Université de Montréal

The Embodied Mind in Sleep and Dreaming: A theoretical framework and an empirical study of sleep, dreams and memory in meditators and controls

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Programme de doctorat individualisé
Sciences biomédicales
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Thèse présentée à la faculté de médecine
en vue de l'obtention du grade de doctorat
en sciences biomédicales
option individualisée

Août 2017

Résumé

Les théories récentes de la conscience incarnée (*embodiment*) soulignent que l'esprit est un processus incarné, impliquant le cerveau, le corps et l'environnement. Plusieurs aspects de la cognition, de l’interaction sensorimotrice avec l’environnement à la pensée abstraite et métaphorique, ont été conceptualisés dans ce paradigme. Le sommeil et le rêve, cependant, ont rarement été abordés par des chercheurs dans le domaine de la conscience incarnée. Cette dissertation vise à montrer, en s’appuyant sur la phénoménologie, la philosophie énactive et des sciences cognitives du sommeil et des rêves, que le rêve est un processus incarné de formation de sens dans le monde onirique. Ce travail comporte trois objectifs principaux : 1) de démontrer que le rêve est incarné; 2) de clarifier les liens entre les expériences corporelles et la formation onirique; et 3) de préciser si la sensibilité corporelle accrue, en tant qu’une compétence entraînable, mène à des changements globaux dans la façon dont l'information est traitée en sommeil.

Le premier objectif est une proposition inédite dans la science des rêves. Dans ce travail, j’analyse les études théoriques et empiriques sur le sujet afin de motiver la notion de l’incarnation corporelle du rêve. Je propose un cadre théorique et pratique pour la recherche en neurophénoménologie du sommeil (article I). Je montre que les rêves sont incarnés à plusieurs niveaux. Tout d'abord, de nombreux rêves contiennent des représentations du corps ou du mouvement corporel. Deuxièmement, les rêves sont vécus d’un à la première personne et ont une qualité spatiale. Troisièmement, les rêves sont structurés par l'émotion et l'affect, et sont ainsi enracinés dans le corps. Enfin, le corps du rêveur et le corps onirique ne sont pas indépendants l'un de l'autre : leur perméabilité est illustrée par les rêves intensifiés, les parasomnies (article II) et les études sur l'intégration des stimuli somato-sensoriels dans le contenu des rêves.

Le deuxième objectif est d'étudier des exemples concrets dans lesquels les sensations somatiques, ou des altérations dans la perception habituelle du corps, affectent le contenu des rêves. Je procède par une revue de littérature sur l’état actuel des connaissances empiriques sur la paralysie du sommeil, en tant qu’un phénomène illustratif de l'altération dans l'expérience corporelle en sommeil (article II). Je conclus que les expériences corporelles dans le cadre de la paralysie du sommeil (pression sur la poitrine, sensations inhabituelles, et autres) nous informent sur la manière dont le sens altéré du corps modifie la perception de l'environnement, affecte les qualités de la relation intersubjective avec le monde, et illumine les caractéristiques subjectives fondamentales du sens de l'espace. En outre, les résultats de notre étude empirique démontrent que la stimulation somatosensorielle de la cheville en Stade 1 du sommeil et en sommeil paradoxal produit une variété de changements dans le contenu des rêves.

Le troisième objectif était de tester si la formation contemplative, qui augmente la conscience corporelle, produit des changements dans l'apprentissage procédural, dans l'architecture du sommeil, dans la consolidation de la mémoire dépendante du sommeil et dans le contenu des rêves. Nous avons démontré (article III) que les méditants Vipassana et les sujets témoins avaient des patrons distincts de consolidation de la mémoire en sommeil : l'amélioration d'une tâche d'apprentissage procédural était associée à la densité des fuseaux du sommeil chez les méditants, tandis que les participants témoins avaient une relation forte entre l'amélioration de la tâche et durée du sommeil paradoxal. En outre, nous avons constaté une fréquence réduite des fuseaux du sommeil chez les méditants, ce qui suggère que la pratique de la méditation centrée sur le corps peut avoir un effet à long terme sur l'organisation et la fonction du sommeil.

Dans l'ensemble, les résultats de cette enquête permettent de conclure que le rêve est un processus incarné de formation du sens, texturé par des souvenirs et des émotions, et que le rêveur n'est pas déconnecté de leur corps ou du monde extérieur. En outre, l'entrainement à la conscience corporelle peut produire des changements globaux dans l'architecture du sommeil et dans les processus cognitifs du sommeil, y compris les rêves et la consolidation de la mémoire. Ces résultats ont des implications théoriques et pratiques pour la recherche sur les fonctions du sommeil, des rêves et le rôle du corps dans l'expérience subjective.

Mots clés : sommeil, rêves, conscience incarné, énaction, phénoménologie, mémoire, méditation, fuseaux du sommeil, sommeil paradoxal, stimulation somato-sensorielle

Abstract

Recent theories of cognition have stressed that the mind is an embodied process, one involving brain, body, and environment. Many aspects of cognition, from waking sensorimotor coping with the world to other aspects of the mind, such as metaphor and abstract thought, have been explicated under this framework. Sleep and dreaming, however, have only rarely been approached by embodied mind theorists. In this dissertation, I draw on work in phenomenology, enactivism, and the cognitive science of sleep and dreaming, I aim to show that dreaming is an embodied process of sense-making in the dream world. This work has three main goals: 1) to argue that the dreaming mind is embodied; 2) to clarify the links between bodily experiences and oneiric mentation; and 3) to test whether increased bodily awareness as a trainable skill contributes to global changes in the way that the mind treats information in sleep.

The first goal is a novel proposal in dream science. In this work, I review evidence for embodied dreaming and propose a theoretical and practical framework for neurophenomenological research (Article I). I propose that dreams are embodied in a number of different ways. First, many dreams contain representations of body or bodily movement. Second, dreams are experienced from a first-person point of view, and have a spatial quality. Third, dreams are structured by emotion and affect, and thus are rooted in the body. Finally, sleeping and dreaming bodies are not independent of each other; their permeability is exemplified by intensified dreams, parasomnias (Article II), and studies of somatosensory stimuli incorporation into dream content.

The second goal is to investigate some of the concrete ways in which somatic sensations or alterations in habitual perception of the physical body affect dream content. I review the current state of knowledge on sleep paralysis as an illustration of sleep-dependent alteration in bodily experience (Article II), and conclude that bodily experiences in sleep paralysis (pressure on chest, unusual sensations, and others) provide information about the myriad ways an altered sense of the body changes one's perception of the environment, affects qualities of one's intersubjective relationship with the world, and provides insight into the fundamental subjective features of the sense of space.

Additionally, results of our empirical study show that somatosensory ankle stimulation at sleep onset and during REM sleep produces a variety of changes in dream content.

