Advances in Psychology 心理学进展, 2021, 11(3), 780-785
Published Online March 2021 in Hans. http://www.hanspub.org/journal/ap
https://doi.org/10.12677/ap.2021.113089

Hans汉斯

腹内侧前额叶在多种心理功能中发挥重要作用

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收稿日期：2021年2月24日；录用日期：2021年3月18日；发布日期：2021年3月29日

摘　要

腹内侧前额叶(VMPFC)是皮层和皮层下网络的关键节点。这篇文章综合了近几年对人类和动物的相关研究，阐述了VMPFC在各种情绪、决策、社会认知和自我信息加工等四个心理功能领域的广泛作用。第一，VMPFC通过与杏仁核、终纹床核等相互作用，在负性情绪的产生和调节中发挥重要作用。第二，VMPFC对奖励和价值决策发挥至关重要的作用。第三，VMPFC通过与后扣带回皮质、前叶等脑区相互作用，在社会认知方面发挥重要作用，如面部情绪识别、思维能力等。第四，VMPFC与后扣带回皮质、背内侧前额叶皮质的相互作用，参与自我信息加工。

关键词

腹内侧前额叶，情绪，价值决策，社会认知，自我加工

Ventromedial Prefrontal Cortex Plays an Important Role in Many Psychological Functions

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Received: Feb. 24th, 2021; accepted: Mar. 18th, 2021; published: Mar. 29th, 2021

Abstract

Ventral prefrontal lobe (VMPFC) is a key node of cortical and subcortical networks. This paper synthesizes the relevant research on humans and animals in recent years and expounds the ex-

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文章引用: 刘佳, 刘晓玲, 刘映杰, 张秀军(2021). 腹内侧前额叶在多种心理功能中发挥重要作用. *心理学进展, 11(3),* 780-785. DOI: 10.12677/ap.2021.113089

tensive role of VMPFC in four psychological functional fields, such as various emotions, decision-making, social cognition and self-information processing. First, VMPFC plays an important role in the generation and regulation of negative emotions through interaction with the amygdala and terminal striated bed nucleus. Second, VMPFC plays a vital role in reward and value decision-making. Third, VMPFC plays an important role in social cognition, such as facial emotion recognition, thinking ability and so on. Fourth, the interaction between VMPFC and posterior cingulate cortex and dorsomedial prefrontal cortex is involved in self-information processing.

Keywords

Ventromedial Prefrontal Cortex, Emotion, Decision Making, Social Cognition, Self-Processing

1. 引言

腹内侧前额叶(ventromedial prefrontal cortex, VMPFC)位于大脑前端，眼睛的正上方，大小与一个垒球接近。VMPFC 没有明确的解剖边界和定义，不是特定的核团或脑区。通常指下内侧和眶前额叶皮层相互连接的网络区域(Öngür & Price, 2000; Mackey & Petrides, 2014)。不同的研究者用来描述不同的脑区，取决于实验方法的解剖精度，Clark 等人(Clark et al., 2008)认为腹内侧前额叶包括眶额叶的内侧部分(BA 10, 11, 12)，以及内侧前额皮质和前扣带回的腹侧区域(BA 24, 25, 32)。Koenigs 等人(Koenigs & Grafman, 2009)认为，VMPFC 包括内侧前额叶皮层的腹侧部分(胼胝体膝部以下)和眼眶表面的内侧部分(大约在每个半球的眶额叶内侧的三分之一)，Öngür 等人(Öngür & Price, 2000)研究发现，在啮齿动物、猴子和人类之间有同源的 VMPFC 区域。这为 VMPFC 功能的研究提供了大量数据，以下各节对 VMPFC 各种心理和行为功能展开综述。

2. VMPFC 在情绪调节中的作用

有研究发现，VMPFC 能够调节多个与情绪有关的脑区，比如杏仁核、基底前脑、下丘脑和脑干(Petrides & Pandya, 2002; Öngür & Price, 2000; Al Omran et al., 2014)。VMPFC 主要与整合情绪有关(Asp, Gullickson, Warner, Koscik, Denburg, & Tranel, 2019; Buckholtz & Marois, 2012)，VMPFC 的激活与负性情绪的诱发直接相关(Etkin, Egner, & Kalisch, 2011)。已有研究发现，VMPFC 损伤后，人们控制情绪的功能将出现障碍和钝化(Anderson, Barrash, Bechara, & Tranel, 2006)以及社会情绪出现异常(Beadle, Paradiso, & Tranel, 2018; Krajbich, Adolphs, Tranel, Denburg, & Camerer, 2009)。Myers-Schulz 等人(Myers-Schulz & Koenigs, 2012)研究发现 VMPFC 后侧的区域更多地与社交恐惧症、预期焦虑等消极情绪有关，而 VMPFC 前侧区域则与恐惧的消除、对有吸引力面孔的知觉等积极情绪有关，他们发现重度抑郁患者的 VMPFC 后部的一些子区域激活，而前面区域的活动反而减少。

Likhtik 等人(Likhtik, Pelletier, Paz, & Pare, 2005)研究发现 VMPFC 通过抑制杏仁核来调节恐惧反应，有研究表明杏仁核对条件性恐惧的表达至关重要(Le Doux, 2003)。McDonald 等人(McDonald, Mascagni, & Guo, 1996)在大鼠的解剖研究中，Ghashghaei 等人(Ghashghaei & Barbas, 2002)在恒河猴的解剖研究中，分别发现了从 VMPFC 到杏仁核内的抑制性中间神经元，为 VMPFC 调节恐惧情绪提供了可行解剖学证据。另外，人类功能成像研究表明，在条件恐惧的消退过程中(Kalisch, Korenfeld, Stephan, Weiskopf, Seymour,

