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The elusive role of sleep in emotional memory

Reinhold, F.L.

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References

Ackermann, S., Hartmann, F., Papassotiropoulos, A., de Quervain, D. J. F., & Rasch, B. (2015). No Associations between Interindividual Differences in Sleep Parameters and Episodic Memory Consolidation. *Sleep*, *38*(6), 951–959.

Adan, A., & Almirall, H. (1991). Horne & Östberg morningness-eveningness questionnaire: A reduced scale. *Personality and Individual Differences*, *12*(3), 241–253.

Alger, S. E., Chambers, A. M., Cunningham, T., & Payne, J. D. (2015). The Role of Sleep in Human Declarative Memory Consolidation. In P. Meerlo, R. M. Benca, & T. Abel (Eds.), *Sleep, Neuronal Plasticity and Brain Function* (pp. 269–306). Springer.

Ambrosini, M. V., Sadile, A. G., Gironi Carnevale, U. A., Mattiaccio, M., & Giuditta, A. (1988). The sequential hypothesis on sleep function. I. Evidence that the structure of sleep depends on the nature of the previous waking experience. *Physiology & Behavior*, *43*(3), 325–337.

Arntz, A. (2020). A plea for more attention to mental representations. *Journal of Behavior Therapy and Experimental Psychiatry*, *67*, 101510.

Aston-Jones, G., & Bloom, F. E. (1981a). Activity of norepinephrine-containing locus coeruleus neurons in behaving rats anticipates fluctuations in the sleep-waking cycle. *Journal of Neuroscience*, *1*(8), 876–886.

Aston-Jones, G., & Bloom, F. E. (1981b). Nonrepinephrine-containing locus coeruleus neurons in behaving rats exhibit pronounced responses to non-noxious environmental stimuli. *Journal of Neuroscience*, *1*(8), 887–900.

Azza, Y., Wilhelm, F. H., Seifritz, E., Junghanns, K., Kleim, B., & Wilhelm, I. (2022). Sleep's role in updating aversive autobiographical memories. *Translational Psychiatry*, *12*(1), 1–9.

Azza, Y., Wilhelm, I., & Kleim, B. (2020). Sleep Early After Trauma. *European Psychologist*, *25*(4), 239–251.

Baker, S. L., Heinrichs, N., Kim, H.-J., & Hofmann, S. G. (2002). The Liebowitz social anxiety scale as a self-report instrument: A preliminary psychometric analysis. *Behaviour Research and Therapy*, *40*(6), 701–715.

Baran, B., Pace-Schott, E. F., Ericson, C., & Spencer, R. M. C. (2012). Processing of emotional reactivity and emotional memory over sleep. *Journal of Neuroscience*, *32*(3), 1035–1042.

Barlow, D. H. (2004). *Anxiety and Its Disorders: The Nature and Treatment of Anxiety and Panic*. Guilford Press.

Beck, A. T. (1979). *Cognitive Therapy and the Emotional Disorders*. Penguin.

Bennion, K. A., Payne, J. D., & Kensinger, E. A. (2016). The impact of napping on memory for future-relevant stimuli: Prioritization among multiple salience cues. *Behavioral Neuroscience*, *130*(3), 281–289.

Benson, K., & Feinberg, I. (1977). The Beneficial Effect of Sleep in an Extended Jenkins and Dallenbach Paradigm. *Psychophysiology*, *14*(4), 375–384.

Berntsen, D. (2010). The Unbidden Past: Involuntary Autobiographical Memories as a Basic Mode of Remembering. *Current Directions in Psychological Science*, *19*(3), 138–142.

Bögels, S. M., Alberts, M., & de Jong, P. J. (1996). Self-consciousness, self-focused attention, blushing propensity and fear of blushing. *Personality and Individual Differences*, *21*(4), 573–581.

Bolinger, E., Cunningham, T. J., Payne, J. D., Bowman, M. A., Bulca, E., Born, J., & Zinke, K. (2019). Sleep's benefits to emotional processing emerge in the long term. *Cortex*, *120*, 457–470.

Bonnet, M. H., & Arand, D. L. (2010). Hyperarousal and insomnia: State of the science. *Sleep Medicine Reviews*, *14*(1), 9–15.

Bookbinder, S. H., & Brainerd, C. J. (2017). Emotionally negative pictures enhance gist memory. *Emotion*, *17*(1), 102–119.

Boucsein, W., Fowles, D. C., Grimnes, S., Ben-Shakhar, G., Roth, W. T., Dawson, M. E., & Filion, D. L. (2012). Publication recommendations for electrodermal measurements. *Psychophysiology*, *49*(8), 1017–1034. Scopus.

Bradley, M. M., Codispoti, M., Cuthbert, B. N., & Lang, P. J. (2001). Emotion and motivation I: Defensive and appetitive reactions in picture processing. *Emotion*, *1*(3), 276–298.

Bradley, M. M., & Lang, P. J. (1994). Measuring emotion: The Self-Assessment Manikin and the semantic differential. *Journal of Behavior Therapy and Experimental Psychiatry*, *25*(1), 49–59.

Brewin, C. R., & Burgess, N. (2014). Contextualisation in the revised dual representation theory of PTSD: A response to Pearson and colleagues. *Journal of Behavior Therapy and Experimental Psychiatry*, *45*(1), 217–219.

Brewin, C. R., Dalgleish, T., & Joseph, S. (1996). A dual representation theory of posttraumatic stress disorder. *Psychological Review*, *103*(4), 670–686.

Brewin, C. R., Gregory, J. D., Lipton, M., & Burgess, N. (2010). Intrusive images in psychological disorders: Characteristics, neural mechanisms, and treatment implications. *Psychological Review*, *117*(1), 210–232.

Brewin, C. R., & Holmes, E. A. (2003). Psychological theories of posttraumatic stress disorder. *Clinical Psychology Review*, *23*(3), 339–376.

Brown, L. K. (2012). Can sleep deprivation studies explain why human adults sleep? *Current Opinion in Pulmonary Medicine*, *18*(6), 541.

Buysse, D. J., Reynolds, C. F., Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The Pittsburgh sleep quality index: A new instrument for psychiatric practice and research. *Psychiatry Research*, *28*(2), 193–213.

Cabrera, Y., Koymans, K. J., Poe, G. R., Kessels, H. W., Van Someren, E. J. W., & Wassing, R. (2024). Overnight neuronal plasticity and adaptation to emotional distress. *Nature Reviews Neuroscience*, *25*(4), 253–271.

Cahill, L., & Alkire, M. T. (2003). Epinephrine enhancement of human memory consolidation: Interaction with arousal at encoding. *Neurobiology of Learning and Memory*, *79*(2), 194–198.

Carney, C. E., Buysse, D. J., Ancoli-Israel, S., Edinger, J. D., Krystal, A. D., Lichstein, K. L., & Morin, C. M. (2012). The consensus sleep diary: Standardizing prospective sleep self-monitoring. *Sleep*, *35*(2), 287–302.

Cellini, N., Mercurio, M., & Sarlo, M. (2019). The Fate of Emotional Memories Over a Week: Does Sleep Play Any Role? *Frontiers in Psychology*, *10*.

Chai, Y., Fang, Z., Yang, F. N., Xu, S., Deng, Y., Raine, A., Wang, J., Yu, M., Basner, M., Goel, N., Kim, J. J., Wolk, D. A., Detre, J. A., Dinges, D. F., & Rao, H. (2020). Two nights of recovery sleep restores hippocampal connectivity but not episodic memory after total sleep deprivation. *Scientific Reports*, *10*(1), 8774.

Chambers, A. M., & Payne, J. D. (2014). Laugh yourself to sleep: Memory consolidation for humorous information. *Experimental Brain Research*, *232*(5), 1415–1427.

Clark, I. A., Mackay, C. E., & Holmes, E. A. (2015). Low emotional response to traumatic footage is associated with an absence of analogue flashbacks: An individual participant data meta-analysis of 16 trauma film paradigm experiments. *Cognition and Emotion*, *29*(4), 702–713.