The third goal is to study whether contemplative training, which has been shown to increase bodily self-awareness, produces changes in procedural learning, sleep architecture, sleep-dependent memory consolidation and dream content. We showed (Article III) that Vipassana meditators and controls had distinct patterns of sleep-dependent memory consolidation: improvement on a procedural learning task was associated with sleep spindle density in meditators, while control participants had a strong relationship between improvement on the task and REM sleep duration. Additionally, we found a reduced sleep spindle frequency in meditators, suggesting that body-based meditation practice may have long-term effects on sleep organisation and function.

Overall, the results of this inquiry point to the conclusion that dreaming is an embodied process of sense-making, textured by memories and affect, and that the dreamer is not disconnected from their body or the outside world. Furthermore, training in bodily awareness may produce global changes in sleep architecture and sleep cognition, including dreaming and memory consolidation. These results have theoretical and practical implications for research on functions of sleep, dreams and the role of the body in subjective experience.

Keywords: sleep, dreaming, embodiment, enactivism, phenomenology, memory, meditation, sleep spindles, REM sleep, somatosensory stimulation

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4EA: Embodied, Enactive, Extended, Embedded and Affective cognition
CTL: control group
EEG: electroencephalogram
EMG: electromyogram
fMRI: functional magnetic resonance imaging
HiScore: highest score on a procedural task
M: mean
MBSR: mindfulness-based stress reduction
MED: meditation group
MSI: multisensory integration
N2: non-rapid eye movement sleep, stage 2
N3: non-rapid eye movement sleep, stage 3
NREM: non-rapid eye movement sleep
OBE: out-of-body experience
OPC: open peer commentary
PSG: polysomnography
PTSD: post-traumatic stress disorder
RBD: REM sleep behavior disorder
REM: rapid eye movement sleep
SD: standard deviation
SP: sleep paralysis
SWS: Slow wave sleep
T1: task performance prior to the nap
T2: task performance after the nap
WPEH: Weak phenomenal embodiment hypothesis

Acknowledgements

It has been a delightful adventure in the lands of neuroscience, psychology, cognitive science, sleep, dreams, phenomenology, enactivism, media arts, contemplative research and practice. I am humbled and enchanted to have spent these years in such fabulous company. But especially I am grateful to my advisors, Tore Nielsen and Sha Xin Wei, who graciously accepted to direct my studies, invited me to their laboratories and allowed me, during all these years, to wander off into new territories, but who always provided a solid ground to come back to.

Much gratitude is due to Tore Nielsen, who kindly took me as a student in his Dream and Nightmare Laboratory over 13 years ago, which set me on my research path. I do not know how to fully express the extent of my appreciation for having had Tore as an advisor. Working with Tore has been a rare treat: his knowledge, patience, generosity, and friendship made all the difference in my graduate experience and in my formative years as a young scholar. This project is a culmination of years of conversations, research studies and writing. I have benefited enormously from Tore's deep well of wisdom at all stages of research: from new ideas to project design and interpretation of results. I will always think back to our conversations about the dreaming mind as some of the most important and stimulating exchanges of my training. Tore's rigorous, open-minded and creative way of doing science is what made me want to become a scientist myself.

I am also grateful to Sha Xin Wei, who generously let me play and learn at his Topological Media Lab. Xin Wei's creativity and vision emboldened me to not embark on a safe and predictable disciplinary path and instead to wander into the deep forest of interdisciplinarity, new media and philosophy. That travel proved the most enchanting, and I am thankful for Xin Wei's guidance, insight, creativity and friendship along the way. Xin Wei's synthetic approach to research has influenced the way I aspire to do science, and Xin Wei's teaching and conversations often provided catalysts for novel ways of thinking. I could not have wished for better advisors.

I would also like to thank Bettina Bergo, who graciously accepted to be part of the committee for this project from its conception. I have learned a lot in Bettina's brilliant seminars on phenomenology. I am grateful for her advice, knowledge, insightful comments and for her support during these years of training.

I am lucky to have found two intellectual homes to learn and play in Montreal. The first one is Tore Nielsen's Dream and Nightmare Laboratory (DNL). Special thanks are due to Tyna Paquette, without whom I would never have been able to run my study, who was always there with technical and moral support. Many thanks to my fellow dream students who helped me run my doctoral study: Simon Dubé, Cloé Blanchette-Carrière, Arnaud Samson-Richer. Special thanks are due to Michelle Carr for her precious friendship and for hours of conversations about the mind, dreams, sleep and enlightenment. I'm grateful to have shared the PhD experience at the DNL with Sébrina Aubin, Isabelle Godin, Louis-Philippe Marquis, Christian O'Reilly, Claudia Picard-Deland, and Sébastien Saucier. A shout out to my students who helped me develop the experimental protocol at its early stages: Alexandra Duquette, Olivier Dussault, Sarah Hertz, Cécile Rénucci, Émilie Schon, Marisa Racine. A separate warm thank you goes out to Julie Carrier for her support and encouragement over the years at CEAMS.

My other Montreal home, Topological Media Lab (TML) at Concordia University has been a source of the greatest intellectual and methodological challenge to my scientific self. I am lucky to have met, worked and played with TML-labbers and associated community: Nina Bouchard, Nicolaos Chandolias, Patricia Duquette, David (Jhave) Johnston, Vangelis Lympouridis, Michael Montanaro, David Morris, Navid Navab, Harry Smoak, Oana Suteu Khintirian. An extra special high five goes to the very talented Omar Al-Faleh for including me in his installation practice to try out experimental philosophy.

I was also fortunate to participate in summer schools and interdisciplinary initiatives during my PhD training: I owe a great deal of debt to the Mind and Life Summer Research Institute (editions of 2013, 2014, 2016 and 2017) where I not only learned about how to do interdisciplinary research and how to integrate contemplative studies into my work, but also, and possibly even more importantly, had so many inspiring and motivating conversations, which provided a much-needed intellectual and emotional sustenance on the rather lonely interdisciplinary path. A million thanks are due to Evan Thompson, Clifford Saron, Sean Michael Smith, Laura Schmalzl, Michael Lifshitz, Kieran Fox, Michael Sheehy, Ishan Walpola and so many others. Doing work between disciplines is exciting and risky, and I am incredibly thankful to Piet Hut, first, for his many years of friendship at the Kira Institute, and, more recently, for inviting me to be part of the Initiative for a Synthesis in Studies of Awareness and of the YHouse in New York City. These nascent organizations, dedicated to the interdisciplinary study of the mind, rekindled with a new force the excitement and the wonder of venturing fearlessly into risky research projects. Thanks to these initiatives, I was able to remain (reasonably) confident of pursuing the precarious multidisciplinary path. Thanks are due to Eran Agmon, Jelle Bruineberg, Michael Butler, Kenji Doya, Ayako Fukui, Katsunori Miyahara, Kevin Ryan, Sean Sakamoto, Caleb Scharf, Nao Tsuchiya, Ed Turner, Olaf Witkowski, and all the other ISSA and YHouse brave explorers for making me feel at home in my strangest pursuits.

