liu, X., Yan, N., Jia, W., Fan, Y., Yan, H., & Ma, L. (2020). Higher Academic Stress Was Associated with Increased Risk of Overweight and Obesity among College Students in China. *International Journal of Environmental Research and Public Health*, 17, Article 5559. <https://doi.org/10.3390/ijerph17155559>
- Dalton, M., Blundell, J., & Finlayson, G. (2013). Effect of BMI and Binge Eating on Food Reward and Energy Intake: Further Evidence for a Binge Eating Subtype of Obesity. *Obesity Facts*, 6, 348-359. <https://doi.org/10.1159/000354599>
- Denny, B. T. (2020). Getting Better over Time: A Framework for Examining the Impact of Emotion Regulation Training. *Emotion*, 20, 110-114. <https://doi.org/10.1037/emo0000641>
- DiFeliceantonio, A. G., Coppin, G., Rigoux, L., Edwin Thanarajah, S., Dagher, A., Tittgemeyer, M., & Small, D. M. (2018). Supra-Additive Effects of Combining Fat and Carbohydrate on Food Reward. *Cell Metabolism*, 28, 33-44.e33. <https://doi.org/10.1016/j.cmet.2018.05.018>
- Ding, Y. D., Chen, X., Chen, Z. B., Li, L., Li, X. Y., Castellanos, F. X., & Guo, W. B. (2022). Reduced Nucleus Accumbens Functional Connectivity in Reward Network and Default Mode Network in Patients with Recurrent Major Depressive Disorder. *Translational Psychiatry*, 12, Article No. 236. <https://doi.org/10.1038/s41398-022-01995-x>
- Edwin Thanarajah, S., DiFeliceantonio, A. G., Albus, K., Kuzmanovic, B., Rigoux, L., Iglesias, S., & Small, D. M. (2023). Habitual Daily Intake of a Sweet and Fatty Snack Modulates Reward Processing in Humans. *Cell Metabolism*, 35, 571-584.e576. <https://doi.org/10.1016/j.cmet.2023.02.015>
- Epel, E. S., Tomiyama, A. J., Mason, A. E., Laraia, B. A., Hartman, W., Ready, K., & Kessler, D. (2014). The Reward-Based Eating Drive Scale: A Self-Report Index of Reward-Based Eating. *PLOS One*, 9, e101350. <https://doi.org/10.1371/journal.pone.0101350>
- Gill, H., Gill, B., Lipsitz, O., Rodrigues, N. B., Cha, D. S., El-Halabi, S., & McIntyre, R. S. (2021). The Impact of Overweight/Obesity on Monetary Reward Processing: A Systematic Review. *Journal of Psychiatric Research*, 137, 456-464. <https://doi.org/10.1016/j.jpsychires.2021.03.029>
- Hames, J. L., Hagan, C. R., & Joiner, T. E. (2013). Interpersonal Processes in Depression. *Annual Review of Clinical Psychology*, 9, 355-377. <https://doi.org/10.1146/annurev-clinpsy-050212-185553>
- Ilić, M., Pang, H., Vlaški, T., Grujičić, M., & Novaković, B. (2024). Prevalence and Associated Factors of Overweight and Obesity among Medical Students from the Western Balkans (South-East Europe Region). *BMC Public Health*, 24, Article No. 29. <https://doi.org/10.1186/s12889-023-17389-7>
- Knutson, B., Adams, C. M., Fong, G. W., & Hommer, D. (2001). Anticipation of Increasing Monetary Reward Selectively Recruits Nucleus Accumbens. *The Journal of Neuroscience*, 21, RC159. <https://doi.org/10.1523/jneurosci.21-16-j0002.2001>

- Kryza-Lacombe, M., Pearson, N., Lyubomirsky, S., Stein, M. B., Wiggins, J. L., & Taylor, C. T. (2021). Changes in Neural Reward Processing Following Amplification of Positivity Treatment for Depression and Anxiety: Preliminary Findings from a Randomized Waitlist Controlled Trial. *Behavior Research and Therapy*, 142, Article 103860. <https://doi.org/10.1016/j.brat.2021.103860>