Cox, R., van Bronkhorst, M. L. V., Bayda, M., Gomillion, H., Cho, E., Parr, M. E., Manickas-Hill, O. P., Schapiro, A. C., & Stickgold, R. (2018). Sleep selectively stabilizes contextual aspects of negative memories. *Scientific Reports*, *8*(1), Article 1.

Craske, M. G., Treanor, M., Conway, C. C., Zbozinek, T., & Vervliet, B. (2014). Maximizing exposure therapy: An inhibitory learning approach. *Behaviour Research and Therapy*, *58*, 10–23.

Crozier, W. R., & de Jong, P. J. (2012). *The Psychological Significance of the Blush*. Cambridge University Press.

Cunningham, T. J., Chambers, A. M., & Payne, J. D. (2014). Prospection and emotional memory: How expectation affects emotional memory formation following sleep and wake. *Frontiers in Psychology*, *5*.

Cunningham, T. J., Crowell, C. R., Alger, S. E., Kensinger, E. A., Villano, M. A., Mattingly, S. M., & Payne, J. D. (2014). Psychophysiological arousal at encoding leads to reduced reactivity but enhanced emotional memory following sleep. *Neurobiology of Learning and Memory*, *114*, 155–164.

Cunningham, T. J., Stickgold, R., & Kensinger, E. A. (2022). Investigating the effects of sleep and sleep loss on the different stages of episodic emotional memory: A narrative review and guide to the future. *Frontiers in Behavioral Neuroscience*, *16*.

Davidson, P., Jönsson, P., Carlsson, I., & Pace-Schott, E. (2021). Does Sleep Selectively Strengthen Certain Memories Over Others Based on Emotion and Perceived Future Relevance? *Nature and Science of Sleep*, *13*, 1257–1306.

Davidson, P., & Marcusson-Clavertz, D. (2023). The effect of sleep on intrusive memories in daily life: A systematic review and meta-analysis of trauma film experiments. *Sleep*, *46*(2), zsac280.

Davidson, P., & Pace-Schott, E. (2021). Go to bed and you might feel better in the morning—The effect of sleep on affective tone and intrusiveness of emotional memories. *Current Sleep Medicine Reports*, *7*(2), 31–46.

Diagnostic and statistical manual of mental disorders: DSM-5™, 5th ed (pp. xliv, 947). (2013). American Psychiatric Publishing, Inc.

Diekelmann, S., & Born, J. (2010). The memory function of sleep. *Nature Reviews Neuroscience*, *11*(2), 114–126.

Dietch, J. R., Ruggero, C. J., Schuler, K., Taylor, D. J., Luft, B. J., & Kotov, R. (2019). Posttraumatic stress disorder symptoms and sleep in the daily lives of World Trade Center responders. *Journal of Occupational Health Psychology*, *24*(6), 689–702.

Drake, C. L., Jefferson, C., Roehrs, T., & Roth, T. (2006). Stress-related sleep disturbance and polysomnographic response to caffeine. *Sleep Medicine*, *7*(7), 567–572.

Drummond, P. D. (2013). Psychophysiology of the blush. In *The psychological significance of the blush* (pp. 15–38). Cambridge University Press.

Drummond, P. D., Back, K., Harrison, J., Dogg Helgadottir, F., Lange, B., Lee, C., Leavy, K., Novatscou, C., Orner, A., Pham, H., Prance, J., Radford, D., & Wheatley, L. (2007). Blushing during social interactions in people with a fear of blushing. *Behaviour Research and Therapy*, *45*(7), 1601–1608.

Dudai, Y., & Eisenberg, M. (2004). Rites of Passage of the Engram: Reconsolidation and the Lingering Consolidation Hypothesis. *Neuron*, *44*(1), 93–100.

Dudai, Y., Karni, A., & Born, J. (2015). The Consolidation and Transformation of Memory. *Neuron*, *88*(1), 20–32.

Dussutour, A. (2021). Learning in single cell organisms. *Biochemical and Biophysical Research Communications*, *564*, 92–102.

Ehlers, A. (2015). Understanding and Treating Unwanted Trauma Memories in Posttraumatic Stress Disorder. *Zeitschrift Für Psychologie / Journal of Psychology*.

Ehlers, A., & Clark, D. M. (2000). A cognitive model of posttraumatic stress disorder. *Behaviour Research and Therapy*, *38*(4), 319–345.

Ehlers, A., Hackmann, A., Steil, R., Clohessy, S., Wenninger, K., & Winter, H. (2002). The nature of intrusive memories after trauma: The warning signal hypothesis. *Behaviour Research and Therapy*, *40*(9), 995–1002.

Ehlers, A., Hackmann, A., & Michael, T. (2004). Intrusive re-experiencing in post-traumatic stress disorder: Phenomenology, theory, and therapy. *Memory*, *12*(4), 403–415.

Ehlers, A., & Steil, R. (1995). Maintenance of Intrusive Memories in Posttraumatic Stress Disorder: A Cognitive Approach. *Behavioural and Cognitive Psychotherapy*, *23*(3), 217–249.

Emrick, J. J., Gross, B. A., Riley, B. T., & Poe, G. R. (2016). Different Simultaneous Sleep States in the Hippocampus and Neocortex. *Sleep*, *39*(12), 2201–2209.

Fiorino, A. S. (1996). Sleep, genes and death: Fatal familial insomnia. *Brain Research Reviews*, *22*(3), 258–264.

Foa, E. B., & Kozak, M. J. (1986). Emotional processing of fear: Exposure to corrective information. *Psychological Bulletin*, *99*(1), 20–35.

Foa, E. B., & Rothbaum, B. O. (2001). *Treating the Trauma of Rape: Cognitive-Behavioral Therapy for PTSD*. Guilford Press.

Foa, E. B., Steketee, G., & Rothbaum, B. O. (1989). Behavioral/cognitive conceptualizations of post-traumatic stress disorder. *Behavior Therapy*, *20*(2), 155–176.

Foster, H. H. (1901). The Necessity for a New Standpoint in Sleep Theories. *The American Journal of Psychology*, *12*(2), 145–177.

Freeman, D., Sheaves, B., Waite, F., Harvey, A. G., & Harrison, P. J. (2020). Sleep disturbance and psychiatric disorders. *The Lancet Psychiatry*, *7*(7), 628–637.

Freund, I. M., Arntz, A., Visser, R. M., & Kindt, M. (2022). Jumping back onto the giants' shoulders: Why emotional memory should be considered in a network perspective of psychopathology. *Behaviour Research and Therapy*, *156*, 104154.

Freund, I. M., Peters, J., van Emmerik, A. A. P., Kindt, M., & Visser, R. M. (2025). Expanding the toolset of experimental Psychopathology: The Trier Social Stress Test induces a personally relevant emotional memory. *Behaviour Research and Therapy*, *191*, 104783.

Gais, S., Lucas, B., & Born, J. (2006). Sleep after learning aids memory recall. *Learning & Memory*, *13*(3), 259–262.

Genzel, L., Spoormaker, V. I., Konrad, B. N., & Dresler, M. (2015). The role of rapid eye movement sleep for amygdala-related memory processing. *Neurobiology of Learning and Memory*, *122*, 110–121.

Gilson, M., Deliens, G., Leproult, R., Bodart, A., Nonclercq, A., Ercek, R., & Peigneux, P. (2016). REM-enriched naps are associated with memory consolidation for sad stories and enhance mood-related reactivity. *Brain Sciences*, *6*(1), Article 1.

Girardeau, G., Inema, I., & Buzsáki, G. (2017). Reactivations of emotional memory in the hippocampus–amygdala system during sleep. *Nature Neuroscience*, *20*(11), 1634–1642.

Giuditta, A. (2014). Sleep memory processing: The sequential hypothesis. *Frontiers in Systems Neuroscience*, *8*.

