

睡眠不足对人际交互的影响及其认知神经机制*

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摘要 睡眠不足会对人的认知、情感和人际交互产生诸多影响。这种影响在社会情绪层面表现为个体情绪共情和认知共情的减少, 易激惹性与愤怒情绪的增加; 在社会行为层面则表现为亲社会行为的减少和攻击行为的增加。在睡眠不足状态下, 情绪系统和认知系统功能连接的减弱可能是这些变化的潜在机制。未来应结合生态效度较高的睡眠操作手段, 系统考察睡眠不足如何导致各种高级社会情绪的改变, 以及这些社会情绪的变化如何导致社会行为的变化。

关键词 睡眠不足 睡眠剥夺 睡眠限制 共情 易激惹性/愤怒 亲社会行为 攻击行为

1 引言

充足的睡眠是个体正常生理和心理活动的重要保障。由于巨大的生活压力和快节奏的生活, 越来越多的人长期处于睡眠不足的状态。目前, 探讨睡眠不足如何影响生理和心理的研究也越来越多。睡眠不足的早期研究主要关注基本认知过程, 发现睡眠不足会引起注意、记忆和认知控制等认知功能的损伤 (Killgore, 2010)。近期的研究开始考察睡眠不足如何影响复杂的社会情绪和行为, 比如共情 (Guadagni, Burles, Ferrara, & Iaria, 2014)、亲社会行为 (Anderson & Dickinson, 2010) 和攻击行为 (Cote, McCormick, Geniole, Renn, & MacAulay, 2013) 等。这些研究积累了大量的实证证据。鉴于这些研究与实际生活的联系紧密, 对这些证据的整理和归纳, 不仅能促进本领域研究的进一步发展, 还可以为现实生活提供直接的理论指导。已有李爱梅、谭磊、孙海龙、熊冠星和潘集阳的综述 (2016) 探讨了睡眠不足对风险决策的影响及其心理机制。但实验室模拟的风险决策通常涉及到单人赌博任务, 并不涉

及与他人的互动。本文则系统综述睡眠不足对人际交互的影响。

研究者通常使用问卷调查、心理量表 (Freitag, Ireland, & Niesten, 2017) 及腕动计 (Guadagni et al., 2017) 来评估个体的睡眠质量和睡眠时长, 或者通过睡眠剥夺 (一次性的从一夜到几十小时的剥夺) (Anderson & Dickinson, 2010) 和睡眠限制 (1~2 周的每天 4~6 小时的睡眠时长) (Dickinson & McElroy, 2017) 来操纵个体的睡眠不足状态。在人际交互方面, 目前学术界普遍认为, 爱意-敌意 (love-hostility) 是最基本的维度 (Pincus, Gurtman, & Ruiz, 1998)。这个维度在情感层面表现为多种亲和与敌对的社会情绪 (Adolphs, 2003), 在行为层面则表现为亲社会行为与攻击行为。本文将从亲和情绪 (主要为共情)、敌对情绪 (主要为易激惹性与愤怒)、亲社会行为和攻击行为四个方面对相关研究进行系统综述, 结合已有研究和理论模型, 探讨睡眠不足影响人际交互的认知神经机制, 并在此基础上展望未来的研究方向。

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2 睡眠不足状态下的社会情绪

社会情绪是指在社会交往中产生、并对人的社会行为或倾向产生影响的情绪反应,包括共情、内疚、感激和愤怒等(Adolphs, 2003)。不同于基本情绪,社会情绪的产生基于个体对他人心理状态的表征(Burnett, Bird, Moll, Frith, & Blakemore, 2009)。对睡眠不足如何影响社会情绪,已有的研究在深度与广度上都存在较大的局限性,主要集中在共情、易激惹性与愤怒。

2.1 共情

研究者通常将共情分为情绪共情和认知共情。情绪共情指个体替代性地感受他人的内在状态,与他人产生情感共鸣的过程;认知共情则指个体对他人内在感受和行为及其原因进行细致判断和推理的过程(Blair, 2005)。

睡眠不足会减少情绪共情。Rosen等人(2006)发现,在一年实习期期间,实习医生睡眠不足程度从开始的9%上升至之后的43%,主观睡意显著增加,在人际反应性指针量表(interpersonal reactivity index)中的共情关注维度得分显著降低。这反映了睡眠不足状态下个体情绪共情水平的降低。Guadagni等人(2017)用腕动计、睡眠日记和睡眠量表测量个体的睡眠质量,发现睡眠质量越差,通过多维度共情测验(multifaceted empathy test)测得的个体情绪共情水平越低。为了验证睡眠不足与情绪共情的因果联系,Guadagni等人(2014)采用睡眠剥夺方法,发现睡眠剥夺组在多维度共情测验中的情绪共情水平显著低于对照组。