At the end of my PhD, I was fortunate to add another home to my collection of Montreal spaces: the Neurophilosophy Lab and McGill's Culture, Mind and Brain community. I'm very grateful to Ian Gold for welcoming me into his lab and for generously letting me write my thesis in a "room of my own" in a haunted house on Peel street.

And to the extended Montreal's vibrant community of intellectuals, artists, scientists and other rebel friends, cheers to Philippe Blouin, Lara Braitstein, Noah Moss Brender, Maxime Doyon, Patricia Duquette, Elena Frantova, Yann Harel, Danielle Landreville, Tatiana Koroleva, Maxwell Ramstead, Joseph Therriault, and Samuel Veissière. Thanks to generous and attentive care and yoga instruction by fabulous Patrick Winogrond I was able to stay reasonably alive during the whole PhD adventure.

A traditional "last but not least" hug and bow to my family. To my fearless parents, Olga and Leonid for bravely embarking on the Canadian adventure and for making sure that everything is within reach, always. To my brother, Kirill, for playing, cooking and hanging out. To Phil, my colleague and partner in everything, from science to Twin Peaks marathons: I would not have been able to do any of it if it were not for your presence and kindness. And to my daughter, Sasha, for making it all worthwhile.

Finally, this work would not be possible without financial support of the following organizations. I am grateful for doctoral scholarships from the Social Sciences and Humanities Research Council of Canada, from Sacré-Coeur Hospital's foundation and from the Dream and Nightmare Laboratory. My empirical study was generously funded by the Francisco J. Varela Research Award from the Mind and Life Institute.

1. Introduction

The present dissertation is motivated by an overarching ambition to discuss the mind in sleep from philosophical approaches derived from phenomenology, namely enactivism and the embodied mind framework, and to complement these with empirical research. The dissertation focuses on the following considerations about the mind in sleep: 1) how embodied subjectivity is expressed in sleep and dreams; 2) what role, if any, the body plays in dream content; and 3) how expertise in body awareness contributes to sleep- and dream-dependent processes of memory consolidation.

A number of theories grounding the mind in the body and in an active relationship with the world have been proposed in the last 30 years in philosophy of mind and cognitive science (Clark, 2008; Gallagher, 2005; Johnson, 2007; Lakoff, 2012; Noe, 2006, 2010; Shapiro, 2010; Varela, Thompson, & Rosch, 1992; Wilson, 2002). One key principle of many of them is the idea that the classical mind-body dualism must be abandoned in favour of the view that the mind is embodied, i.e., is a process of interaction between an organism and the world that is conditioned by the kind of a body than an organism is. These embodied and situated sensorimotor interactions between an autonomous agent and the world are constitutive of the development of the agent's mind. This principle is inherited from classical phenomenology and existentialism, especially the work of Husserl, Merleau-Ponty, Heidegger, Sartre, as well as from contemporary phenomenology (Husserl, 1982; Merleau-Ponty, 1945; Sartre, 1943; Taipale, 2014; Weiss, 2013). The embodied subject, then, is an active creator of their world; by moving through the world, animated by emotions and goals, geared towards particular aspects of the world, the subject is engaged in a relationship between the self, the world and others. None of this, however, would be possible without sleep, since all cognitive and physical functions appear to depend on us spending about a third of our lives immobile, disengaged from our relations, solitary and in retreat from the world.

Sleep and dreaming have been largely absent from the embodied mind and phenomenology work. Indeed, rich, vivid and immersive oneiric experiences provide a challenge to the embodied mind hypothesis, since the dreamer appears to be immobilized and largely "disconnected" from the outside world, and yet is able to create and experience realistic scenarios in compelling and vivid dream worlds. Does this mean that dreams are disembodied experiences, simply virtual reality simulations "in the head"? Is the dreamer fully away from the world, or is there a relationship between the sleeping body in the world and the dreaming body in the dream world? Are dreams embodied like perception? Or are dreams more like processes of imagination? What is the relationship between lived experiences when awake and lived experiences in dreams: what are dreams made of? What is the role of somatosensory learning in other sleep experiences, for example unconscious processing of newly learned information? These are some of the guiding questions of the present work.

1.1. Overall goals and structure of the dissertation

The main goals of the present dissertation are: 1) to argue the case that the dreaming mind is embodied; 2) to clarify the links between bodily experiences and oneiric mentation; 3) to test whether increased bodily awareness as a trainable skill contributes to global changes in the way that the mind treats information in sleep (see Table 1 for the relationship between these goals and elements of the dissertation).

The first goal, which is a novel proposal in dream science, is treated in various ways throughout the dissertation. Section 1.2.4 of the present Introduction provides review of evidence from a variety of perspectives which support the notion that dreaming is a strongly embodied state of being. Drawing on work from phenomenology, psychology, philosophy, and the cognitive science of sleep and dreams, I argue that dream subjectivity is not separate from subjectivity of the waking self, and that dreams are embodied processes of sense-making in sleep, conditioned by memory and affect. Article I (Solomonova & Sha, 2016) develops this proposal and argues the case for dreaming as embodied from an enactive perspective. It stipulates that dreams are processes of spontaneous embodied imagination in sleep, and proposes a neurophenomenological research program with fine-grained phenomenological tools to study how bodily experiences contribute to fundamental aspects of dream formation. In Article III, we test the idea that developing expertise in bodily awareness through contemplative training in the Vipassana meditation tradition changes how dream content incorporates elements of a novel procedural task and how it relates to sleep-dependent memory consolidation.

The second goal is to investigate some concrete ways in which somatic sensations or alterations in habitual perception of the body affect dream content. I review the current state of knowledge on sleep paralysis as an illustration of sleep-related alterations in bodily experience, and in Article II (Solomonova, in press), I conclude that dream embodiment can manifest in an interpersonal and metaphorical way under such unusual conditions as transient muscle paralysis. Further, in section 6.2.2 of the Discussion, I propose that bodily experiences in sleep paralysis are informative about the way that an altered sense of the body changes one's sense of environment, affects relationships with the world, and provides insights into fundamental subjective features of the sense of space. Additionally, in section 6.3.7 of Discussion I present some preliminary results of our empirical study, consisting of experiential examples of how dream content reacts in different ways to somatosensory leg stimulation during sleep. These first-person dream reports provide further evidence for a strong connection between the sleeping and dreaming bodies and for the causal role of bodily sensations in dream formation.

The third goal of the present work is to study whether contemplative training that increases bodily self-awareness produces changes in the way that procedural learning affects sleep and memory consolidation. In Article III we show that Vipassana meditation practitioners possess a neurobiological pattern of sleep-dependent memory consolidation that is markedly different from that of matched, meditation-naïve controls. In addition, we show that body-based meditation practice may alter sleep architecture in a general way, suggesting that training in bodily awareness may have long-term effects on the structure and function of sleep. Finally, in Discussion section 6.3.8 I discuss the few differences in dream content that were found between meditation practitioners and controls.