Glass, I. (Host). (2008, August 8). *Fear of sleep* (No. 361) [Audio podcast episode]. In *This American Life*. Public Radio International. https://www.thisamericanlife.org/361/fear-of-sleep

Goel, N., Rao, H., Durmer, J. S., & Dinges, D. F. (2009). Neurocognitive Consequences of Sleep Deprivation. *Seminars in Neurology*, *29*, 320–339.

Goodrich, B., Gabry, J., Ali, I., & Brilleman, S. (2020). *Rstanarm: Bayesian applied regression modeling via Stan* (Version 2.21.1) [Computer software]. https://mc-stan.org/rstanarm/

Grillon, C. (2008). Models and mechanisms of anxiety: Evidence from startle studies. *Psychopharmacology*, *199*(3), 421–437.

Groch, S., Zinke, K., Wilhelm, I., & Born, J. (2015). Dissociating the contributions of slow-wave sleep and rapid eye movement sleep to emotional item and source memory. *Neurobiology of Learning and Memory*, *122*, 122–130.

Gruber, R., & Cassoff, J. (2014). The Interplay Between Sleep and Emotion Regulation: Conceptual Framework Empirical Evidence and Future Directions. *Current Psychiatry Reports*, *16*(11), 500.

Gujar, N., McDonald, S. A., Nishida, M., & Walker, M. P. (2011). A Role for REM Sleep in Recalibrating the Sensitivity of the Human Brain to Specific Emotions. *Cerebral Cortex*, *21*(1), 115–123.

Hackmann, A., & Holmes, E. (2004). Reflecting on imagery: A clinical perspective and overview of the special issue of Memory on mental imagery and memory in psychopathology. *Memory*, *12*(4), 389–402.

Halonen, R., Kuula, L., Makkonen, T., Kauramäki, J., & Pesonen, A.-K. (2021). *Self-conscious affect is modulated by rapid eye movement sleep but not by targeted memory reactivation–a pilot study*.

Halonen, R., Kuula, L., Selin, M., Suutari, A., Antila, M., & Pesonen, A.-K. (2024). REM Sleep Preserves Affective Response to Social Stress—Experimental Study. *eNeuro*, *11*(6).

Hammad, G., Reyt, M., Beliy, N., Baillet, M., Deantoni, M., Lesoinne, A., Muto, V., & Schmidt, C. (2020). *pyActigraphy: Open-source python package for actigraphy data visualisation and analysis* [Preprint]. Bioinformatics.

Harrington, M. O., Nedberge, K. M., & Durrant, S. J. (2018). The effect of sleep deprivation on emotional memory consolidation in participants reporting depressive symptoms. *Neurobiology of Learning and Memory*, *152*, 10–19.

Harvey, A. G. (2008). Insomnia, psychiatric disorders, and the transdiagnostic perspective. *Current Directions in Psychological Science*, *17*(5), 299–303.

Hein, E., Halonen, R., Wolbers, T., Makkonen, T., Kyllönen, M., Kuula, L., Kurki, I., Stepnicka, P., & Pesonen, A.-K. (2024). Does sleep promote adaptation to acute stress: An experimental study. *Neurobiology of Stress*, *29*, 100613.

Hirsch, C. R., & Holmes, E. A. (2007). Mental imagery in anxiety disorders. *Psychiatry*, *6*(4), 161–165.

Hoddes, E., Zarcone, V., & Dement, W. (1972). Stanford sleepiness scale. *Enzyklopädie Der Schlafmedizin*, *1184*(1).

Holman, E. A., Garfin, D. R., & Silver, R. C. (2014). Media's role in broadcasting acute stress following the Boston Marathon bombings. *Proceedings of the National Academy of Sciences*, *111*(1), 93–98.

Hu, P., Stylos-Allan, M., & Walker, M. P. (2006). Sleep facilitates consolidation of emotional declarative memory. *Psychological Science*, *17*(10), 891–898.

Hutchison, I. C., & Rathore, S. (2015). The role of REM sleep theta activity in emotional memory. *Frontiers in Psychology*, *6*.

Ibarra-Coronado, E. G., Pantaleón-Martínez, A. Ma., Velazquéz-Moctezuma, J., Prospéro-García, O., Méndez-Díaz, M., Pérez-Tapia, M., Pavón, L., & Morales-Montor, J. (2015). The Bidirectional Relationship between Sleep and Immunity against Infections. *Journal of Immunology Research*, *2015*(1), 678164.

Inozu, M., Hacıömeroğlu, A. B., Keser, E., Akın-Sarı, B., & Özmenler, K. N. (2021). What does differentiate unwanted mental intrusions in OCD? A phenomenological study of the mental intrusions in OCD, anxiety disorders, and non-clinical groups using the interview technique. *Journal of Obsessive-Compulsive and Related Disorders*, *29*, 100640.

Iyadurai, L., Visser, R. M., Lau-Zhu, A., Porcheret, K., Horsch, A., Holmes, E. A., & James, E. L. (2019). Intrusive memories of trauma: A target for research bridging cognitive science and its clinical application. *Clinical Psychology Review*, *69*, 67–82.

James, E. L., Lau-Zhu, A., Clark, I. A., Visser, R. M., Hagenaars, M. A., & Holmes, E. A. (2016). The trauma film paradigm as an experimental psychopathology model of psychological trauma: Intrusive memories and beyond. *Clinical Psychology Review*, *47*, 106–142.

JASP Team. (2020). *JASP* (Version 0.14) [Computer software]. https://jasp-stats.org/

JASP Team. (2024). *JASP* (Version 0.18.3) [Computer software]. https://jasp-stats.org/

JASP Team. (2025). *JASP* (Version 0.19.3) [Computer software]. https://jasp-stats.org/

Jones, B. J., Mackay, A., Mantua, J., Schultz, K. S., & Spencer, R. M. C. (2018a). The role of sleep in emotional memory processing in middle age. *Neurobiology of Learning and Memory*, *155*, 208–215.

Jones, B. J., Mackay, A., Mantua, J., Schultz, K. S., & Spencer, R. M. C. (2018b). The role of sleep in emotional memory processing in middle age. *Neurobiology of Learning and Memory*, *155*, 208–215.

Jones, B. J., Schultz, K. S., Adams, S., Baran, B., & Spencer, R. M. C. (2016). Emotional bias of sleep-dependent processing shifts from negative to positive with aging. *Neurobiology of Aging*, *45*, 178–189.

Jones, B. J., & Spencer, R. M. C. (2019a). Sleep preserves subjective and sympathetic emotional response of memories. *Neurobiology of Learning and Memory*, *166*, 107096.

Jones, B. J., & Spencer, R. M. C. (2019b). Sleep preserves subjective and sympathetic emotional response of memories. *Neurobiology of Learning and Memory*, *166*, 107096.

Kessler, R. C., Chiu, W. T., Demler, O., Merikangas, K. R., & Walters, E. E. (2005). Prevalence, severity, and comorbidity of 12-month DSM-IV disorders in the National Comorbidity Survey Replication. *Archives of General Psychiatry*, *62*(6), 617–627.

Killgore, W. D. S. (2010). Effects of sleep deprivation on cognition. In G. A. Kerkhof & H. P. A. van Dongen (Eds.), *Progress in Brain Research* (Vol. 185, pp. 105–129). Elsevier.

Kindt, M. (2014). A behavioural neuroscience perspective on the aetiology and treatment of anxiety disorders. *Behaviour Research and Therapy*, *62*, 24–36.

Kindt, M., Soeter, M., & Vervliet, B. (2009). Beyond extinction: Erasing human fear responses and preventing the return of fear. *Nature Neuroscience*, *12*(3), 256–258.

Kirschbaum, C., Pirke, K.-M., & Hellhammer, D. (1993). The 'Trier Social Stress Test' – A Tool for Investigating Psychobiological Stress Responses in a Laboratory Setting. *Neuropsychobiology*, *28*, 76–81.

Kleim, B., Wysokowsky, J., Schmid, N., Seifritz, E., & Rasch, B. (2016). Effects of sleep after experimental trauma on intrusive emotional memories. *Sleep*, *39*(12), 2125–2132.

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (1990). Emotion, Attention, and the Startle Reflex. *Psychological Review*, *97*(3), 377–395.