睡眠不足会减少认知共情。Rosen等人(2006)发现,在实习期间,实习医生睡眠不足程度的上升会伴随着认知共情水平的降低(即人际反应性指针量表中观点采择维度和幻想维度上的得分均显著降低)。与此一致,Shea等人(2014)发现,实习医生在熬夜值班期间睡觉时间越少,其在观点采择维度上的得分就越低。严格的实验室观察研究显示,相比于情侣两人都睡眠充足时,如果有一方睡眠不足,情侣双方在冲突中对彼此感受和观点理解的准确性也会显著降低(Gordon & Chen, 2014)。此外,假定对他人面孔情绪识别的能力能够反映识别者的认知共情水平(Dziobek et al., 2008),有证据表明,睡眠剥夺会损伤个体对高兴和悲伤等面部情绪的识别,但一晚的恢复性睡眠以及兴奋性药物能够

逆转这种损伤(Cote, Mondloch, Sergeeva, Taylor, & Semplonius, 2014; Killgore, Balkin, Yarnell, & Capaldi, 2017; van der Helm et al., 2011)。

2.2 易激惹性与愤怒

易激惹性与愤怒都是评估敌意的重要维度,其中易激惹性是指个体对轻微挑衅爆发负性情绪的准备倾向,而愤怒则是指个体在受到挑衅或不当对待后产生的、并驱动报复行为的情绪反应(Buss & Durkee, 1957)。

睡眠不足会增加个体易激惹性和愤怒情绪。Bauducco, Flink, Jansson-Fröjmark 和 Linton (2016)发现,青少年睡眠时间越短,就越会报告出更多的负性情绪,包括愤怒、抑郁和焦虑等。在日本高中生群体中,Itani等人(2016)也发现,睡眠时间不足与愤怒、抑郁和冲动性的增加存在正相关关系。分别考察成年男性(Randler & Vollmer, 2013)和成年女性(Romney et al., 2016)的研究表明,睡眠时间与愤怒情绪呈负相关;在睡眠不足状态下,伴随愤怒情绪的增加,男性身体攻击和口头攻击的倾向也显著增加(Randler & Vollmer, 2013)。采用睡眠剥夺或睡眠限制手段操纵睡眠不足的实验性研究也证实了这些发现。睡眠限制会增加青少年(14~17岁)自我报告的愤怒与敌意,以及父母报告的青少年的易激惹性与对立性(Baum et al., 2014)。睡眠剥夺增加了成人(18~30岁)报告的愤怒与敌意(Schwarz et al., 2019)。操纵刺激情境的研究(Minkel et al., 2012)表明,在低压力情境下,相较于控制组,睡眠剥夺组报告了更大的主观压力、焦虑和愤怒情绪,而在高压力情境下,两组没有显著差异。这些结果提示,睡眠不足会增加个体对情绪刺激的敏感性。

3 睡眠不足状态下的社会行为

3.1 亲社会行为

亲社会行为泛指一切能够使他人及社会获益的行为。睡眠不足会减少个体的亲社会行为,使个体变得自私、不信任他人、辜负他人的信任、对分配方案中自己的收益要求更高、在社交上更为退缩等。睡眠剥夺会显著减少个体在独裁者游戏中分配给对家的钱数,即降低个体的慷慨程度(Anderson & Dickinson, 2010; Ferrara et al., 2015),也会显著减少个体作为投资人给受托人的信任投资(Anderson

& Dickinson, 2010)。睡眠限制时长与个体最佳睡眠时长之间的差距越大，个体给受托人的信任投资就越少，作为受托人，个体在接受投资后回馈给投资人的钱数也越少 (Dickinson & McElroy, 2017)。睡眠剥夺还会增加个体对分配方案的拒绝率。睡眠剥夺后，个体作为反应者更加倾向于拒绝劣势不公平 (对方的收益高于自己) 的分配方案，甚至也会拒绝公平 (双方各得 50%) 的分配方案 (Anderson & Dickinson, 2010)。最近的一项孤独感研究发现，无论是实验室睡眠剥夺还是实际生活中睡眠质量差造成的睡眠不足，都会导致个体拉大自己与他人的社会距离，增加其孤独感，并使得他人也更不愿意与其交往 (Ben Simon & Walker, 2018)。