In sum, this work aims to situate sleep and dreaming within the context of the embodied mind and enactive cognitive science. To do so, insights and methodologies from phenomenology, enactivism, sleep research, dream science and contemplative research are considered for how they elucidate different aspects of embodiment in sleep. A general phenomenology and enactivism-based framework for the neurophenomenology of embodied dreaming is proposed. The role of bodily experiences and sensations in processes of oneiric sense-making and dream formation are investigated, using sleep paralysis experiences and the effects of experimental somatosensory stimulation in sleep to illustrate relationships between the two domains. Finally, an empirical study, focused on the relationship between bodily awareness, cultivated through sustained contemplative practice of Vipassana meditation, and sleep-dependent consolidation of a full-body procedural task, is reported. The latter reveals a distinct neurobiological learning style in meditation practitioners and further supports the notion that bodily self-awareness changes neurobiological features of sleep and, possibly, learning and memory more globally.

Table 1. Map of the dissertation goals and key ideas

Research Goal	Dissertation Parts	Key ideas
Are dreams embodied?	Introduction section 1.2.4	Dreams are embodied experiences of sense-making in sleep
	Article I	Neurophenomenology of sleep and dreaming needs sensitive tools for the study of how embodiment conditions dream content
	Article III	How full body task incorporation into dream content is related to learning
What is the role of bodily sensations in dream formation?	Article II	Sleep paralysis is an example of how altered sense of body changes contributes to oneiric imagery
	Discussion section 6.3.7	Examples of changes in dream content following somatosensory stimulation
Does bodily awareness training change cognitive neurophysiology of sleep?	Article III	Meditation practitioners show a different neurobiological learning style of a procedural task than non-meditating controls Meditation may change general sleep architecture
	Discussion section 6.3.8	Dream content differences between meditation practitioners and non-meditating controls

1.2. The mind is dynamically embodied: phenomenology and 4EA cognition

1.2.1. Embodiment in phenomenology: Husserl and Merleau-Ponty

In the following sections I will introduce the basic notions of phenomenology with specific emphasis on the notions of embodiment. While dreams have not traditionally been at the center of the phenomenological discourse, arguments for the irreducible embodiment of mental life, including dreaming, can be traced back to work of phenomenologists, such as Husserl and Merleau-Ponty. These notions have been taken on in more recent cognitive philosophy approaches, including enactivism. The present section describes several of these foundational roots. In Sections 1.2.1.1 and 1.2.1.2 I outline the basic notions of how early phenomenologists conceptualized subjective experience in general, and the role of body in particular. Further, in the section 1.2.1.3 I provide an overview of the phenomenological work focused on dreaming.

1.2.1.1. Disclosing the world through phenomenological attitude and the *epoché*

Phenomenology as a philosophical tradition is often associated with Husserl's famous motto: "to the things themselves", which characterises a turn towards the intimate, intuitive and intentional direct engagement with the *lifeworld* (*Liebenswelt*) and with the way that the world discloses itself to consciousness. The ambition of the phenomenological project was to step out of the Cartesian objectivist position and of the internalist view of the phenomena and let the things, as they appear, speak for themselves. Then, through the study of the modes of their appearance to the perceiving, sensing and sense-making living subject, one can make manifest the essential structures of consciousness. In contrast, in contemporary psychology and the cognitive sciences uses of the term 'phenomenology' have largely been inconsistent and often refer to different (albeit related) methods. While in philosophy phenomenology is a specific school of thought with its own methods, including phenomenological reduction and the epoché (see below), in empirical research phenomenology is often used synonymously with any first-person report on subjective experience, or with introspection.

The Husserlian method consists of suspending the 'natural attitude' of naïve, non-phenomenologically minded subjects, and instead adopting a 'phenomenological attitude' through which one may perceive the world with its "…corporeal physical things with some spatial distribution or other (as) *simply there for me, 'on hand'* in the literal or figurative sense" (Husserl, 1982) p.51). Adopting the phenomenological attitude changes the very nature of one's relationship with the world. One no longer accepts a stable, external ready-made world, but rather recognizes that the world and its objects, people and significations are part of an experiential realm. Using this attitude to gain insight into regularities of the world is possible by virtue of the *epoché* (*ἐποχή*), a practice also referred to as parenthesizing or bracketing: a process of suspending habitual judgements about the world. For a scientist, *epoché* is a practical alternative to a predetermined theory-laden judgement about phenomena, and it is designed to free the scientist from the limitations and pre-given assumptions about their object of study.

The relationship between the subject and the world is based on the phenomenological concept of intentionality. The intentional stance (consciousness *of something*, or the *aboutness* of conscious experience) brings the Husserlian subject into a space right between the body and the world: "Reality (…) has the essentiality of something which, of necessity, is *only* intentional, *only* an object of consciousness, something presented in the manner peculiar to consciousness, something apparent as apparent" (Husserl, 1913 (1982), p.113). Reality makes itself apparent, discloses itself as an intentional object, as a correlate of consciousness, and the manner in which it is presented reveals something about the nature of consciousness itself. Phenomenology, then, aims at uncovering the essential qualities of the relationship between the mind and the world through epoché and phenomenological reduction, which can be conceptualized as practices of disciplined attending to the manner in which the world discloses itself to an experiencing subject.

What emerges from such disciplined attending to one's own mental processes are invariants of knowledge about the world and ourselves, invariants that are not externallyvalidated objective things that exist independently in the world, but instead "unities of sense" (Husserl 1913 (1982), p.129), that are bound together not by an objective natural law, but by their being experienced through the subject's intentional stance toward the world. The phenomenological method, achieved through phenomenological reduction, is not a 'reductionist' method, but rather an inductive practice of systematic "seizing upon, analysing and describing generic essences" (Husserl, 1913 (1982), p.169), and developing an intuition in deliberate relationship with the phenomena.

While in early works such as *Logical Investigations* and *Ideas* Husserl posits his phenomenology within a significant distance from natural and psychological sciences of the time, in later works, such as in *Analyses Concerning Passive and Active Synthesis* he states that the underlying ambition of the phenomenological method is to lay the philosophical foundation for a science of consciousness. He writes, in relation to the phenomenon of thinking: "And thus I set the task (…) to open up this expansive, great world of the interiority of consciousness and under the guiding point of a theory of science" (Husserl, 2001), p.32). This ambition further develops into a call for the genetic "transcendental sciences" (Husserl, 2001, pp. 271-272) of nature, space, time, psychology, physiology, etcetera. As Depraz sums up, "… for Husserl, the categorical *specificity* of phenomenology derives from the specific form of its eidetics; its *radicality* from the transcendental *epoché*, its experiential *individuation* from the reflective conversion" (Depraz, 1999). Thus, Husserl laid the basis for the contemporary philosophy of embodied cognition by shifting the focus from an objectivist position on science, which presupposes a detached, objective stance toward the world as something other, to situating the epistemology of the experiencing subject right there, always already in a relationship with the world. Through the practice of phenomenology, this habitual entanglement loses its unreflective grip, and it becomes possible to uncover essential qualities of the relationship between the subject and the world, and between elements of the world.