- Leenaerts, N., Jongen, D., Ceccarini, J., Van Oudenhove, L., & Vrieze, E. (2022). The Neurobiological Reward System and Binge Eating: A Critical Systematic Review of Neuroimaging Studies. *International Journal of Eating Disorders*, 55, 1421-1458. <https://doi.org/10.1002/eat.23776>
- Li, X., Wu, C., Lu, J., Chen, B., Li, Y., Yang, Y. et al. (2020). Cardiovascular Risk Factors in China: A Nationwide Population-Based Cohort Study. *The Lancet Public Health*, 5, e672-e681. [https://doi.org/10.1016/s2468-2667\(20\)30191-2](https://doi.org/10.1016/s2468-2667(20)30191-2)
- Manelis, A., Halchenko, Y., Satz, S., Ragozzino, R., Iyengar, S., Swartz, H. et al. (2022). The Interaction between Depression Diagnosis and BMI Is Related to Altered Activation Pattern in the Right Inferior Frontal Gyrus and Anterior Cingulate Cortex during Food Anticipation. *Brain and Behavior*, 12, e2695. <https://doi.org/10.1002/brb3.2695>
- Mansur, R. B., Subramaniapillai, M., Zuckerman, H., Park, C., Iacobucci, M., Lee, Y. et al. (2019). Effort-Based Decision-Making Is Affected by Overweight/obesity in Major Depressive Disorder. *Journal of Affective Disorders*, 256, 221-227. <https://doi.org/10.1016/j.jad.2019.06.002>
- National Institute for Health and Care Excellence (2023). Depression in Adults: Treatment and Management. *NICE Website*.
- O'Sullivan, D., Gordon, B. R., Lyons, M., Meyer, J. D., & Herring, M. P. (2023). Effects of Resistance Exercise Training on Depressive Symptoms among Young Adults: A Randomized Controlled Trial. *Psychiatry Research*, 326, Article 115322. <https://doi.org/10.1016/j.psychres.2023.115322>
- Opel, N., Redlich, R., Reppe, J., Kaehler, C., Grotegerd, D., Dohm, K. et al. (2019). Childhood Maltreatment Moderates the Influence of Genetic Load for Obesity on Reward Related Brain Structure and Function in Major Depression. *Psychoneuroendocrinology*, 100, 18-26. <https://doi.org/10.1016/j.psyneuen.2018.09.027>
- Pont, S. J., Puhl, R., Cook, S. R., & Slusser, W. (2017). Stigma Experienced by Children and Adolescents with Obesity. *Pediatrics*, 140, e20173034. <https://doi.org/10.1542/peds.2017-3034>
- Privitera, G. J., McGrath, H. K., Windus, B. A., & Doraiswamy, P. M. (2015). Eat Now or Later: Self-Control as an Overlapping Cognitive Mechanism of Depression and Obesity. *PLOS ONE*, 10, e0123136. <https://doi.org/10.1371/journal.pone.0123136>
- Ravichandran, S., Bhatt, R. R., Pandit, B., Osadchiy, V., Alaverdyan, A., Vora, P. et al. (2021). Alterations in Reward Network Functional Connectivity Are Associated with Increased Food Addiction in Obese Individuals. *Scientific Reports*, 11, Article No. 3386. <https://doi.org/10.1038/s41598-021-83116-0>
- Rivera-Iñiguez, I., Panduro, A., Villaseñor-Bayardo, S. J., Sepulveda-Villegas, M., Ojeda-Granados, C., & Roman, S. (2022). Influence of a Nutrigenetic Intervention on Self-Efficacy, Emotions, and Rewarding Behaviors in Unhealthy Eating among Mexicans: An Exploratory Pilot Study. *Nutrients*, 14, Article 213. <https://doi.org/10.3390/nu14010213>
- Russo, S. J., & Nestler, E. J. (2013). The Brain Reward Circuitry in Mood Disorders. *Nature Reviews Neuroscience*, 14, 609-625. <https://doi.org/10.1038/nrn3381>
- Salvy, S., Bowker, J. C., Nitecki, L. A., Kluczynski, M. A., Germeroth, L. J., & Roemmich, J. N. (2011). Impact of Simulated Ostracism on Overweight and Normal-Weight Youths' Motivation to Eat and Food Intake. *Appetite*, 56, 39-45. <https://doi.org/10.1016/j.appet.2010.11.140>
