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应激引起记忆改变的相关机制及其改善方法

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摘　要

应激被广泛认为是记忆变化的潜在诱因，它对记忆既有有利影响，也有不利影响。本综述论文旨在全面概述目前对应激诱发记忆变化的理解，重点关注应激对记忆形成、巩固、检索和遗忘的影响机制。除此之外，本文还讨论了这些发现对旨在改善应激个体记忆表现的干预措施的影响。

关键词

应激，记忆，记忆形成，记忆巩固，记忆检索，改善方法

The Mechanism Associated with Stress-Induced Memory Alterations and Improvement Methods

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Abstract

Stress is widely recognized as a potential trigger of memory change, with both favorable and unfavorable effects on memory. The aim of this review paper is to provide a comprehensive overview of the current understanding of stress-induced memory changes, focusing on the mechanisms by which stress affects memory formation, consolidation, retrieval and forgetting. In addition to this, the paper discusses the implications of these findings for interventions aimed at improving memory performance in stressed individuals.

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Keywords

Stress, Memory, Memory Formation, Memory Consolidation, Memory Retrieval, Improvement Methods

1. 引言

记忆是能够保障我们日常生活的重要组成部分，它的主要功能是使我们在特定环境中可以有效能够获取、存储和检索所需要的信息。记忆的正常运行是至关重要的，无论对于个体的学习还是适应。应激是一种常见的心理与生理结合的反应。在应激状态下，会对个体的认知加工(包括记忆)产生一定的影响。相关研究表明，应激对记忆既有有利影响，也有不利影响，这取决于应激暴露的时间、强度和持续时间。了解应激诱发记忆变化的内在机制对于制定干预措施以改善应激个体的记忆表现至关重要。本综述旨在概述目前对应激引起的记忆变化的理解，重点关注应激对记忆形成、巩固、检索和遗忘的影响机制。

2. 应激在社会层面下研究的重要性

应激是个体在日常生活中的一种常见的体验，它影响着我们的机体、情感和认知(Epel et al., 2018)。同时，它也是生活中不可避免的一部分，可以在各种情况下发生，比如考试工作截止日期(Daniel, 2019; Yasmin, Khalil, & Mazhar, 2020)、关系冲突(Giebels & Janssen, 2020; Simpson & Rholes, 2017)、经济应激(French & McKillop, 2017; Guan et al., 2022)和健康问题(Lundberg, 2005; Slavich, 2016)。应激对个体既有正面的提升，也有负面的下降，这取决于应激的强度、持续时间和应对策略(Elomaa et al., 2023; Schäfer, Pels, & Kleinert, 2020)。然而，当应激持续时间较长或个体继续难以承受一定程度的应激状态时时，它也会导致各种健康问题(McEwen, 2008)，从而降低生活质量(Ribeiro et al., 2018)。因此，应激在社会层面下进行研究有着一定的重要性。

在社会环境层面，应激对个人、家庭、社区和社会都可能存在一定的影响。对于我们个体来说，应激会影响个人的精神和身体健康，导致抑郁、焦虑、心脏病、糖尿病和其他疾病(Cohen, Janicki-Deverts, & Miller, 2007; Cohen, Edmondso, & Kronish, 2015)。其次，应激带来的经济影响也很庞大，每年医疗成本、缺勤和生产力损失总计达数十亿美元(McTernan, Dollard, & LaMontagne, 2013; Pradoto, Haryono, & Wahyuningsih, 2022)。此外，应激还会影响人际关系和社会功能，导致婚姻问题和家庭暴力(Lacey et al., 2021)，以及药物滥用和犯罪(Hoffmann & Su, 1997)。

应激的研究可以提供在社会层面应激的原因、影响以及调节的方法。目前一部分研究已经探索了各种可以诱发应激的应激源对于个体的影响。比如，环境因素(如噪音、污染和拥挤) (Baum, Deckel, & Gatchel, 2013)，以及个人因素(如社会排斥) (Goosby, Cheadle, & Mitchell, 2018)。通过了解这些应激源及其相互作用，研究人员可以制定减少应激的干预措施，如改善生活条件、提供社会支持和促进健康的应对技能。

