

Table of Contents

General introduction.....	19
Chapter 1. Sleep and memory consolidation.....	23
1.1. Electrophysiology of brain states	25
1.1.1. Wake.....	26
1.1.2. Non-rapid eye movement sleep.....	26
1.1.3. Rapid eye movement sleep.....	27
1.1.4. Sleep cycles and alternating sleep phases	28
1.2. Memory consolidation	31
1.2.1. Memory systems	31
1.2.2. The dynamics of memory formation.....	32
1.2.3. Cellular correlates of memory consolidation.....	36
1.2.4. Emotional memory	36
1.3. Sleep and memory consolidation: an overview	38
1.3.1. Introduction	38
1.3.2. Sleep stages and memory systems: a complex interaction.....	39
1.3.3. Sleep and the consolidation of declarative memories.....	41
1.3.4. Sleep and the consolidation of non-declarative memories	43
1.3.5. Mechanisms of sleep-dependent memory consolidation.....	47
Chapter 2. Sleep and the consolidation of emotional memories	51
2.1. How negative emotions modulate sleep architecture.....	53
2.2. Sleep as an emotional regulator	55
2.3. Emotion modulates sleep-dependent memory consolidation and its neurophysiological substrates.....	60
2.4. Is sleep stripping emotions from experience ?.....	64
2.5. Sleep and dreaming	69
2.6. Conclusions	73

2.7. Aims of the experimental studies	73
STUDY 1	75
REM-enriched Naps Contribute to Memory Consolidation for Sad Stories and Enhance Mood-Related Reactivity	75
1. Introduction	77
2. Experimental Section	81
2.1. Participants.....	81
2.2. Procedure	82
2.3. Material.....	84
2.4. Data Analysis	86
3. Results	87
3.1. Sleep and Vigilance.....	87
3.2. Memory Performance and Relation with Sleep.....	92
3.3. Emotional Reactivity, Mood and Arousal Measures.....	94
3.4. Affective Rating for Neutral and Sad Stories before vs. after the Nap.....	97
4. Discussion.....	98
4.1. The Influence of Sleep on Memory Consolidation.....	99
4.2. Objective and Self-Reported Emotional Reactivity.....	101
4.3. Emotional Rating of Neutral and Sad Stories.....	103
4.4. Limitations	104
5. Conclusions.....	105
STUDY 2.	107
Sleep Unbinds Memories from their Emotional Context.....	107
1. Introduction	109
2. Methods	110
3. Results	112
4. Discussion.....	114

5. Conclusion.....	116
6. Additional studies	116
Chapter 3. Sleep and the reactivation of memories.....	119
3.1. Spontaneous reactivation of memories during sleep.....	121
3.1.1. Evidence from animals studies	121
3.1.2. Evidence from human studies	122
3.2. Auditory processing during sleep	124
3.3. Tickling memories during sleep.....	126
3.4. Which memories are preferentially reactivated during sleep?	131
3.5. Hypnopedia	132
3.6. Aims of the studies.....	133
STUDY 3.....	135
Emotion does not modulate the memory consolidation benefits of Target Memory Reactivation during NREM sleep.....	135
1. Introduction	137
2. Methods.....	140
2.1. Participants.	140
2.2. Material.....	141
2.3. Procedure.....	142
2.4. Polysomnography.....	145
2.5. Data analysis.....	146
3. Results	147
3.1. Sleep during the three nights preceding the testing sessions	147
3.2. Sleepiness and vigilance during the experimental sessions.....	148
3.3. Sleep and Targeted Memory Reactivation	148
3.4. Memory performance	149
3.5. EEG correlates of auditory cueing	152

4. Discussion.....	156
4.1. TMR benefits the consolidation of verbal declarative memory	156
4.2. Emotion does not modulate TMR effects	157
4.3. EEG correlates of auditory cueing.....	158
4.4. Limitations	160
5. Conclusion	161
STUDY 4.....	163
Verbatim targeted memory reactivation of word pairs during NREM sleep paradoxically blocks memory consolidation benefits.....	163
1. Introduction.....	165
2. Methods.....	167
2.1. Participants	167
2.2. Material.....	168
2.3. Procedure.....	168
2.4. Polysomnography	172
2.5. Data analysis	173
3. Results	175
3.1. Sleepiness and vigilance in the Sleep group	175
3.2. TMR-related effects on memory	176
3.3. Modulations of EEG power induced by reactivation during sleep.....	177
3.2. Delta power, sleep stages duration and memory performance	180
4. Discussion.....	180
4.1. Is a silent post-cueing time window necessary to trigger memory consolidation? Behavioral effects.....	181
4.2. Is a silent post-cueing time window necessary to trigger memory consolidation? Electrophysiological effects.....	182
4.3. Verbatim TMR of word pairs does not alter memory consolidation for non-cued word pairs.....	184