1.2.1.2. Phenomenological conception of the embodied mind

Husserl developed a view of the experiential subject as embodied and in reciprocal relationship with the lifeworld: "a thing 'inserted' between the rest of the material world and the ‘subjective sphere” (Husserl, 1982). Arguably, he did not elaborate sufficiently on the significance of bodily intentionality. Merleau-Ponty, on the other hand, bases his phenomenology on the centrality of the body as the site of experience, sense-making and being-in-the-world. In fact, *être au monde* can be translated not only as being-in-the-world, but also as being-of-the-world, indicating the essential inseparability of the individual body and the environment, the concept that he articulated as the flesh of the world (*la chair du monde*). In the words of Merleau-Ponty: “my body is made of the same flesh as the world (…), this flesh of my body is shared by the world, the world *reflects* it, encroaches upon it and it encroaches upon the world” (Merleau-Ponty, 1968): 24).

For Merleau-Ponty, the absolute phenomenological reduction is impossible, and he offers the reflective analysis as an alternative. He does not reject reduction altogether, however, but rather he conceives of the subject of experience as an opaque being, never quite transparent to themselves: “ambiguity is of the essence of human existence (…), existence is indeterminate in itself, by reason of its fundamental structure” (Merleau-Ponty, 2012: p.169). It is not surprising, therefore, that he states: “the incompleteness of reduction … is not an obstacle to the reduction, it is the reduction itself …” (Merleau-Ponty, 1968: 178). This indicates that in Merleau-Ponty’s work, nothing in experience can be completely explained away or ever seen in its entirety. What is more, the experiencing subject, the scientist, can never quite completely be aware of their own stance toward the world. This, however, is not necessarily an obstacle for phenomenology, but rather a constitutive feature of how experience is structured.

The reflective analysis of Merleau-Ponty reveals the subject to be an embodied, engaged being in the world, oriented, geared towards other objects and people. Use of the word sense (*sens*) in his work is revealing: it denotes at once meaning and orientation. The sensorimotor basis of consciousness, characteristic also of the contemporary schools of embodied cognition and of neurophenomenology, is discussed at length in his *Phenomenology of Perception*. By substituting the Cartesian “I am” with the Husserlian “I Can”, Merleau-Ponty posits the moving, sensing and sense-making body in an active and engaged, intentional relationship with the world. On a practical level, the body is no longer a “dumb machine”, it is not an object of analysis but rather is a subject of reflection. A fully external, transcendental constituting consciousness is not possible, but by starting from the ambiguity and opacity of experience, by reflecting on the way the world discloses itself, one can “rediscover, as anterior to the ideas of subject and object, that primordial layer at which both things and ideas come into being” (Merleau-Ponty, 2012: 219).

In sum, the phenomenological reflection proposed by Merleau-Ponty allows for discovery of the dynamics of consciousness in relation to the world and from within the world. This consciousness is not an abstract disconnected entity that just happens to inhabit the body, but rather it *is* the body in the way that the body relates to the world. In the words of Gallagher and Zahavi, the practice of phenomenology is about “how we are immersed in our everyday situations and projects, how we experience the world, relate to others, and engage in the kinds of actions and practices that define our lives” (Gallagher & Zahavi, 2012), p.28).

1.2.1.3. Dreaming in phenomenology

Dreaming has been largely absent from these early phenomenological works and thus the notion of dreaming as rooted in bodily experience has languished. Most phenomenological analyses of dreams, albeit fragmented, concern the issue of whether dreaming is perception or imagination, thus addressing Descartes’ famous sceptical argument that dreams are so compelling that it is impossible to distinguish them from reality, which led him to question the very nature of sensory perception (Descartes, 1996).

Husserl devoted very little attention to dreaming, essentially equating dreaming to activities of imagination (as opposed to perception), of bringing to mind something that is not real, and thus not experienced in any perceptual richness (de Warren, 2012; Husserl, 2006; Zippel, 2016). More recently, however, de Warren (2012) offered an alternative reading of Husserl’s position on dreams, suggesting that while dreams may be experienced as real, there is a sense in which the dreamer is pre-reflectively aware (even if not lucid) on a fundamental level, of the fact that he/she is dreaming, and that, while compelling, the dream experience is experientially different from that of waking experience.

The most detailed account of dreaming in phenomenology is found in Sartre, who posited that because dreams are experienced as real, in dreaming the reflective capacity is absent and thus dreams are fictional worlds, closed in on themselves (Sartre, 2005). These fictional worlds charm and seduce the dreamer into believing in them and accordingly have a deceitful quality (Fowler, 1956). Thus, dreams operate on the level of fascination and enchantment and force the dreamer into submission to its own imagination (Kearney, 1998). In Sartre, there is a sense of fatalism in not being able to escape the way that the mind is able to turn the real (experiences and memories) into the unreal.

While in Merleau-Ponty the treatment of dreaming is also fragmentary, in passing he offers important reflections not only on the debate about whether or not dreaming is imaginary or perceptual in quality, but also on how to integrate dreaming subjectivity with the physical body. In his discussion of the sense of space, he uses the example of dreams as illuminating the constitutive nature of spatiality for experience (Merleau-Ponty, 2012). In Merleau-Ponty's writing, space is a relational quality of our connection to the world and to everything in it. Further, for Merleau-Ponty, it is through the living and moving body that our experience of space and time are actualized (Morris, 2004), thus the spatiotemporal nature of dreaming is emblematic of the very fundamental way that we embody the world (Morley, 1999). The body in sleep is not an external element, temporarily bracketed from experience, but rather is the very manner by which dreams exist as a certain relation to the world, the body is the "subject of dreams" (Merleau-Ponty, 2010). The task of the phenomenologist, therefore, is to discover the intentionality of dreams. Furthermore, Merleau-Ponty considers dreams to be poetic manifestations of not only one's existential position but also of ongoing physical states, such as desire and breathing. Consider the following passage from *Phenomenology of Perception* as an illustration of the kinds of subtle interplay between the sensing sleeping body and the dreaming mind:

> "The dreamer lends himself entirely to the bodily facts of breathing and of desire and hence infuses them with a general and symbolic signification to the point of only seeing them appear in the dream in the form of an image – such as the image of a giant bird that glides and that, hit by a bullet, falls and is reduced to a small pile of burnt paper. We need to understand how respiratory or sexual events, which have their place in the objective space, detach from

> that space in the dream and are established within a different theater" (Merleau-Ponty, 1945/2012: 297).