此外，组织中的利他行为——组织公民行为的相关研究同样支持了这一结论：睡眠数量越多，即睡眠越充足，个体做出的有益于个体和组织的组织公民行为就越多 (Barnes, Ghumman, & Scott, 2013)。

3.2 攻击行为

攻击行为是指针对他人、以引起他人身体或心理痛苦为目的的故意行为。睡眠不足越严重，个体的攻击性越强。这一结论在多个样本中得到了验证，如英国人 (Freitag et al., 2017)、非裔美国人 (Vaughn, Salas-Wright, White, & Kremer, 2015)、男性犯人 (Barker, Ireland, Chu, & Ireland, 2016)、儿童和青少年 (Gregory, van der Ende, Willis, & Verhulst, 2008) 等。纵向研究发现，儿童和青少年时期 (4~19 岁) 的睡眠不足能够预测个体 13 年后进入成年早期阶段 (18~32 岁) 时的情绪问题和攻击行为 (Gregory et al., 2008)。多个研究采用睡眠剥夺方法来检验睡眠不足与攻击行为的因果联系，但结论不完全一致。Kahn-Greene 等人 (2006) 发现，经过 55 小时的睡眠剥夺，个体在面对沮丧的图片情境时更容易将其归因为他人的责任并责备他人。Cote 等人 (2013) 使用减点 - 攻击范式发现，33 小时的睡眠剥夺只会减少男性的攻击行为，对女性的攻击行为没有影响。Vohs 等人 (2011) 则发现，24 小时的睡眠剥夺并未改变个体在泰勒攻击范式中的攻击行为。上述实验研究结果的不一致可能与范式有关。一方面，Vohs 等人 (2011) 使用的泰勒攻击范式只使用噪音作为惩罚刺激，而噪音对某些个体来说可能不属于厌恶性或伤害性刺激。有研究者认为，单纯给对方施加噪音刺激，这种行为可能不能被定义为攻击行

为 (Ferguson & Rueda, 2009)。最近一项使用改良版泰勒攻击范式 (惩罚刺激为噪音和扣钱) 的褪黑素研究发现，增加脑中褪黑素水平，会同时增加个体的嗜睡程度和攻击水平 (Liu et al., 2017)。另一方面，Cote 等人 (2013) 通过手指按键行为 (减点 - 攻击范式)，量化睡眠不足个体的攻击水平——按键次数越多，攻击他人越多。但睡眠不足会减少个体的按键动作倾向本身 (Hosokawa, Kennerley, Sloan, & Wallis, 2013)，因此，使用这种范式衡量睡眠不足个体的攻击倾向，就存在低估的可能性。

4 睡眠不足影响人际交互的认知神经机制

前人研究的结果总结如下：睡眠不足减少情绪共情和认知共情，增加易激惹性与愤怒情绪，减少亲社会行为，增加攻击性。睡眠不足状态下所引起的个体人际交互的变化，可以通过双加工理论 (dual-process theory) 来解释。该理论认为，个体众多心理功能都涉及两个相互独立却又相互制约的系统：一个系统基于审慎的思考推理过程，产生分析性反应，涉及前额叶等认知相关脑区，被称为“认知系统”；另一个系统则基于较为节约的启发式过程，产生直觉性反应，涉及边缘系统等情绪相关脑区，被称为“情绪系统” (Evans & Frankish, 2009)。许多行为证据提示，相比于正常睡眠状态，在睡眠不足状态下，两系统协同作用的变化可能决定了个体人际交互的变化 (见图 1)。