对应激的研究在社会层面是至关重要的，因为它对个人、家庭、社区和社会的健康和福祉有影响。应激是一种影响每个人的普遍体验，但当它变成慢性或程度极高甚至突破临界状态时，应激就会阻碍我们的日常生活甚至诱发更多难以预料的问题。因此，对应激的研究可以从不同的角度探索应激出现的原

因，会产生怎样的影响以及如何调节应激程度从而更好服务于生活。

3. 记忆功能变化的理论基础

记忆是一个复杂的认知过程，涉及信息的编码、存储和检索。许多理论框架被提出来解释记忆功能在不同情况下发生的变化。理解这些变化的理论基础对于深入了解记忆潜在机制以及探究记忆性能受到的相关影响至关重要。

对于记忆的相关理论中，信息加工模型(Information Processing Model)是及其重要的。这个理论认为记忆的整体加工可以理解为一系列阶段，其中包括感觉记忆、短期记忆和长期记忆。根据这个模型，记忆功能的变化是由于在每个阶段处理信息的方式不同而发生的(Angelopoulou & Drigas, 2021; Cowan, 1998; Lutz & Huitt, 2003; Simon, 1979; Wickens & Carswell, 2021)。

当我们记忆某一刺激时，最先开始的认知加工为编码。编码是对传入信息的初始处理，并将其转换成可存储在内存中的形式(Rebola, Carta, & Mulle, 2017)。在编码过程中，注意水平和加工的深度会影响产生的记忆痕迹的强度和持久性。在这种前提下，与建立有意义的联系和联想的深度处理相比，比如只是对复述信息进行浅层加工，而没有进行更深入的理解或阐述，会导致更弱的记忆表征(Brady & Störmer, 2022)。

当对刺激进行有效编码以后，就会进入下一阶段：存储。存储中编码信息的质量会随时间的变化而变化。信息处理模型根据信息的特点和持续时间，将信息存储在不同的记忆系统中(Cowan, 1988; Mutlu et al., 2022)。短期记忆暂时储存信息，而长期记忆储存信息的时间更长。记忆功能的变化可能是由于将信息从短期记忆转移到长期记忆的干扰、衰减或巩固过程等因素造成的。

当对刺激进行编码以及储存以后，就到了记忆加工的最后阶段：提取。提取是指一段时间后再访问存储信息的过程(Cowan et al., 2021)。语境、线索、提取策略的可用性等因素将会潜在影响记忆提取的效果。并且，在记忆提取这个过程中也可能会受到有意识加工(如：刻意回忆)或自动加工(如：识别)的潜在调节。

加工层次框架(Levels of Processing Framework)相较于信息加工模型不同，它强调加工深度在记忆功能中的作用。根据这一理论，记忆性能受信息在语义上(即基于意义)而不是表面上(即基于物理特征)加工程度的影响。因此，加工层次框架将对刺激进行的记忆加工分为浅加工和深加工(Lockhart & Craik, 1990)。

浅加工涉及到对基于刺激的物理特征的编码，如刺激的外观或声音。在日常生活中，当我们需要记住一个单词只注意到单词的物理性外观(字母)而不考虑它的意思，这就意味着我们对该记忆目标只进行了浅加工。浅层加工的信息更容易被遗忘，并且与其他方面的关联有限，这就是说浅加工形成的记忆表征将会非常脆弱。与浅层加工相比，更深层次的加工，也就是涉及到对记忆刺激进行精细加工和产生有意义的连接，能更好地形成记忆表征以在后期对该表征维持和检索。深度加工包括语义的编码和与已有知识的连接。这种级别的加工将会在目标刺激上绑定更多表征以促进更好的储存表现(Dragomir & Niculescu, 2022; Gallo et al., 2008; Innocenti et al., 2010)。如果能够将需要加工的刺激信息与个人经历联系起来，形成联想，这就有可能形成更加稳定和丰富的记忆表征以提升记忆功能的表现(Gilboa & Moscovitch, 2021)。加工层次框架的不同加工程度表明，通过在编码期间操纵对目标刺激的加工深度，记忆功能可以随着这种加工深度随之发生变化。通过鼓励个体进行更深入、更有意义的加工，记忆性能就可以得到改善。