Lara-Carrasco, J., Nielsen, T. A., Solomonova, E., Levrier, K., & Popova, A. (2009). Overnight emotional adaptation to negative stimuli is altered by REM sleep deprivation and is correlated with intervening dream emotions. *Journal of Sleep Research*, *18*(2), 178–187.

Larsen, R. J., & Fredrickson, B. L. (1999). Measurement issues in emotion research. In *D. Kahneman, D. Diener, & N. Schwarz (Eds.), Well-being: The Foundations of Hedonic Psychology* (pp. 40–60). New York: Russell Sage Foundation.

Larson, O., Schapiro, A. C., & Gehrman, P. R. (2023). Effect of sleep manipulations on intrusive memories after exposure to an experimental analogue trauma: A meta-analytic review. *Sleep Medicine Reviews*, *69*, 101768.

Lipinska, G., Stuart, B., Thomas, K. G. F., Baldwin, D. S., & Bolinger, E. (2019). Preferential Consolidation of Emotional Memory During Sleep: A Meta-Analysis. *Frontiers in Psychology*, *10*.

Mader, E. C., & Mader, A. C. L. (2016). Sleep as spatiotemporal integration of biological processes that evolved to periodically reinforce neurodynamic and metabolic homeostasis: The 2m3d paradigm of sleep. *Journal of the Neurological Sciences*, *367*, 63–80.

Maquet, P., Péters, J.-M., Aerts, J., Delfiore, G., Degueldre, C., Luxen, A., & Franck, G. (1996). Functional neuroanatomy of human rapid-eye-movement sleep and dreaming. *Nature*, *383*(6596), 163–166.

Marchewka, A., Żurawski, Ł., Jednoróg, K., & Grabowska, A. (2014). The Nencki Affective Picture System (NAPS): Introduction to a novel, standardized, wide-range, high-quality, realistic picture database. *Behavior Research Methods*, *46*(2), 596–610.

McGaugh, J. L. (2000). Memory—A century of consolidation. *Science*, *287*(5451), 248–251.

McGaugh, J. L., & Roozendaal, B. (2002). Role of adrenal stress hormones in forming lasting memories in the brain. *Current Opinion in Neurobiology*, *12*(2), 205–210.

McGillycuddy, M., Popovic, G., Bolker, B. M., & Warton, D. I. (2025). Parsimoniously Fitting Large Multivariate Random Effects in glmmTMB. *Journal of Statistical Software*, *112*, 1–19.

Michael, T., Ehlers, A., Halligan, S. L., & Clark, D. M. (2005). Unwanted memories of assault: What intrusion characteristics are associated with PTSD? *Behaviour Research and Therapy*, *43*(5), 613–628.

Mineka, S., & Zinbarg, R. (2006). A contemporary learning theory perspective on the etiology of anxiety disorders: It's not what you thought it was. *American Psychologist*, *61*(1), 10–26.

Minkel, J., Moreta, M., Muto, J., Htaik, O., Jones, C., Basner, M., & Dinges, D. (2014). Sleep deprivation potentiates HPA axis stress reactivity in healthy adults. *Health Psychology*, *33*(11), 1430–1434.

Miyamoto, D., Hirai, D., & Murayama, M. (2017). The Roles of Cortical Slow Waves in Synaptic Plasticity and Memory Consolidation. *Frontiers in Neural Circuits*, *11*.

Molenkamp, B. (2011). *VSRRP98 manual, version 8.0.* [Computer software]. Amsterdam, Netherlands: University of Amsterdam.

Nader, K., Schafe, G. E., & Le Doux, J. E. (2000). Fear memories require protein synthesis in the amygdala for reconsolidation after retrieval. *Nature*, *406*(6797), Article 6797.

Nagamine, M., Noguchi, H., Takahashi, N., Kim, Y., & Matsuoka, Y. (2017). Effect of cortisol diurnal rhythm on emotional memory in healthy young adults. *Scientific Reports*, *7*(1), Article 1.

Ogden, J., Jobson, L., & Drummond, S. P. A. (2024). Does Sleep Reduce Intrusive Memories After Analogue Trauma? Recent Findings of Experimental Sleep Manipulations Using the Trauma Film Paradigm. *Current Sleep Medicine Reports*, *10*(3), 368–377.

Ohayon, M. M., & Roth, T. (2003). Place of chronic insomnia in the course of depressive and anxiety disorders. *Journal of Psychiatric Research*, *37*(1), 9–15.

O'Leary, K., Small, B. J., Panaite, V., Bylsma, L. M., & Rottenberg, J. (2017). Sleep quality in healthy and mood-disordered persons predicts daily life emotional reactivity. *Cognition and Emotion*, *31*(3), 435–443.

Osorio-Forero, A., Cherrad, N., Banterle, L., Fernandez, L. M. J., & Lüthi, A. (2022). When the Locus Coeruleus Speaks Up in Sleep: Recent Insights, Emerging Perspectives. *International Journal of Molecular Sciences*, *23*(9), Article 9.

Pace-Schott, E. F., Shepherd, E., Spencer, R. M. C., Marcello, M., Tucker, M., Propper, R. E., & Stickgold, R. (2011). Napping promotes inter-session habituation to emotional stimuli. *Neurobiology of Learning and Memory*, *95*(1), 24–36.

Payne, J. D. (2011). Learning, Memory, and Sleep in Humans. *Sleep Medicine Clinics*, *6*(1), 15–30.

Payne, J. D., Ellenbogen, J. M., Walker, M. P., & Stickgold, R. (2008). 2.35—The Role of Sleep in Memory Consolidation. In J. H. Byrne (Ed.), *Learning and Memory: A Comprehensive Reference* (pp. 663–685). Academic Press.

Payne, J. D., Stickgold, R., Swanberg, K., & Kensinger, E. A. (2008). Sleep Preferentially Enhances Memory for Emotional Components of Scenes. *Psychological Science*, *19*(8), 781–788.

Porcheret, K., Holmes, E. A., Goodwin, G. M., Foster, R. G., & Wulff, K. (2015). Psychological Effect of an Analogue Traumatic Event Reduced by Sleep Deprivation. *Sleep*, *38*(7), 1017–1025.

Porcheret, K., van Heugten–van der Kloet, D., Goodwin, G. M., Foster, R. G., Wulff, K., & Holmes, E. A. (2019). Investigation of the impact of total sleep deprivation at home on the number of intrusive memories to an analogue trauma. *Translational Psychiatry*, *9*(1), 104.

Posit Team. (2021). *RStudio* [Computer software]. Posit, PBC. https://posit.co/

Posit Team. (2024). *RStudio* [Computer software]. Posit, PBC. https://posit.co/

R Core Team. (2025). *R: A Language and Environment for Statistical Computing* [Computer software]. R Foundation for Statistical Computing. https://www.R-project.org/

Rattel, J. A., Miedl, S. F., Franke, L. K., Ehring, T., & Wilhelm, F. H. (2022). Lifetime adversity interacts with peritraumatic data-driven processing to predict intrusive memories. *Journal of Behavior Therapy and Experimental Psychiatry*, *74*, 101688.

Rattel, J. A., Wegerer, M., Miedl, S. F., Blechert, J., Grünberger, L. M., Craske, M. G., & Wilhelm, F. H. (2019). Peritraumatic unconditioned and conditioned responding explains sex differences in intrusions after analogue trauma. *Behaviour Research and Therapy*, *116*, 19–29.

Rechtschaffen, A., & Bergmann, B. M. (1995). Sleep deprivation in the rat by the disk-over-water method. *Behavioural Brain Research*, *69*(1), 55–63.

Regambal, M. J., & Alden, L. E. (2009). Pathways to intrusive memories in a trauma analogue paradigm: A structural equation model. *Depression and Anxiety*, *26*(2), 155–166.

Reinhold, F. L., Gerlicher, A. M. V., van Someren, E. J. W., & Kindt, M. (2022). Do your troubles today seem further away than yesterday? On sleep's role in mitigating the blushing response to a reactivated embarrassing episode. *Sleep*, *45*(11), zsac220.