Merleau-Ponty does not draw a sharp line between waking and dreaming experiences and links dreams, much like Freud before him, to processes of creativity, mythology and artistic practices. Sleep and dreaming, can be seen as processes that require a special kind of an existential step – a transition into becoming a sleeper. One does not just "fall asleep", i.e. passively change a state of consciousness, rather, one "lends herself to sleep" (Merleau-Ponty, 2010) by engaging, bodily, in a ritualized practice of opening up to dreaming. The world and the body are not absent in or negated by sleep, rather, dreaming consciousness continues to anchor itself in body and world. Further, not only do dreams have wake-like perceptual qualities, but according to Merleau-Ponty, waking consciousness has oneiric characteristics in the way that one relates to and makes sense of one's lived experiences.

In sum, although phenomenologists have only rarely and somewhat indirectly targeted dreams, insights from the work of Husserl and Merleau-Ponty are useful in illuminating qualities of dream formation that are not usually targeted by cognitive sciences. This is especially true for the notions of embodiment, sense-making and intersubjectivity that inform this dissertation and provide an alternative to the Cartesian mechanistic approach to dreams so prevalent in contemporary neuroscience. Further, insights into dreams as embodied and meaningful processes of imagination that these philosophers supply help to better contextualize the discussion of dream formation, spatial and social cognition during sleep paralysis, and the role of body and intentional practices in processes of memory consolidation. The work of Husserl and Merleau-Ponty continue to influence the development of contemporary iterations of the embodied mind proposition that will be discussed in the following sections and that constitute the theoretical grounding of the present work.

1.2.2. Embodied mind paradigms in cognitive science

Cognitive science, including sleep and dream science, generally focuses on mental phenomena as somewhat separated from the body (Thagard, 2014). Much of the cognitive science, is strongly influenced by its roots in Wundt's experimental psychology, behaviorism, and early work on artificial intelligence. This frequently colors the interpretation of findings concerning cognition, thought, intelligence and other mental processes, as these are often seen as processes of information treatment by the brain and in the brain – constituting a so-called "embrained" (Damasio, 2000) view of the mind. From this view, the body plays only a peripheral role as a "dumb machine" (Morris, 2010). This sharp separation between body and mind, so prevalent in philosophy and science, can be traced back to Plato (1973) and, in its modern form, to Descartes (1996), who posited a dualism between two categorically different substances, between body as matter and mind as an immaterial substance.

Much of current cognitive science inherited what is often referred to as Cartesian prejudice in some sort of implicit or explicit form, and thus treats various cognitive processes as relatively independent systems. The mind, then, creates a representation of external reality (Lycan, 1987). And if visual perception, thought and language in an awake and engaged individual are dependent on the neural events that interface with stimuli from outside world, then the sleeper is nearly entirely disconnected from this world (Hobson, Pace-Schott, & Stickgold, 2000; Rechtschaffen, 1997). For sleep and dream science this means that the prevalent view of mental events in sleep is one of a hallucinatory activity, a sort of a simulation of a world in absence of body and environment. Consider the following illustrative passage from Revonsuo:

> "The conscious experiences we have during dreaming are isolated from behavioural and perceptual interactions with the environment, which refutes any theory that states that organism-environment interaction or other external relationships are constitutive of the existence of consciousness" (Revonsuo, Tuominen, & Valli, 2016).

It is not surprising, then, that in current dream neuroscience, dreams are often referred to as "simulations" (Domhoff, 2011b; Revonsuo, 2006; Revonsuo et al., 2016; Tart, 1987) of a world, using a computer-based metaphor of a virtual reality, which run similar to software while the sleeper is "offline"(Wamsley & Stickgold, 2010; Wamsley, Tucker, Payne, Benavides, & Stickgold, 2010). In the following sections I challenge this view of dreams as passive hallucinatory experience presenting, first, a review of approaches that support the embodied mind notion in a general sense (4EA cognition) and, then, the proposal that dreaming in particular relies upon embodied and enactive processes of spontaneous imagination (section 1.2.4 and Article I).

1.2.3. Embodiment and the core propositions of the 4EA cognition

Recent embodied mind theories are often collectively referred to as the 4E (Menary, 2010) or even the 4EA (Protevi, 2010) theories of cognition. Ever since publication of *The Embodied Mind* by Varela, Thompson and Rosch (1992), ideas concerning inseparability of the mind from the body and world have been adopted with increasing frequency by cognitive scientists and have formed the basis for a number of theoretical and experimental research programs; most of these include the 4EA cognition and neurophenomenology approach. The 4E acronym refers to cognition being *embodied*, *extended*, *enactive*, and *embedded*; and the A in 4EA refers to *affective*. The 4EA framework consists of a mosaic of loosely related theories that are sometimes in contradiction with each other, but which share a common general orientation toward a non-reductive and a non-dualist view of the mind. By these views, the subject is an active participant in the construction of meaningful experiences that involve the body, the world and other people. The core tenets of 4EA-oriented scholars can be summarized as follows:

- The mind is <u>embodied</u>: development of individual subjectivity is dependent on the physical properties of the organism's body, including the sensory apparatus, perceptual capacities, and its history of sensorimotor coupling with the world (Gallagher, 2005; Thompson, 2007; Varela et al., 1992).
- Consciousness does not belong simply to the mind, but can be <u>extended</u> into the world in such a way that the environment itself becomes part of the cognitive activity. The world with its meaningful objects and tools (e.g., musical instruments, dictionaries, the internet) provides scaffolding through which mental processes are realized (Chalmers & Clark, 1998; Rowlands, 2010).

- Embeddedness refers to the position that the cognitive capacities of the embodied organism are ontogenetically adapted to that organism's environmental niche, which provides it with particular physical and social affordances (Albers, 2008; Gibson, 1977; Stotz, 2010).
- The enactive approach stresses that cognition is embodied action. The organism is not a passive receiver of information from the environment, but an active and motivated agent engaged in a process of skillful sense-making (Noe, 2006; Thompson, 2005, 2007; Thompson & Stapleton, 2009; Varela, 1999; Varela et al., 1992).
- There is no separation between cognition and emotion. Affective processes are a fundamental property of all cognitions, sensations and perceptions, and the mind is an integrated cognitive-affective system (Colombetti, 2009, 2013; Colombetti & Thompson, 2005; Pessoa, 2013).

1.2.3.1. Enactivism: embodied sense-making

Sleep and dreaming provide an intriguing challenge to the 4EA in general and to enactivism in particular. When asleep, the individual seems to be disconnected from the world and only minimally responsive behaviorally to outside stimuli. This would seem to suggest that sensorimotor subjectivity is not essential for the constitution of dream experience. If it is not necessary for dreaming, it follows that it may also not be necessary for subjective experiences of wakefulness. Dreaming, then, could be seen as a test case for examining 4EA theories.