除此之外，记忆功能变化的理论还涉及到双加工理论(Dual-Process Theory)。该理论认为，记忆功能可能会受到回忆和熟悉两个不同水平的认知加工的影响(Bronstein et al., 2019; Jones & Jacoby, 2001; Wixted, 2007)。回忆指的是有意识地、费力地检索过去事件的具体细节，其中涉及到与储存在记忆当中相关的详细信息的检索，如具体事件、背景细节或源记忆(记住信息在哪里遇到)。回忆依赖于有意识的努力，并与海马体和相关的大脑区域相关(Schneider et al., 2021)。注意、编码深度和细化等因素影响记忆。

而熟悉是指一种没有能力回忆具体细节的感觉，具体来说，熟悉是一种不需要有意识回忆具体细节的熟悉感或识别感。这是一个自动的、毫不费力的加工，即使在明确回忆失败时也会发生(Wittwer et al., 2022)。双加工理论认为记忆功能的改变可能是由于这两个过程的相对贡献的改变。

综上所述，理解记忆功能变化的理论基础为了解影响记忆改变的潜在机制和因素提供了有价值的见解。信息加工模型强调了编码、存储和检索过程在记忆变化中的作用。加工层次框架强调了深度语义加工对于优化记忆储存性能的重要性。双加工理论阐明了回忆和熟悉过的作用及其对记忆功能的调节。通过从不同视角整合这些理论可以制定策略来优化记忆表现，并解决在不同背景下的出现不同类别的记忆障碍。

4. 应激诱导记忆变化的机制

应激可通过多种机制影响记忆过程，包括激活下丘脑－垂体－肾上腺(hypothalamic pituitary adrenal, HPA)轴、释放糖皮质激素、激活交感神经系统(sympathetic nervous system, SNS)以及调节神经可塑性机制(Boucher & Plusquellec, 2019)。

HPA 轴在应对应激时会被激活，从而释放皮质醇等糖皮质激素(Herman & Tasker, 2016)。一些研究已经发现，皮质醇对个体在陈述性记忆表现存在有害影响(Cohen et al., 2020; de Quervain et al., 2000; Dos Santos et al., 2018; Newcomer et al., 1999)。除此之外，皮质醇可通过促进对情绪显著信息的编码来增强记忆的形成和巩固(Borrell et al., 1983, 1984; Cunningham et al., 2021)。这些效应依赖于杏仁核基底外侧核的完整(Roozendaal & McGaugh, 1997; Guadagno et al., 2021)，它被认为通过对海马和尾状核或壳核等其他结构的影响来增强记忆巩固(Packard, Cahill, & McGaugh, 1994; Gann et al., 2023)。虽然肾上腺素不易穿过血脑屏障，但它可能通过外周 β 肾上腺素受体介导的反馈影响中枢记忆(McGaugh, 2000)。

应激反应也会激活 SNS，导致儿茶酚胺(如肾上腺素和去甲肾上腺素)的释放，而儿茶酚胺可通过激活杏仁核和海马来促进记忆的形成和巩固(李佳琪等，2017；James et al., 2021)。然而，长期接触儿茶酚胺会损害记忆检索，并导致神经元损伤。应激还能调节神经可塑性机制，包括对记忆形成和巩固至关重要的长期电位和长期抑制(Kumar, 2011)。应激引起的神经可塑性机制的变化会改变突触连接的强度，从而导致记忆表现的变化(Deppermann et al., 2014)。

在分子水平上，神经递质调节和表观遗传修饰被认为是应激导致记忆改变的关键机制。神经递质如去甲肾上腺素和多巴胺调节记忆巩固和提取过程。表观遗传修饰，包括 DNA 甲基化和组蛋白乙酰化，可调节基因表达模式，影响记忆的形成和可塑性(Mifsud et al., 2011)。目前涉及动物模型和人类研究的研究提供了有价值的证据，支持应激诱发记忆变化的复杂性。

应激对记忆过程产生复杂的影响，既有增强，也有损害。应激对记忆改变的机制涉及应激激素、神经递质、脑区、遗传因素和表观遗传修饰的相互作用。突触可塑性和神经回路的改变进一步促进了应激相关的记忆改变。对这些机制的全面理解对发展干预措施以减轻应激对记忆和认知功能的负面影响具有重要意义。