Reinhold, F. L., van Someren, E. J. W., & Kindt, M. (2025). Nighttime is the right time: The time interval to overnight sleep following an embarrassing experience does not influence long-term emotional responses to its reactivated episode. *Sleep Advances: A Journal of the Sleep Research Society*, *6*(2), zpaf029.

Richards, A., Inslicht, S. S., Metzler, T. J., Mohlenhoff, B. S., Rao, M. N., O'Donovan, A., & Neylan, T. C. (2017). Sleep and Cognitive Performance From Teens To Old Age: More Is Not Better. *Sleep*, *40*(1), zsw029.

Riemann, D., Spiegelhalder, K., Feige, B., Voderholzer, U., Berger, M., Perlis, M., & Nissen, C. (2010). The hyperarousal model of insomnia: A review of the concept and its evidence. *Sleep Medicine Reviews*, *14*(1), 19–31.

Riemann, D., Spiegelhalder, K., Nissen, C., Hirscher, V., Baglioni, C., & Feige, B. (2012). Rem sleep instability – a new pathway for insomnia? *Pharmacopsychiatry*, *45*(5), 167–176.

Rosales-Lagarde, A., Armony, J., del Río-Portilla, Y., Trejo-Martínez, D., Conde, R., & Corsi-Cabrera, M. (2012). Enhanced emotional reactivity after selective REM sleep deprivation in humans: An fMRI study. *Frontiers in Behavioral Neuroscience*, *6*.

Sara, S. J. (2000). Retrieval and reconsolidation: Toward a neurobiology of remembering. *Learning & Memory*, *7*(2), 73–84.

Schacter, D. L., & Addis, D. R. (2007). The cognitive neuroscience of constructive memory: Remembering the past and imagining the future. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *362*(1481), 773–786.

Schäfer, S. K., Lüder, C. C., Porcheret, K., Hu, X., Margraf, J., Michael, T., Holmes, E. A., Werner, G. G., Wilhelm, I., Woud, M. L., Zeng, S., Friesen, E., Haim-Nachum, S., Lass-Hennemann, J., Lieb, K., Kunzler, A. M., Wirth, B. E., & Sopp, M. R. (2023). To sleep or not to sleep, that is the question: A systematic review and meta-analysis on the effect of post-trauma sleep on intrusive memories of analog trauma. *Behaviour Research and Therapy*, *167*, 104359.

Schönbrodt, F. D., Wagenmakers, E.-J., Zehetleitner, M., & Perugini, M. (2017). Sequential hypothesis testing with Bayes factors: Efficiently testing mean differences. *Psychological Methods*, *22*(2), 322–339.

Sevenster, D., Beckers, T., & Kindt, M. (2012a). Instructed extinction differentially affects the emotional and cognitive expression of associative fear memory. *Psychophysiology*, *49*(10), 1426–1435.

Sevenster, D., Beckers, T., & Kindt, M. (2012b). Retrieval per se is not sufficient to trigger reconsolidation of human fear memory. *Neurobiology of Learning and Memory*, *97*(3), 338–345.

Sevenster, D., Beckers, T., & Kindt, M. (2013). Prediction Error Governs Pharmacologically Induced Amnesia for Learned Fear. *Science*, *339*(6121), 830–833.

Shalev, A. Y. (1992). Posttraumatic Stress Disorder among Injured Survivors of a Terrorist Attack: Predictive Value of Early Intrusion and Avoidance Symptoms. *The Journal of Nervous and Mental Disease*, *180*(8), 505.

Siegel, J. M. (2005). Clues to the functions of mammalian sleep. *Nature*, *437*(7063), 1264–1271.

Silver, R. C., Holman, E. A., Andersen, J. P., Poulin, M., McIntosh, D. N., & Gil-Rivas, V. (2013). Mental- and Physical-Health Effects of Acute Exposure to Media Images of the September 11, 2001, Attacks and the Iraq War. *Psychological Science*, *24*(9), 1623–1634.

Soeter, M., & Kindt, M. (2010). Dissociating response systems: Erasing fear from memory. *Neurobiology of Learning and Memory*, *94*(1), 30–41.

Soeter, M., & Kindt, M. (2012a). Erasing fear for an imagined threat event. *Psychoneuroendocrinology*, *37*(11), 1769–1779.

Soeter, M., & Kindt, M. (2012b). Stimulation of the noradrenergic system during memory formation impairs extinction learning but not the disruption of reconsolidation. *Neuropsychopharmacology*, *37*(5), Article 5.

Soeter, M., & Kindt, M. (2015). Retrieval cues that trigger reconsolidation of associative fear memory are not necessarily an exact replica of the original learning experience. *Frontiers in Behavioral Neuroscience*, *9*.

Sopp, M. R., Brueckner, A. H., Schäfer, S. K., Lass-Hennemann, J., & Michael, T. (2019a). Differential effects of sleep on explicit and implicit memory for potential trauma reminders: Findings from an analogue study. *European Journal of Psychotraumatology*, *10*(1), 1644128.

Sopp, M. R., Brueckner, A. H., Schäfer, S. K., Lass-Hennemann, J., & Michael, T. (2019b). REM theta activity predicts re-experiencing symptoms after exposure to a traumatic film. *Sleep Medicine*, *54*, 142–152.

Sopp, M. R., Friesen, E., Schäfer, S. K., Brueckner, A. H., Wirth, B. E., Weber, J., Lass-Hennemann, J., & Michael, T. (2021). Wakefulness impairs selective consolidation of relevant trauma-associated memories resulting in more frequent intrusions. *Behaviour Research and Therapy*, *136*, 103776.

Sopp, M. R., Michael, T., Weeß, H.-G., & Mecklinger, A. (2017). Remembering specific features of emotional events across time: The role of REM sleep and prefrontal theta oscillations. *Cognitive, Affective, & Behavioral Neuroscience*, *17*(6), 1186–1209.

Spielberger, C. D. (1983). State-trait anxiety inventory for adults (STAI-AD). *Consulting Psychologists Press, Palo Alto, CA*.

Squire, L. R., & Dede, A. J. O. (2015). Conscious and Unconscious Memory Systems. *Cold Spring Harbor Perspectives in Biology*, *7*(3), a021667.

Stepanski, E. J., & Rybarczyk, B. (2006). Emerging research on the treatment and etiology of secondary or comorbid insomnia. *Sleep Medicine Reviews*, *10*(1), 7–18.

Sterina, E., Michopoulos, V., Linnstaedt, S. D., Neylan, T. C., Clifford, G. D., Ethun, K. F., Lori, A., Wingo, A. P., Rothbaum, B. O., Ressler, K. J., & Stevens, J. S. (2022). Time of trauma prospectively affects PTSD symptom severity: The impact of circadian rhythms and cortisol. *Psychoneuroendocrinology*, *141*, 105729.

Stickgold, R., & Walker, M. P. (2013). Sleep-dependent memory triage: Evolving generalization through selective processing. *Nature Neuroscience*, *16*(2), 139–145.

Swift, K. M., Gross, B. A., Frazer, M. A., Bauer, D. S., Clark, K. J. D., Vazey, E. M., Aston-Jones, G., Li, Y., Pickering, A. E., Sara, S. J., & Poe, G. R. (2018). Abnormal locus coeruleus sleep activity alters sleep signatures of memory consolidation and impairs place cell stability and spatial memory. *Current Biology*, *28*(22), 3599-3609.e4.

Talamini, L. M., Bringmann, L. F., Boer, M. de, & Hofman, W. F. (2013). Sleeping worries away or worrying away sleep? Physiological evidence on sleep-emotion interactions. *PLOS ONE*, *8*(5), e62480.

Tangney, J. P., Dearing, R. L., Wagner, P. E., & Gramzov, R. (2000). The test of self- conscious affect-3 (TOSCA-3). *Fairfax, VA: George Mason University*.