Enactivism is a recent approach to the mind that is influenced by phenomenology and that and integrates findings from such diverse fields as cell biology, psychology, systems theory and cognitive neuroscience. The view rejects a strong representational approach to the mind, instead stressing it as a process of sense-making by an embodied organism that is embedded in the world. Some key characteristics of the enactive approach to cognition are rooted in sensorimotor engagement with the world: autonomy, primacy of experience, embodiment and sense-making (De Jaegher & Di Paolo, 2007; Noe, 2006; Stewart, Gapenne, & Di Paolo, 2010; Thompson, 2005, 2007; Varela et al., 1992).

Thompson and Stapleton (2009) define sense-making as "behaviour or conduct in relation to environmental significance and valence, which the organism itself enacts or brings forth on the basis of its autonomy" (Thompson & Stapleton, 2009: 25). This implies that there is no sharp separation between behavior, cognition and affect, and that a living organism is always emotionally and motivationally attuned to their world (Colombetti, 2009, 2013; Colombetti & Thompson, 2005; Pessoa, 2013). In other words, a living being is never neutral or indifferent to their world but is always a part of it through their physical embodiment and active interaction. According to the enactive perspective, the mind is a process rather than a thing, and that process is a developmental achievement or a *know-how* of being in the world (Varela, 1999). This notion of sense-making is useful for conceptualizing dream embodiment and navigation of the dream world. It implies that the patterns of interaction with the real environment that are developed via meaningful (e.g., attractive or repulsive) interactions with the world, are not situated anywhere outside of the organism, but rather are rather constituents of the mind itself. In a sense, due to its history of structural coupling with the world, an organism becomes a model of that world (Varela et al., 1992). That model is not just a collection of explicit or declarative memories and knowledge about the world, but is also a style of relations between the self and several physical, social and symbolic domains. Thus, enactivism provides a rich and non-reductionist framework for dream science, whereby dreams can be approached not as hallucinatory, bottom-up, misperceptions of the sleeping brain, but as processes of embodied enactive imagination (Thompson, 2014).

The principal notions of the embodiment influence on my research program are illustrated in the following passage from *The Embodied Mind:*

> "By using the term *embodied* we mean to highlight two points: first, the cognition depends upon the kinds of experience that come from having a body with various sensorimotor capacities, and second, that these individual sensorimotor capacities are themselves embedded in a more encompassing biological, psychological and cultural context" (Varela, Thompson & Rosch, 1991: 173)

The enactive view stipulates consciousness as neither a passive computational process nor an epiphenomenal feature of brain activity. Rather, it is a dynamic temporal process of sense-making (Thompson & Stapleton, 2009) that involves the whole embodied organism, its relationship with the world, intentionality (the *aboutness* of consciousness), and the way in which subjectivity is geared towards certain features/qualities in the world in a meaningful way. In addition to consciousness being a dynamic temporal process (Thompson, 2014; Noe, 2009), it is also a developmental and skillful activity. Perceptual actions are motivated by internal states of the organism and are also mediated by previously acquired perceptual knowledge of the world (O'Regan & Noe, 2001). In other words, our interactions with the world are constantly shaped and changed by our acquired expertise in dealing with the world; perception is thus a particular kind of know-how (Varela, 1999).

Recent developments in enactive cognition help expand the discussion of dreams as solitary and personal experiences into dreams as skillful interactions with the landscape of affordances. Additionally, mental life, including perception, imagining, and dreaming, has been conceptualized as a set of intersubjective, shared and collective practices. This is especially the case for authors who focus on an eco-enactive approach to skilled intentionality (Bruineberg & Rietveld, 2014; van Dijk & Rietveld, 2016); on socio- cultural affordances (Ramstead, Veissiere, & Kirmayer, 2016); and on participatory sense-making (De Jaegher & Di Paolo, 2007).

With exception of Thompson (2014), dreams have not been explored systematically by enactivist scholars. Noe, for instance, posits that dream experience may be produced by neural activity alone, that dreams are not experienced as realistic, and that dreams are unstable and perceptually weak precisely because the engagement with the world is lacking (Noe, 2006). However, Block (2005a) and Clark (2012) object to such a characterization of dreaming, suggesting instead that dream experience, like memory, inherits some of the perceptual habits that characterize waking sensorimotor engagement with the world. If one can imagine a setting and an activity in a realistic and compelling way, there is no reason why one could not dream it as well. Thompson (2014) proposes that dreaming is a process of enactive imagination, wherein the dream ego is fully immersed in the ongoing experience, and the actual self has little or no awareness of being physically in bed (with the exception of sleep paralysis and lucid dreaming among other anomalous states). According to Thompson, this complete immersion does not signify that dreaming constitutes a distinct state of consciousness. Rather, it is a process of spontaneous imagination, which is very similar to waking imagination, that is sometimes deliberate and sometimes spontaneous, e.g., day-dreaming, mind-wandering or reverie. Subjective involvement in the dream-world is immersive and realistic precisely because this is a habitual way in which we experience ourselves as subjects in the world. This connection between dreaming and waking processes of mind-wandering have been suggested by a number of authors (Domhoff, 2011b; Domhoff & Fox, 2015; Fox, Nijeboer, Solomonova, Domhoff, & Christoff, 2013), including Hartmann, who placed dreams on a continuum of mental experiences that includes imagery, fantasy, day-dreaming, creativity and imagination (Hartmann, 1996).

Articles I and II of the present dissertation aim to further situate dreaming within the context of embodied mind and enactive cognition approaches. Following Thompson (2014), I suggest that dreams are processes of imagination that embody skillful activity that has developed through repeated sensorimotor and meaningful relationships with the waking world.

1.2.4. Embodiment and dreams

Many positions exist about the relationship between bodily experience and dream content. On one hand, the dreaming individual is largely immobile and appears to be disconnected from the environment all the while living through an immersively rich experience. In this superficial sense, dreaming appears to be a disembodied process and it is understandable why, in many religious and spiritual traditions, the dreamer's soul was thought to leave the body and travel to other dimensions (Bulkeley, 2008). On the other hand, dreams have often been thought of as a means for understanding physical states, even used as diagnostic tools. For example, dreams were traditionally used as instruments of diagnosis and prescription in the incubation cults of ancient Greece (Oberhelman, 1981). Contemporary views of how dreaming is related to bodily experience reflect these same two positions. Some scholars claim that dreaming is a mentally generated virtual reality, a purely brain-based simulation of the real world, while others posit that the physical body plays a constitutive role in dream formation. The following section will elaborate upon the second of these positions in reviewing four different facets of dream embodiment, especially focusing on an enactive perspective on dreams. Specifically, dreams can be characterized as embodied in the following four ways: 1) through references to one's own body and stimuli incorporation; 2) in examining the role of the body in lucid dreams; 3) by clarifying the role of emotion and affect in shaping dream mentation; and 4) by means of examples of body connection in cases of intensified dreams and parasomnias.