& Dolan, 2006)以及消极情绪的意志抑制过程中(Johnstone, Van, Urry, Kalin, & Davidson, 2007)，VMPFC和杏仁核的活动是反向相关的。Atlas 等人(Atlas & Wager, 2014)研究认为 VMPFC 是通过安慰剂效应或到达预期操纵来调节负性情绪的。Motzkin 等人(Motzkin, Philippi, Oler, Kalin, Baskaya, & Koenigs, 2015)研究发现 VMPFC 损伤降低了皮层下终纹床核的活性，终纹床核的作用主要是参与焦虑(Adhikari, 2014)。

3. VMPFC 在价值决策和奖赏中的作用

Bechara 等人(Bechara, Damasio, Damasio, & Anderson, 1994)在一项赌博任务中，要求 VMPFC 损伤的受试者在风险、模糊和扭转意外情况的三种条件下学习奖惩，证实了 VMPFC 损伤的患者基于价值的决策严重缺陷。后来 Pujara 等研究者(Pujara, Wolf, Baskaya, & Koenigs, 2015)证实 VMPFC 病变患者在风险赌博中价值决策的缺陷。Krajbich 等人(Krajbich, Adolphs, Tranel, Denburg, & Camerer, 2009)证实 VMPFC 病变患者在经济交换中价值决策的缺陷。Wheeler 和 Fellows (Wheeler & Fellows, 2008)研究证明 VMPFC 病变患者在概率强化学习中的缺陷。Henri-Bhargava 等研究者(Henri-Bhargava, Simioni & Fellows, 2012)证明 VMPFC 病变患者在简单二元项目偏好方面也存在决策缺陷。

随着功能成像技术的发展，在各种决策环境中，用评分将 VMPFC 活动与价值决策和奖励联系起来(Liu, Hairston, Schrier, & Fan, 2011; Levy & Glimcher, 2012)。动物研究已经证明了 VMPFC 在代表和更新刺激和结果的奖励值方面的关键作用。例如，动物电生理记录研究表明，猴子的 VMPFC 病变破坏了奖励价值和奖励偶然性指导的选择(Izquierdo, Suda, & Murray, 2004)，猴子和大鼠的 VMPFC 编码、评估刺激的奖励特性(Tremblay & Schultz, 1999; Lopatina et al., 2016)。

有研究发现，VMPFC 是与奖赏加工有关的脑区(De Quervain et al., 2004; Hu, Strang, & Weber, 2015)，能够评估他人违背规范的意图以及造成的实际损害(Glass et al., 2016)，评估违背规范的意图和价值，使人们根据情境做出适合的决策(Baumgartner, Götte, Gügler, & Fehr, 2012)。

VMPFC 参与信任、怀疑等风险决策的加工(Fumagalli & Priori, 2012)。老年人的 VMPFC 可能受到不同程度的损伤，从而老年人容易上当受骗(Denburg et al., 2007)。

4. VMPFC 在社会认知中的作用

研究者们在一些精神疾病患者的研究中发现 VMPFC 还参与了一些社会认知功能(Barrash, Tranel, & Anderson, 2000)。VMPFC 损伤患者保留相对正常的智力，但在动机、移情、灵活性、行为抑制、及洞察力方面表现出缺陷。Tsuchida 和 Fellows (Tsuchida & Fellows, 2012)研究发现 VMPFC 损伤破坏对细微面部情绪表情的识别，这种病人很难区分情绪表情和中性表情。Wolf 等人(Wolf, Philippi, Motzkin, Baskaya, & Koenigs, 2014)在对双侧 VMPFC 损伤的患者进行面部情感识别测试时，发现对面部眼睛区域的视觉注意。

5. VMPFC 在自我加工中的作用

VMPFC 还参与了自我信息加工，比如唤起自传式回忆，或在假设的情况下想象自己的感觉(Northoff, Heinzel, de Greck, Bermpohl, Dobrowolny, & Panksepp, 2006; Svoboda, McKinnon, & Levine, 2006)。Raichle 等人(Raichle, MacLeod, Snyder, Powers, Gusnard, & Shulman, 2001)研究发现 VMPFC 与背内侧 PFC 以及后扣带回皮质和前叶等脑区组成“默认模式网络”，参与自我有关的加工。还有研究表名，腹内侧前额叶皮质及周边系统主要参与包含外部刺激在内的自我相关加工(Schmitz & Johnson, 2006)。

6. 研究前景

VMPFC 是一个复杂的脑区，本文简单阐述了 VMPFC 在情绪调节、价值决策和奖赏、社会认知以及自我加工起到的关键作用。事实上，VMPFC 远远不只本文阐述的几种功能，而 VMPFC 的诸多功能也与

杏仁核、纹状体、海马等边缘系统结构有关，未来对 VMPFC 的研究应深入探索 VMPFC 在其他方面的作用，以及背后的神经机制。

根据目前的几个领域的研究，将来可以继续进行一些研究。比如在抑郁症、焦虑症、恐惧症及燥狂等精神疾病的诊断和治疗中，进一步研究 VMPFC 不同亚区的作用及与其他脑结构的联系，制定更细致更具针对性的诊断及治疗方案。再比如在社会心理学和经济学中，继续研究价值决策和奖赏的脑机制，研究成瘾的治疗，研究疾病导致的风险决策能力下降等。另外，在认知心理学的基础研究中，可以在更多的患者及实验动物被试中探索出更多 VMPFC 是如何在各个复杂任务中发挥作用及其他脑区结构之间配合的机制，以及更多人脑 VMPFC 与动物脑中 VMPFC 的区别，从而探索更多人脑认知神经机制。

基金项目

2020 年河北省省属高校科研业务项目(JSQ2019006)；2020 年河北省社会科学发展研究课题(20200303120)；2020 年河北省社会科学基金(HB20SH013)。

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