Tempesta, D., De Gennaro, L., Natale, V., & Ferrara, M. (2015). Emotional memory processing is influenced by sleep quality. *Sleep Medicine*, *16*(7), 862–870.

Tempesta, D., Socci, V., De Gennaro, L., & Ferrara, M. (2018). Sleep and emotional processing. *Sleep Medicine Reviews*, *40*, 183–195.

Tomaso, C. C., Johnson, A. B., & Nelson, T. D. (2021). The effect of sleep deprivation and restriction on mood, emotion, and emotion regulation: Three meta-analyses in one. *Sleep*, *44*(6), zsaa289.

Turner, J. E. (2014). Researching state shame with the experiential shame scale. *The Journal of Psychology*, *148*(5), 577–601.

Van Der Werf, Y. D., Van Der Helm, E., Schoonheim, M. M., Ridderikhoff, A., & Van Someren, E. J. W. (2009). Learning by observation requires an early sleep window. *Proceedings of the National Academy of Sciences*, *106*(45), 18926–18930.

van Doorn, J., van den Bergh, D., Böhm, U., Dablander, F., Derks, K., Draws, T., Etz, A., Evans, N. J., Gronau, Q. F., Haaf, J. M., Hinne, M., Kucharský, Š., Ly, A., Marsman, M., Matzke, D., Gupta, A. R. K. N., Sarafoglou, A., Stefan, A., Voelkel, J. G., & Wagenmakers, E.-J. (2021). The JASP guidelines for conducting and reporting a Bayesian analysis. *Psychonomic Bulletin & Review*, *28*(3), 813–826.

Van Someren, E. J. W. (2021). Brain mechanisms of insomnia: New perspectives on causes and consequences. *Physiological Reviews*, *101*(3), 995–1046.

Vandekerckhove, M., & Cluydts, R. (2010). The emotional brain and sleep: An intimate relationship. *Sleep Medicine Reviews*, *14*(4), 219–226.

van der Helm, E., Yao, J., Dutt, S., Rao, V., Saletin, J. M., & Walker, M. P. (2011). REM Sleep Depotentiates Amygdala Activity to Previous Emotional Experiences. *Current Biology*, *21*(23), 2029–2032.

Vanderheyden, W. M., Poe, G. R., & Liberzon, I. (2014). Trauma exposure and sleep: Using a rodent model to understand sleep function in PTSD. *Experimental Brain Research*, *232*(5), 1575–1584.

Varma, M. M., Zeng, S., Singh, L., Holmes, E. A., Huang, J., Chiu, M. H., & Hu, X. (2024). A systematic review and meta-analysis of experimental methods for modulating intrusive memories following lab-analogue trauma exposure in non-clinical populations. *Nature Human Behaviour*, *8*(10), 1968–1987.

Visser, R. M., Lau-Zhu, A., Henson, R. N., & Holmes, E. A. (2018). Multiple memory systems, multiple time points: How science can inform treatment to control the expression of unwanted emotional memories. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *373*(1742), 20170209.

Wagner, U., Fischer, S., & Born, J. (2002). Changes in emotional responses to aversive pictures across periods rich in slow-wave sleep versus rapid eye movement sleep. *Psychosomatic Medicine*, *64*(4), 627–634. Scopus.

Wagner, U., Gais, S., & Born, J. (2001). Emotional memory formation is enhanced across sleep intervals with high amounts of rapid eye movement sleep. *Learning & Memory*, *8*(2), 112–119.

Walker, M. P., & Stickgold, R. (2006). Sleep, memory, and plasticity. *Annual Review of Psychology*, *57*(1), 139–166.

Walker, M. P., & van der Helm, E. (2009). Overnight therapy? The role of sleep in emotional brain processing. *Psychological Bulletin*, *135*(5), 731–748.

Wassing, R., Benjamins, J. S., Talamini, L. M., Schalkwijk, F., & Van Someren, E. J. W. (2019). Overnight worsening of emotional distress indicates maladaptive sleep in insomnia. *Sleep*, *42*(4), zsy268.

Wassing, R., Lakbila-Kamal, O., Ramautar, J. R., Stoffers, D., Schalkwijk, F., & Van Someren, E. J. W. (2019). Restless REM sleep impedes overnight amygdala adaptation. *Current Biology*, *29*(14), 2351-2358.e4.

Wassing, R., Schalkwijk, F., Lakbila-Kamal, O., Ramautar, J. R., Stoffers, D., Mutsaerts, H. J. M. M., Talamini, L. M., & Van Someren, E. J. W. (2019). Haunted by the past: Old emotions remain salient in insomnia disorder. *Brain*, *142*(6), 1783–1796.

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and Validation of Brief Measures of Positive and Negative Affect: The PANAS Scales. *Journal of Personality and Social Psychology*, *54*(6), 1063–1070.

Wells, B. (2019). *The end of loneliness*. Penguin Books.

Werner, G. G., Schabus, M., Blechert, J., Kolodyazhniy, V., & Wilhelm, F. H. (2015). Pre- to postsleep change in psychophysiological reactivity to emotional films: Late-night REM sleep is associated with attenuated emotional processing. *Psychophysiology*, *52*(6), 813–825.

Werner, G. G., Schabus, M., Blechert, J., & Wilhelm, F. H. (2021). Differential Effects of REM Sleep on Emotional Processing: Initial Evidence for Increased Short-term Emotional Responses and Reduced Long-term Intrusive Memories. *Behavioral Sleep Medicine*, *19*(1), 83–98.

Westfall, P. H., Johnson, W. O., & Utts, J. M. (1997). A Bayesian perspective on the Bonferroni adjustment. *Biometrika*, *84*(2), 419–427.

Wiesner, C. D., Pulst, J., Krause, F., Elsner, M., Baving, L., Pedersen, A., Prehn-Kristensen, A., & Göder, R. (2015). The effect of selective REM-sleep deprivation on the consolidation and affective evaluation of emotional memories. *Neurobiology of Learning and Memory*, *122*, 131–141.

Wilhelm, I., Azza, Y., Brennwald, K., Ehrt-Schäfer, Y., Seifritz, E., & Kleim, B. (2021). Investigating the effect of a nap following experimental trauma on analogue PTSD symptoms. *Scientific Reports*, *11*(1), 4710.

Wittchen, H.-U., & Jacobi, F. (2005). Size and burden of mental disorders in Europe—A critical review and appraisal of 27 studies. *European Neuropsychopharmacology*, *15*(4), 357–376.

Woud, M. L., Cwik, J. C., Blackwell, S. E., Kleim, B., Holmes, E. A., Adolph, D., Zhang, H., & Margraf, J. (2018). Does napping enhance the effects of Cognitive Bias Modification-Appraisal training? An experimental study. *PLOS ONE*, *13*(2), e0192837.

Yoo, S.-S., Gujar, N., Hu, P., Jolesz, F. A., & Walker, M. P. (2007). The human emotional brain without sleep—A prefrontal amygdala disconnect. *Current Biology*, *17*(20), R877–R878.

Zeng, S., Lau, E. Y. Y., Li, S. X., & Hu, X. (2021). Sleep differentially impacts involuntary intrusions and voluntary recognitions of lab-analogue traumatic memories. *Journal of Sleep Research*, *30*(3), e13208.

Zeng, S., Lin, X., Wang, J., & Hu, X. (2021). Sleep's short-term memory preservation and long-term affect depotentiation effect in emotional memory consolidation: Behavioral and EEG evidence. *Sleep*, *44*(11), zsab155.

Summary

It was a hot summer day when my father decided to take me to a petting zoo. I was two years old (or maybe three or four), holding his hand as we wandered among a crowd of other children and parents filling the farm. My eyes swept across the fields as I spotted a bird, staring straight at me. I stopped and stared back. I had never seen such a big bird before, white as snow, with a bright orange beak. Mesmerized, I let go of my father's hand and stepped closer to the fence that separated the bird and me, now locked in a gaze, just the two of us. Feeling the spark of something special, I pushed my index finger through the wire. For some people, this might mark their "spark bird" moment, the encounter with *the one bird* that ignites a lifelong passion (or obsession) for birds, spending their lives with binoculars in hand, chasing rare sightings, and memorizing bird calls. For me, though, this moment sparked something very different. What happens next, as I remember it, is this: the bird slowly lunges forward. But instead of reaching out its wing in friendship, like I thought it would, it suddenly cranes its long neck, and before I know it, snaps its bright orange beak around my finger. In shock, I pull back my hand. Tears well up as I run back to my father, swearing to myself that I'd never go near those birds ever again.