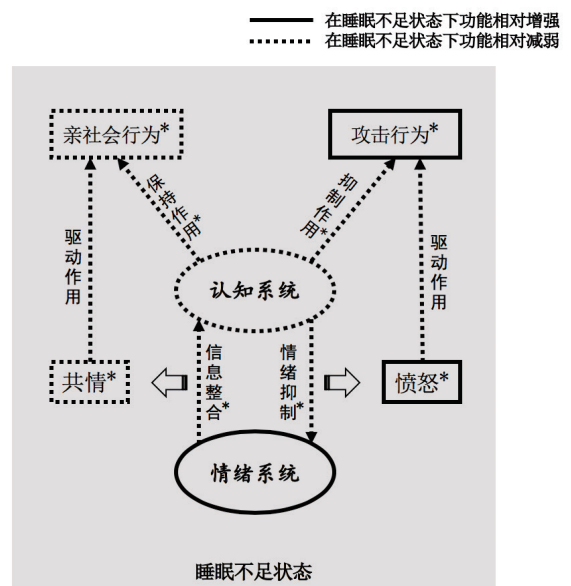


图 1 睡眠不足影响人际交互的认知神经机制理论模型。

注：* 表示来自实证证据的支持。

在社会情绪方面，两系统功能联系的减弱导致了睡眠不足个体社会情绪的变化。具体作用机制包括两个方向。在自上而下的方向上，睡眠不足使得认知系统对情绪系统的抑制作用减弱，导致个体的情绪反应增强。这使得睡眠剥夺个体面对较弱的负性刺激，也会产生不合时宜的、较强的愤怒情绪（Minkel et al., 2012）；当面对正性刺激时，个体同样也会产生较强的正性情绪反应（Gujar, Yoo, Hu, & Walker, 2011）。这一假设得到了众多神经科学研究证据的支持，这些研究均发现，伴随睡眠剥夺个体对情绪图片行为反应的增强，个体前额叶到杏仁核的功能连接减弱，杏仁核活动增强（Gujar, Yoo et al., 2011; Motomura et al., 2013; Yoo, Gujar, Hu, Jolesz, & Walker, 2007）。在自下而上的方向上，睡眠不足使得认知系统无法很好地整合下游情绪系统的信号并将其用于上游的认知信息加工中。这意味着，虽然下游情绪系统对情绪刺激的反应增强，但因为缺乏认知系统的整合，个体基于下游情绪信号而在上游认知系统中实现的情绪识别、自身情感体验以及对他人情绪的模拟等过程都会受损（Goldstein & Walker, 2014; Krause et al., 2017）。许多行为证据支持了这一假设。睡眠不足会损害个体对正性和负性情绪的辨别（Cote et al., 2014; Goldstein-Piekarski, Greer, Saletin, & Walker, 2015; Gujar, McDonald, Nishida, & Walker et al., 2011; Killgore et al., 2017; van der Helm et al., 2011），减弱个体的情绪共情和认知共情（Gordon & Chen, 2014; Guadagni et al., 2014, 2017），导致个人情感体验变得更为负性（Motomura, Katsunuma, Yoshimura, & Mishima, 2017）。相关的神经科学研究发现佐证了行为结果：虽然睡眠剥夺会增加前脑岛对威胁面孔的激活，但前脑岛对威胁面孔的辨别力却有所下降（Goldstein-Piekarski et al., 2015）；静息态下杏仁核与内侧前额叶功能连接越弱，个体主观报告的焦虑情绪就越强（Motomura et al., 2017）。

作为人类社会交往中产生的情绪，社会情绪具备独特的社会动机属性——能够激发和调节社会行为，例如愤怒促进攻击行为，共情促进亲社会行为等（周晓林，于宏波，2015）。然而，在睡眠不足状态下，情绪和认知系统功能联系的减弱（主要是自下而上的认知系统对情绪信息的整合减弱），可能会影响社会情绪对社会行为的动机作用，进而间接影响睡眠不足状态下的社会行为。同时，认知系

统对行为控制（对不恰当行为的抑制和对恰当行为的保持）的减弱，可能会直接影响睡眠不足状态下的社会行为。在两种作用途径的共同影响下，睡眠不足状态下攻击行为的变化可能表现为：虽然愤怒情绪对攻击行为的动机（促进）作用减弱，使得攻击行为减少，但个体易激惹性与愤怒的增加，却使得攻击行为增加。对攻击行为抑制作用的减弱进一步地增加了个体攻击行为出现的概率，最终导致睡眠不足个体攻击行为的增加。众多有关睡眠不足的相关性和因果性研究均发现，睡眠不足会损害个体的抑制控制能力，增加冲动性行为（Krizan & Hisler, 2016）。这提示，睡眠不足可以通过损伤个体对行为冲动的抑制来增加个体将已有的攻击意图真正付诸于攻击行为的概率。在神经层面上，伴随受损的抑制控制能力，睡眠剥夺下个体的额叶前侧和腹侧激活程度均显著降低（Chuah, Venkatraman, Dinges, & Chee, 2006）；睡眠障碍患者在表现出较差的反应抑制能力的同时，其相关认知脑区（具体包括左侧中央后回、扣带回、顶下小叶以及右侧脑岛和壳核）的激活也显著降低（Ayalon, Ancoli-Israel, & Drummond, 2009）。这些证据在一定程度上支持了我们的假设。同样受两种作用途径的影响，睡眠不足状态下亲社会行为的变化则可能表现为：共情的动机（促进）作用减弱，共情水平降低；加以认知功能受损（对适宜行为的保持减弱），两者共同减少了睡眠不足个体的亲社会行为。在行为证据方面，Ferrara 等人（2015）印证了这一假设：他们发现，分析型认知风格的个体（认知系统更占优势），相较于直觉型认知风格的个体（情绪系统更占优势），其亲社会行为受睡眠不足的影响较小。在神经证据方面，众多研究发现，前额叶区域脑损伤病人的亲社会行为减少（Rilling & Sanfey, 2011），而前额叶区域又是最易受睡眠不足影响的脑区（Killgore, 2010），这又进一步支持了我们的假设。