4.4. TMR during wake benefited memory consolidation.....	184
5. Conclusions.....	185
6. Supplementary material.....	186
6.1. Figure 5.....	186
6.2. List of word pairs.....	187
Chapter 4. The use of transcranial Direct Current Consolidation for memory consolidation	189
4.1. Transcranial Direct Current Stimulation: definition and mechanisms of action 191	
4.1.1. Definition.....	191
4.1.2. Current intensity	192
4.1.3. Duration of stimulation	192
4.1.4. Electrode montage, size and positioning	193
4.1.5. Mechanisms of action	195
4.1.6. Transcranial Alternating Current Stimulation (tACS)	197
4.2. tDCS and episodic memory consolidation	198
4.2.1. Wake experiments	198
4.2.2. Sleep experiments.....	200
4.3. Aim of the experimental study	203
STUDY 5.....	205
Transcranial Direct Current Stimulation improves global learning, but does not potentiate the selective benefits of Targeted Memory Reactivation on memory consolidation.....	205
1. Introduction	207
2. Methods.....	210
2.1. Participants.....	210
2.2. Material.....	210
2.3. Procedure	211

2.4. Transcranial Direct Current Stimulation	213
3. Results	214
3.1. Sleepiness and vigilance	214
3.2. Pre-stimulation Learning Session (IRT)	215
3.3. Immediate post-stimulation testing session (RT1).....	216
3.4. Long term memory consolidation (RT2).....	218
4. Discussion.....	219
4.1. The benefits of auditory cueing on memory consolidation	220
4.2. The effects of tDCS on memory consolidation	221
4.3. Consolidation of emotional memories and lateralisation of tDCS polarity.....	224
4.4. No long-term benefits of TMR and tDCS.....	225
5. Conclusions	226
Chapter 5. General discussion and perspectives.....	227
5.3. Sleep, emotional memory consolidation, and the attenuation of the emotional response.....	229
5.3.1. Summary of the experimental findings	229
5.3.2. Rapid eye movement density is associated with memory for a sad story .	230
5.3.3. REM-enriched nap improves resting mood state, but enhances the emotional response during re-exposure to the sad story	232
5.3.4. Perspectives	234
5.4. Targeted memory reactivation during sleep.....	234
5.4.1. Summary of the experimental findings	234
5.4.2. The benefits of auditory cueing on declarative memory	235
5.4.3. Auditory cueing impacts the spontaneous EEG oscillations	236
5.4.4. The critical role of a sensitive plastic period following TMR.....	238
5.4.5. The TMR benefits in light of the active system consolidation and the synaptic homeostasis hypotheses.....	239

5.4.6. TMR during NREM sleep equally benefits the consolidation of neutral and negative word pairs.....	241
5.4.7. Perspectives	243
5.5. The combination of transcranial Direct Current Stimulation and Targeted Memory Reactivation to enhance memory consolidation.....	244
5.5.1. Summary of the experimental findings.....	244
5.5.2. Wake TMR benefits memory consolidation.....	245
5.5.3. tDCS improves global learning.....	246
5.5.4. The lateralization of tDCS did not modulate the consolidation of negative items.....	248
5.5.5. Perspectives	249
General conclusion.....	251
References.....	253
Appendices.....	291
Appendix 1. Gilson, M., Peigneux, P. Sleep and Memory. <i>International Encyclopedia of the Social & Behavioral Sciences</i> , 2nd edition. Elsevier. pp 1-7.	
Appendix 2. Deliens, G., Gilson, M., & Peigneux, P. (2014). Sleep and the processing of emotions. <i>Experimental Brain Research</i> , 232(5), 1403–1414.	
Appendix 3. Deliens, G., Gilson, M., Schmitz, R. & Peigneux, P. (2013). Sleep unbinds memories from their emotional context. <i>Cortex</i> , 49(8), 2221–2228.	