Emotional moments, whether filled with joy or fear, tend to stay with us long after they have passed, shaping how we see ourselves, others, and the world around us. Most of the times, these memories guide us in functional ways, but sometimes they can influence our thoughts and behaviours in limiting and unwanted ways. Indeed, overly intense or poorly processed emotional memories are thought to be central to the onset and persistence of many affective disorders. The substantial burden they place on individuals and society underscores the need for more effective strategies to prevent and treat them. Among the factors influencing how emotional memories are processed, sleep has been suggested as an important contributor. Sleep disturbances are common in affective disorders and appear to interact bidirectionally with emotion: poor sleep can worsen emotional regulation, while intense emotions, in turn, can impair sleep. Beyond this general link, researchers are increasingly interested in whether sleep might directly shape the way emotional memories are stored and transformed. Building on evidence that sleep enhances the long-term storage of emotionally salient over neutral information, two dominant hypotheses have emerged offering contradicting views on how sleep modulates the affective tone of these memories: one hypothesis suggests that sleep preserves or amplifies the emotional salience of memories, while the other hypothesis proposes a downregulating effect of sleep. These contradicting propositions hold important clinical implications. If the first hypothesis holds, sleep could inadvertently maintain the emotional intensity of distressing memories,

potentially contributing to the development of symptoms in affective disorders. In this case, interventions might aim to avoid sleep in the immediate aftermath of an aversive event. On the other hand, if the second hypothesis holds, sleep may act as a natural form of "overnight therapy", helping to downregulate the emotional impact of distressing memories. This would suggest that promoting healthy sleep following an aversive event may be used as a tool for preventing the development of emotional memory-related disorders.

Empirical findings regarding the hypotheses are mixed: some studies associate sleep with either the maintenance, strengthening, or weakening of memories' affective tone, while others report no effect at all. These inconsistencies raise a key question that motivates the work presented in this dissertation: *can sleep alter the emotional impact of memories, and if so, under what conditions?* Differences in study design and methodology may account for the discrepancies in findings. For instance, many studies lack appropriate control stimuli to distinguish changes specific to memory from broader emotion regulation effects and frequently rely solely on self-reports without including physiological measures. Moreover, the common use of negatively valenced images to induce emotional memories often lacks personal relevance and may create only weak emotional memories. Hence, in Chapters 2 and 3, we addressed these limitations and implemented a more ecologically valid and carefully controlled paradigm to elicit naturally embarrassing, autobiographical experiences. In a karaoke paradigm, participants were first recorded singing two songs. One of these recordings was later played back to them to induce an embarrassing episode. After a delay, participants listened to the same recording again to reactivate the previously formed embarrassing memory and assess changes in its emotional intensity. The second recording (which they had not heard before) was also played back as a control stimulus to track changes related to general emotion regulation. Emotional responses were measured in two ways: subjectively, by asking how positive or negative (i.e., valence) and how embarrassed they felt, and objectively, using a physiological marker closely associated with embarrassment – facial blushing. In Chapter 2, participants were re-exposed to their recording after a 12-hr interval, which included either daytime wakefulness or overnight sleep. Although we successfully induced an embarrassing episode as indicated by subjective and objective emotional responses, ratings of embarrassment and valence remained stable after both wakefulness and sleep. In contrast, physiological measures of facial blushing were reduced following sleep, but not after wakefulness. The lower blushing responses, however, did not only occur for the reactivated memory but also for the novel recording. Since the effect of sleep was not specific to memory reactivation triggered by the re-exposed recording, it

remains unclear whether it results from sleep-related changes to the memory itself and generalized to associated memories, or from overall changes in affect.

One reason we may not have observed a memory-specific effect of sleep in Chapter 2 could be the restricted sleep window we provided to participants, as processing emotional memories might take more than just one night. This aligns with one of the dominant hypotheses suggesting that memory processing may require multiple nights to complete. Therefore, in Chapter 3, we conducted a follow-up study where we extended the interval between the original embarrassing experience and the re-exposure to one week. Since shorter delays between initial exposure and subsequent sleep are thought to support memory processing by limiting interference from external stimuli, we varied the timing of sleep to examine its influences on emotional memories. While facial blushing reduced over time, valence ratings became more negative. However, these effects were neither dependent on the timing of sleep nor specific to the memory. The remaining subjective outcomes remained unchanged and unaffected by sleep. Together, these findings suggest that sleeping immediately after encoding does not substantially alter the long-term emotional intensity of embarrassing memories. Even if sleep contributed to the observed changes irrespective of its timing, we again found no evidence for memory-specific effects, despite several nights of sleep.

Given these inconclusive findings, we reconsidered the theoretical framework and drew on ideas suggesting that sleep's effects may be moderated by additional factors. Rather than uniformly preserving or diminishing memories' emotional tone, sleep might instead adjust it in ways that are most adaptive to the current situation. We hypothesized that this adaptive adjustment might depend on the future relevance of a memory: maintaining (or enhancing) the emotional tone of future-relevant memories could help individuals prepare for similar situations, whereas downregulating the emotional tone of future-irrelevant memories may serve to minimize unnecessary emotional burden (Chapter 4). To explore this idea, we employed a novel evaluative learning paradigm where participants viewed a short video of an acted version of the Trier Social Stress Test (TSST), depicting an individual delivering a speech in front of an evaluative panel. Some of the panel members were later introduced as potential panel members during participants' own presentations one week later, assigning future relevance or irrelevance to the previously formed memories. Changes in emotional responses to memory cues were measured after a 12-hr interval of either daytime wakefulness or overnight sleep and again one week later. Our findings showed that valence ratings remained stable over time, while subjective arousal decreased for future-

irrelevant memories after both 12 hr and one week, with no observable effect of sleep. We concluded that future relevance appears to modulate emotional memory independently of sleep.

In a final effort to identify clear sleep-related changes in the emotional intensity of distressing memories, Chapter 5 employs a more ecologically valid measure – intrusive memories – linked to a personally meaningful experience. To elicit intrusive memories, we employed the TSST as part of the study described in Chapter 4, which has been shown to reliably induce social-evaluative distress. Participants performed the TSST either in the morning and stayed awake for an extended period during the day or in the evening and slept shortly afterward. Over the following week, they tracked the occurrence of intrusive memories and the distress they evoked. This allowed us to test whether the timing of sleep affects the development of intrusive memories in the week following the stressful event. While prior research examined intrusion frequency and distress separately, we combined these measures into a single metric – *intrusion load*. This measure may be clinically more relevant because it better captures the disruptiveness of intrusive memories in daily life. Although the TSST elicited a distressing experience, as reflected by increased subjective state anxiety, we observed no effect of sleep timing on intrusion load. However, there was tentative evidence suggesting that subjective sleep quality and its variability influenced intrusion load. Nevertheless, these results should be interpreted with caution, as only a small number of intrusions were recorded following the TSST. This suggests that the TSST may not be optimal for reliably inducing intrusive memories, highlighting a limitation of the paradigm.

What began as a straightforward question – *can sleep alter the emotional impact of memories* – reveals just how elusive this relationship remains. Despite the systematic changes in our experiments, this body of work underscores the difficulty of drawing clear conclusions about whether sleep reduces or enhances the emotional intensity of memories. Instead, the results point to a complex interplay of factors that current paradigms may not fully capture. In Chapter 6 and the preceding chapters, we discuss methodological challenges such as time-of-day effects and difficulties in reliably reactivating memories that constrain our findings. Broader issues in the field, including small sample sizes and replication challenges, further hinder a clear understanding of sleep-dependent emotional memory processing. As a result, the effectiveness of sleep as a stand-alone intervention for preventing the development of emotional memory disorders remains uncertain.