5 研究展望

综上所述，目前对睡眠不足如何影响人际交互的研究已取得了较大的进展，但也存在一些明显的不足。未来研究建议从以下方向开展：第一，在机制层面，应在一个实验中同时考察睡眠不足状态下社会情绪和行为的变化，以及社会情绪如何驱动社会行为，进而探索其背后的神经机制。第二，在内容层面，应考察睡眠不足对其他更为复杂、高级的

社会情绪（如感激、内疚等）的影响。第三，在方法层面，应采用睡眠限制等生态效度更高的方法来控制、操纵睡眠不足，以精确评估睡眠不足在现实生活中的负面影响。

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The Impact and Neural Correlates of Sleep Loss on Interpersonal Interactions

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Abstract Sleep is important for our physical and mental health. Over the past decade, researchers have begun to focus on the impact of sleep loss on social interaction. The current article systematically reviews these studies and points out directions for further investigation. In terms of social emotion, interpersonal interaction involves a variety of prosocial and antisocial emotions, such as empathy and irritability/anger. Both correlational and experimental studies have found that emotional and cognitive empathy decrease with sleep loss, whereas irritability/anger increases with sleep loss. In terms of social behavior, interpersonal interaction refers to two, opposite types of behaviors. One is the prosocial behavior, which decreases with insufficient sleep. Specifically, sleep-deprived individuals are more selfish, distrustful of others, prone to betray others' trust, easily discontented with money sharing proposals, and being lonelier and less drawn into social interaction. The other is the aggressive behavior, which has been reported by many studies to exhibit a positive correlation with sleep loss. That is, the poorer the sleep, the more or stronger the aggressive behavior becomes. However, evidence from several experimental studies is mixed. According to a dual-process theory, the diminished functional connectivity between emotional and cognitive systems may account for the changes after sleep loss. Such neurocognitive mechanisms act on social emotion in two ways: in regards to the top-down process, the inhibitory control of emotion from the cognitive system would be weakened, resulting in a saturated and flattened response to emotional stimuli. This explains why sleep-deprived people are more irritable and angrier at negative stimulation. In regards to the bottom-up process, cognitive system would fail to integrate information from the emotional system into higher-level cognitive judgement and decision-making, which means that although reactions from emotional system to stimulation are intensified, without cognitive integration, advanced cognitive functions such as emotion discrimination, internal mapping of one's own affective state, and the ability to simulate the feelings of others, would be blunted. As a result, both emotional and cognitive empathy are disrupted after sleep loss. As for social behavior, the diminished functional connectivity between emotional and cognitive systems, specifically the disrupted bottom-up integration, may impair the motivational influence of social emotion on social behavior, leading to an indirect impact on social behavior after sleep loss. At the same time, the inhibitory cognitive control over behavior would also be weakened after sleep loss, resulting in a direct impact. Under the combined influence, although the motivation effect of anger/irritability on aggressive behavior may be diminished, enhanced irritability/anger and disrupted cognitive inhibition for behavior after sleep loss jointly increase aggressive behavior with insufficient sleep. Moreover, the impaired role of empathy in facilitating prosocial behavior, blunted empathy, and deficits in cognitive control over prosocial behavior jointly decrease prosocial behavior after sleep loss. Further studies should investigate the effect of sleep deprivation on high-level social emotions such as guilt and gratitude and the motivational influence of social emotion on social behavior via sleep restriction, which has high ecological validity.

Key words sleep loss, sleep deprivation, sleep restriction, empathy, irritability/anger, prosocial behavior, aggressive behavior