- Schultz, W. (2016). Dopamine Reward Prediction-Error Signalling: A Two-Component Response. *Nature Reviews Neuroscience*, 17, 183-195. <https://doi.org/10.1038/nrn.2015.26>
- Singh, M. K., Leslie, S. M., Packer, M. M., Zaiko, Y. V., Phillips, O. R., Weisman, E. F. et al. (2019). Brain and Behavioral Correlates of Insulin Resistance in Youth with Depression and Obesity. *Hormones and Behavior*, 108, 73-83. <https://doi.org/10.1016/j.yhbeh.2018.03.009>
- Stanislowski, M. A., Frank, D. N., Borengasser, S. J., Ostendorf, D. M., Ir, D., Jambal, P. et al. (2021). The Gut Microbiota during a Behavioral Weight Loss Intervention. *Nutrients*, 13, Article 3248. <https://doi.org/10.3390/nu13093248>
- Telleria-Aramburu, N., & Arroyo-Izaga, M. (2022). Risk Factors of Overweight/Obesity-Related Lifestyles in University Students: Results from the EHU12/24 Study. *British Journal of Nutrition*, 127, 914-926. <https://doi.org/10.1017/s0007114521001483>
- Volkow, N. D., Wang, G., Fowler, J. S., & Tomasi, D. (2012). Addiction Circuitry in the Human Brain. *Annual Review of Pharmacology and Toxicology*, 52, 321-336. <https://doi.org/10.1146/annurev-pharmtox-010611-134625>
- Wang, X., He, K., Chen, T., Shi, B., Yang, J., Geng, W. et al. (2021). Therapeutic Efficacy of Connectivity-Directed Transcranial Magnetic Stimulation on Anticipatory Anhedonia. *Depression and Anxiety*, 38, 972-984. <https://doi.org/10.1002/da.23188>
- Wilson, J. B., Epstein, M., Lopez, B., Brown, A. K., Lutfy, K., & Friedman, T. C. (2023). The Role of Neurochemicals, Stress

-
- Hormones and Immune System in the Positive Feedback Loops between Diabetes, Obesity and Depression. *Frontiers in Endocrinology*, 14, Article 1224612. <https://doi.org/10.3389/fendo.2023.1224612>
- Winter, S. R., Yokum, S., Stice, E., Osipowicz, K., & Lowe, M. R. (2017). Elevated Reward Response to Receipt of Palatable Food Predicts Future Weight Variability in Healthy-Weight Adolescents. *The American Journal of Clinical Nutrition*, 105, 781-789. <https://doi.org/10.3945/ajcn.116.141143>
- Wu, C. C., Samanez-Larkin, G. R., Katovich, K., & Knutson, B. (2014). Affective Traits Link to Reliable Neural Markers of Incentive Anticipation. *NeuroImage*, 84, 279-289. <https://doi.org/10.1016/j.neuroimage.2013.08.055>
- Xu, T., Zhou, X., Kanen, J. W., Wang, L., Li, J., Chen, Z. et al. (2023). Angiotensin Blockade Enhances Motivational Reward Learning via Enhancing Striatal Prediction Error Signaling and Frontostriatal Communication. *Molecular Psychiatry*, 28, 1692-1702. <https://doi.org/10.1038/s41380-023-02001-6>
- Yang, L., & Li, M. T. (2014). The Review of Acceptance, Cognitive Reappraisal, Expression Suppression in Emotion Regulation Strategies. *Advances in Psychology*, 4, 80-88.
- Yankouskaya, A., Denholm-Smith, T., Yi, D., Greenshaw, A. J., Cao, B., & Sui, J. (2022). Neural Connectivity Underlying Reward and Emotion-Related Processing: Evidence from a Large-Scale Network Analysis. *Frontiers in Systems Neuroscience*, 16, Article 833625. <https://doi.org/10.3389/fnsys.2022.833625>
- Zhang, D., Shen, J., Bi, R., Zhang, Y., Zhou, F., Feng, C. et al. (2022). Differentiating the Abnormalities of Social and Monetary Reward Processing Associated with Depressive Symptoms. *Psychological Medicine*, 52, 2080-2094. <https://doi.org/10.1017/s0033291720003967>