Taken together, the only clear conclusion we can draw from our results is that sleep does not appear to be more harmful than wakefulness in the immediate aftermath of

distressing events in a relatively healthy population. Future research could benefit from investigating the role of sleep disturbances, such as insomnia, in emotional memory processing. While healthy sleep may support general emotion regulation, it may not reliably change the emotional impact of memories. In turn, poor sleep may have a stronger impact on emotional memory processing than healthy sleep does. Incorporating more naturalistic paradigms using autobiographical memories may better capture the complexity of real-world experiences. Such approaches can provide deeper insights into whether and how sleep modulates emotional memories and inform preventive efforts. We hope this dissertation helps shift the focus from simplistic models of sleep-dependent processing of emotional memories toward a more nuanced view, and that our use of naturalistic approaches inspires future studies to explore emotional memory modulation more effectively.

Samenvatting

Het was een snikhete zomerdag toen mijn vader besloot mij mee te nemen naar de kinderboerderij. Ik was een peuter – misschien drie of vier jaar oud – en hield zijn hand stevig vast, terwijl we samen tussen andere kinderen en ouders rondliepen. Plotseling viel mijn oog op een grote, sneeuwwitte vogel met een feloranje snavel, die me recht aankeek. Gefascineerd liet ik mijn vaders hand los en liep naar het hek dat ons scheidde. Voor mijn gevoel waren we even helemaal alleen, gevangen in elkaars blik. Ik stak nieuwsgierig mijn wijsvinger door het gaas, alsof er iets bijzonders stond te gebeuren. Voor sommige mensen markeert dit hun "spark bird"-moment, de ontmoeting met die ene vogel die een levenslange passie (of obsessie) voor vogels ontketent: verrekijker in de hand, het najagen van zeldzame waarnemingen, het uit het hoofd leren van vogelgeluiden. Bij mij leidde dit moment tot iets heel anders. Wat er gebeurde, herinner ik mij als volgt: de vogel boog langzaam naar voren. Maar in plaats van zijn vleugel vriendschappelijk uit te steken, zoals ik verwachtte, strekte hij plotseling zijn lange nek en klemde zijn feloranje snavel zich om mijn vinger. Geschrokken trok ik mijn hand terug. Met tranen in mijn ogen rende ik naar mijn vader – vastbesloten om nooit meer in de buurt van zulke vogels te komen.

Emotionele momenten – of ze nu gevuld zijn met vreugde of met angst – blijven vaak nog lang nawerken. Ze kleuren hoe we onszelf zien, hoe we anderen ervaren en hoe we de wereld om ons heen begrijpen. Gewoonlijk functioneren deze herinneringen adaptief, maar soms beïnvloeden ze onze gedachten en gedragingen op een beperkende en ongewenste manier. Zo kunnen te intense of slecht verwerkte herinneringen ons denken en doen inperken en een belangrijke rol spelen bij het ontstaan en voortbestaan van stemmingsstoornissen. Omdat deze stoornissen een grote last vormen, zowel voor het individu als voor de samenleving, is er veel behoefte aan effectieve manieren om zulke herinneringen beter te begrijpen en te behandelen.

Een factor die daarbij steeds weer naar voren komt, is slaap. Slaapstoornissen komen vaak voor bij mensen met stemmingsstoornissen en blijken nauw verweven met emoties: slechte slaap kan leiden tot problemen met emotieregulatie, terwijl sterke emoties op hun beurt de slaap kunnen verstoren. Daarnaast groeit de belangstelling voor de vraag of slaap zélf invloed kan hebben op de manier waarop emotionele herinneringen worden opgeslagen en veranderd. Uit eerder onderzoek zijn daarbij twee tegengestelde hypothesen naar voren gekomen. Volgens de ene hypothese houdt slaap de emotionele lading van herinneringen in stand of versterkt die zelfs; volgens de andere hypothese helpt slaap de emotionele intensiteit juist te dempen, alsof de nacht fungeert als een natuurlijke vorm van therapie. Beide visies hebben duidelijke klinische gevolgen: als slaap de intensiteit van nare

herinneringen versterkt, zou het vermijden van slaap direct na een nare gebeurtenis bescherming kunnen bieden. Als slaap die intensiteit juist vermindert, zou gezonde slaap een beschermende rol kunnen spelen.

In dit proefschrift hebben we deze hypothesen getoetst aan de hand van een reeks experimenten. Daarbij kozen we voor een aanpak die dichter bij het dagelijks leven ligt dan de vaak gebruikte emotionele plaatjes of kunstmatige stimuli. In hoofdstuk 2 en 3 maakten we gebruik van een karaokeparadigma: deelnemers zongen liedjes die werden opgenomen, waarna ze later hun eigen opname terug moesten luisteren. Dit riep een sterk gevoel van gêne op – een natuurlijke en persoonlijke emotionele herinnering. Vervolgens onderzochten we hoe slaap deze herinneringen beïnvloedde. Hoewel we duidelijke emotionele reacties konden oproepen, vonden we geen overtuigend bewijs dat slaap de intensiteit van de herinnering specifieker veranderde dan wakker zijn.

Omdat de verwerking van herinneringen mogelijk meer dan één nacht vergt, verlengden we in een vervolgstudie de tijd tussen de ervaring en het opnieuw beleven ervan. Ook hier zagen we veranderingen in emotionele reacties, maar opnieuw zonder een duidelijk en specifiek effect van slaap. In hoofdstuk 4 introduceerden we het idee dat slaap misschien niet altijd dezelfde invloed heeft, maar herinneringen juist aanpast afhankelijk van hun toekomstige relevantie. Onze experimenten lieten zien dat toekomstige relevantie inderdaad een rol speelt in hoe herinneringen veranderen – maar dat dit niet afhankelijk was van slaap.

In hoofdstuk 5 richtten we ons op intrusieve herinneringen, een vorm van emotioneel geheugen die vaak voorkomt na traumatische ervaringen en een grote klinische relevantie heeft. Met behulp van een stressparadigma onderzochten we of slaap direct na een stressvolle ervaring invloed had op de ontwikkeling van zulke intrusies in de dagen daarna. Hoewel we stress konden oproepen, vonden we geen bewijs dat de timing van slaap een doorslaggevende rol speelde.

Gezamenlijk laten de studies in dit proefschrift zien hoe complex de relatie tussen slaap en emotionele herinneringen is. Eenvoudige antwoorden – dat slaap altijd versterkt of altijd vermindert – blijken ontoereikend. Wat wél duidelijk werd, is dat slaap direct na een belastende ervaring in een gezonde populatie niet schadelijker is dan wakker blijven. Mogelijk speelt juist slechte of verstoorde slaap een grotere rol bij het vasthouden van emotionele herinneringen dan gezonde slaap.

Ik hoop dat dit werk bijdraagt aan een verschuiving in ons denken: weg van simplistische modellen, naar een meer genuanceerd begrip van hoe slaap en emotie

samenhangen. Met naturalistische benaderingen, die dichter bij echte ervaringen staan, kunnen we mogelijk nieuwe inzichten krijgen en uiteindelijk betere strategieën ontwikkelen om mensen te helpen die lijden onder hun herinneringen.

Publication List

Research in this dissertation

Reinhold, F. L., Gerlicher, A. M., van Someren, E. J., & Kindt, M. (2022). Do your troubles today seem further away than yesterday? On sleep's role in mitigating the blushing response to a reactivated embarrassing episode. *Sleep*, *45*(11), zsac220.

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Reinhold, F. L., Visser, R. M., van Someren, E. J., & Kindt, M. (under review at *Behaviour Research and Therapy*). Past stories, future worries: sleep does not alter the emotional response to future-relevant or irrelevant negative memories.

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Reinhold, F. L., Visser, R. M., van Someren, E. J., & Kindt, M. (submitted). I can still see all eyes on me: effects of sleep on intrusive memories following a socially stressful experience.

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Other publications

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