5. 应激对记忆形成、巩固、检索和遗忘的影响

记忆作为一种认知功能，探索应激状态下记忆的改变可以作为一个切入点以深入探究应激对于其他以及更高层次的认知功能所带来的影响。应激会对记忆过程产生不同的影响，具体取决于应激暴露的时间、强度和持续时间。一般来说，急性应激反应会增强记忆的形成和巩固，而慢性应激反应则会损害记忆检索并导致遗忘(黄雅梅等，2014；Costanzi et al., 2021)。急性应激反应可以通过提高信息的显著性来增强记忆的形成，从而更好地进行编码。急性应激还能促进信息从短期记忆向长期记忆的转移，从而增

强记忆的巩固(Henckens et al., 2009; Corbett et al., 2017)。长期暴露于应激之下将会形成慢性应激，慢性应激将会破坏从长期记忆中检索以前编码的信息，从而影响记忆检索。除此之外，长期暴露于应激下还会损害记忆巩固并诱发海马体萎缩，从而导致遗忘(Lindau et al., 2016)。

在记忆形成过程中，应激既可以增强也可以削弱编码过程。急性应激(如突发的意外事件)，已被证明能增强情绪记忆的形成。这种现象被称为“闪光灯记忆”效应，会导致对高度唤起的事件产生生动而持久的记忆(Erll & Hirst, 2023)。杏仁核是大脑中涉及情绪处理的区域，在调节这种增强中起着关键作用。另一方面，长期或严重的应激会损害新记忆的形成，尤其是那些与中性或非情绪信息有关的记忆。在长时间或强烈的应激下释放的应激激素，如皮质醇，会干扰对记忆形成至关重要的大脑区域海马体，导致编码和巩固新信息的困难(Schwabe, 2017)。

记忆巩固是指新形成的记忆的稳定和加强。研究发现，适度的应激可以增强情绪记忆的巩固。这种增强被认为是由应激激素的释放介导的，应激激素激活了杏仁核和海马中的 β 肾上腺素能受体。这些受体有助于巩固情绪上突出的信息，从而更好地保留情绪记忆。然而，过度的应激会破坏巩固过程。高水平的应激激素会损害海马的功能，干扰情绪和非情绪记忆的巩固。因此，这会导致记忆保持和回忆的减少(Joëls et al., 2007; Schwabe & Wolf, 2010)。

记忆的提取也会受到应激的影响。适度的应激水平已被发现有助于记忆提取。应激激素的分泌可以提高存储记忆的可及性和可及性，增强对相关信息的回忆。这在需要快速思考和适应性反应的情况下尤其有益(Schwabe & Wolf, 2014)。相反，高水平的应激会导致检索困难和记忆扭曲。应激诱导的记忆提取障碍常与前额叶皮质活动减少和杏仁核激活增加相关。这些改变会对回忆的准确性和完整性产生负面影响，导致记忆错误或遗漏(Roozendaal, McEwen, & Chattarji, 2009; Vo et al., 2022)。

应激也可以在遗忘过程中起到调节作用。应激事件会触发记忆抑制或抑制，导致有意遗忘不必要或创伤性记忆。这种机制被称为动机性遗忘，可以作为一种保护功能，防止回忆痛苦的经历(Brewin, 2018)。负责执行控制和情绪调节的前额叶皮层参与了这一过程的调节。此外，长期经历应激会导致记忆力下降，加速认知老化，可能会增加患阿尔茨海默病等与记忆相关的疾病的风险(Tran, Srivareerat, & Alkadhi, 2011)。

总之，应激对记忆过程产生复杂的影响。急性应激可以增强情绪记忆的形成和巩固，而慢性或严重的应激会损害记忆的形成和巩固，尤其是中性或非情绪信息。适度的应激可以促进记忆提取，而高度的应激则会阻碍记忆提取，导致记忆扭曲。此外，应激可以诱导有意遗忘，作为对不必要或创伤性记忆的应对机制。需要进一步的研究来阐明潜在的神经机制，并制定策略来减轻应激对记忆的负面影响。了解这些影响可以为理解应激与记忆之间的关系提供有价值的见解，最终有助于开发与应激相关的记忆障碍的干预措施。

6. 旨在改善应激个体记忆表现的干预措施

应激会显著影响记忆表现，急性和慢性应激都会对记忆的各个方面产生不利影响。因此，有必要采取干预措施，减轻这些负面影响，并改善应激个体的记忆表现。实施这些干预措施可能对精神健康、认知功能和总体福祉产生重要影响。

改善应激个体记忆表现的一种方法涉及实施应激管理技术。这些技巧旨在降低应激水平，促进放松，最终增强记忆过程。应激管理技巧的例子包括正念冥想、深呼吸练习、渐进式肌肉放松和瑜伽。这些技术已经被发现可以降低应激激素水平，改善认知功能，增强记忆能力。通过减轻应激和促进心境平静，这些干预措施可以优化记忆编码、巩固和提取(Wolever et al., 2012; Mittal et al., 2022)。

认知行为疗法是另一种可以有效改善应激个体记忆表现的干预措施。CBT 侧重于识别和修正导致应激和记忆困难的消极思维模式和行为。通过各种认知重组技术，个体学会挑战并用更有适应性和积极的想法取代消极的想法。这可以帮助缓解应激，通过减少焦虑和提高记忆任务中的注意力来提高记忆表现

(Meichenbaum, 2017; McCrae et al., 2022)。

有规律的体育锻炼已被证明对记忆和认知功能有很多好处，包括对减轻应激的影响。运动促进内啡肽的释放，内啡肽是大脑中天然的增强情绪的化学物质。它还增加大脑的血流量和氧供应，刺激神经发生和改善神经可塑性。这些生理变化可以增强记忆的形成、巩固和提取。应激程度高的人群可以考虑在日常生活中，加入有规律的锻炼可以改善记忆表现和整体认知功能(Mandolesi et al., 2018)。

选择健康的生活方式也有助于改善应激个体的记忆表现(Gibson, 2006)。这包括确保充足的睡眠，保持均衡的饮食，避免过量饮酒和使用药物。充足的睡眠对巩固记忆至关重要，因为它允许大脑有效地处理和存储信息(Chambers, 2017)。富含抗氧化剂、维生素和 ω-3 脂肪酸的营养饮食有助于大脑健康，增强认知功能(Stavrinou et al., 2020)。相反，过量饮酒和药物使用会损害记忆过程，并对整体大脑功能产生不利影响(Salmanzadeh et al., 2020; Ernst et al., 2022)。

参加记忆训练计划对那些有应激的人来说是有益的。这些项目包括练习特定的记忆技巧和策略，如记忆装置和可视化练习。记忆训练可以通过改善注意力集中、组织和阐述信息来增强记忆编码、存储和检索过程(Bovy et al., 2022)。此外，参加记忆训练项目可以增加自信心，减少与记忆任务相关的焦虑，从而提高记忆表现(Youngs et al., 2021)。

实施干预措施以改善应激个体的记忆表现，对他们的整体健康和日常功能有重要影响。通过降低应激水平，促进放松，实施认知和行为策略，这些干预措施可以优化记忆过程，提高认知表现。记忆力的提高可以导致更好的学习或工作表现，提高生产力，提高生活质量。此外，解决应激个体的记忆障碍可以预防或减轻长期慢性应激对心理健康和认知能力下降的负面影响。

总体而言，这些干预措施为支持和提高应激个体的记忆表现提供了有希望的途径，有助于他们的整体认知健康和福祉总之，应激会对记忆过程产生复杂的影响，了解这些影响的内在机制对于制定干预措施以改善应激个体的记忆表现至关重要。急性应激反应可促进记忆的形成和巩固，而慢性应激反应则会损害记忆检索并导致遗忘。针对 HPA 轴、SNS 和神经可塑性机制的干预措施可用于减轻应激对记忆表现的不利影响。还需要进一步的研究来确定应激暴露的最佳时间、强度和持续时间，以提高记忆能力，并为经历应激的个体制定有效的干预措施。

7. 结论

本篇综述系统概览了应激诱发的记忆改变，就其机制以及影响因素进行了全面的概括。并且针对相关的影响提出了一些指导性建议，为未来的临床应用和治疗提供了启示。希望通过更深入地了解应激对记忆的影响，我们能够更好地保护和管理个体的心理健康。

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