1.2.4.1. Explicit references to body and somatosensory incorporation

Windt reviews evidence for the sense of being a body in the dream, and concludes that while the dreaming body is not entirely disconnected from the physical sleeping body – as can be learned from studies of sensory incorporation into dreams – and while the body may anchor some of the aspects of dream formation, it could still be phenomenally absent in some kinds of dreams. Importantly, she argues that having a strong sense of being embodied is not necessary for an experience of being a self in a dream. Windt proposes that degrees of embodiment in dreams can be represented on a continuum whereas some dreams can be characterized by phenomenal disembodiment, phenomenal indeterminacy, and by weak and strong phenomenal embodiment (Windt, 2015: 338). According to her *weak-phenomenal-embodiment hypothesis* (WPEH): "The dream self, in a majority of dreams and for a majority of dreamers, is phenomenally embodied only in a weak sense that is predominantly associated with movement sensations, specifically as are associated with individual body parts rather than the whole body" (Windt, 2015: 339). In a similar vein, Koppehele-Gossel and colleagues (Koppehele-Gossel, Klimke, Schermelleh-Engel, & Voss, 2016) propose that the representation of one's own body in the dream state essentially creates a prototypical and stable minimal virtual body schema, a *mini-me*.

Explicit references to such bodily experiences as touch, pain, etc. are relatively rare in spontaneous dream reports. However, experimental studies clearly demonstrate that such experiences are within the representational capacity of dreaming—and perhaps more common than previously thought. In one study (Nielsen, McGregor, Zadra, Ilnicki, & Ouellet, 1993), pain was found to be reliably (in 31% of 42 stimulation trials) incorporated into the dream content, both directly as sensations of pain and indirectly as negative affect or as pain metaphors, such as dreams characterized by anger. Research on such populations as pregnant women, burn victims and psychosomatic patients also shows that particular bodily conditions manifest in dream content. In pregnant women, a high incidence of references to pregnancy and overall preoccupation with body parts is seen (Lara-Carrasco, Simard, Saint-Onge, Lamoureux-Tremblay, & Nielsen, 2013) A high incidence of incorporation of pain was also found in burn victims (Raymond, Nielsen, Lavigne, & Choiniere, 2002) and, in psychosomatic patients, repetitive traumatic dreams with injury to the body of the dreamer were reported (Levitan, 1980). These examples reflect that transient preoccupations with bodily states (such as pregnancy or burns), often occur in dream content in direct forms, but sometimes also in indirect or metaphoric forms.

Some evidence for body influences on dream content comes from incorporation/stimulation studies that have produced both direct and indirect instances of body representations in dreams. In early studies, Dement and Wolpert (1958) sprayed jets of water on the skin an influenced dream content, Koulack (1969) applied electric pulse stimulations to the same effect, and Wolpert (Witkin & Lewis, 1967) used pre-sleep induced sensation of thirst, with mixed effects. Cubberley (1923) used tensors and oils on the surface of the skin and found a variety of changes in the dream content, ranging from direct incorporations of the stimulated limbs to more subtle, seemingly unrelated changes (e.g., change of body posture). Maury's famous dream of being guillotined (Maury, 1878) during the French Reign of Terror[1] is often cited as an example of a direct incorporation of a kinesthetic sensation into the dream content (headboard of the bed falling on his neck), both interfering and co-shaping the ongoing dream narrative. In studies of sleep onset (hypnagogic) dream imagery (Nielsen, 1991, 2017a), body posture was found to make its

[1] "He was ill in bed; his mother was sitting beside him. He dreamed of the Reign of Terror during the Revolution. He witnessed some terrible scenes of murder, and finally he himself was summoned before the Tribunal. There he saw Robespierre, Marat, Fouquier-Tinville, and all the sorry heroes of those terrible days; he had to give an account of himself, and after all manner of incidents which did not fix themselves in his memory, he was sentenced to death. Accompanied by an enormous crowd, he was led to the place of execution. He mounted the scaffold; the executioner tied him to the plank, it tipped over, and the knife of the guillotine fell. He felt his head severed from his trunk, and awakened in terrible anxiety, only to find that the head-board of the bed had fallen, and had actually struck the cervical vertebrae just where the knife of the guillotine would have fallen" (Cited in Freud, 1900/2010, 58-59)

way into and to modify the imagery, often in surprising and indirect ways. In one study of somatosensory stimulation with inflated blood pressure cuffs during REM sleep (Nielsen, 1993), both indirect metaphorical 'projections' of the stimulated body part were found (such as changes in another character's body part), and more direct bodily and vestibular sensations (such as tingling or pressure in the stimulated leg). Indirect stimulus incorporation was also demonstrated (Schredl et al., 2009) when olfactory stimulation during sleep (presentation of pleasant and unpleasant smells) systematically changed the emotional tone of dreams (to positive vs. negative affect).

In addition to external stimuli, internal physical states have been seen to influence dream content. For example, dreams of individuals with epilepsy have been associated with changes in body experience, e.g., in alterations in the perceived size of limbs or even in mistaking objects for body parts (Epstein, 1967). Some medications, such as antiretroviral drugs (Abers, Shandera, & Kass, 2014) or selective serotonin reuptake inhibitors (Pace-Schott et al., 2001), can cause dream intensification. Similarly, a class of dream experiences known as prodromal dreaming, refers to measurable changes in dream content that foretell progression of an illness, such as chronic cardiac disease (Garfield, 1991; Smith, 1987) or breast cancer (Burk, 2015).

Based on evidence that sensory experiences are often indirectly incorporated into dream content, Windt proposed that these dream experiences are akin to "illusory or distorted perceptions of the sleeping body" (Windt, 2015:386). This notion illustrates the incomplete permeability of the sensory and perceptual boundary between the sleeping and dreaming bodies. Indeed, only rarely are sensations, sounds and smells incorporated into dream content directly; the lack of a general isomorphic relationship between the sleeping and dreaming bodies has prompted many scholars to abandon research on sensory incorporation in dreams altogether. However, evidence suggests that bodily incorporations in dream content are more frequent than previously thought. Dreams incorporate bodily sensations mostly in indirect ways, but, based on the literature, it appears that: 1) body dreams of all kinds are well within the representational capacity of dreaming; 2) most body-related dreams are likely to be indirect in nature; and 3) research participants are possibly less likely to report bodily and somatic aspects of dreams due to the general audio-visual bias in reporting any experience.

1.2.4.2. Role of the body in lucid dreams

Some studies of lucid dreaming (dreaming characterized by metacognitive awareness of being in a dream and possessing a limited degree of control over dream events) further strengthen the notion that there is, under some conditions, a strong direct link between the sleeping and dreaming bodies. LaBerge and his colleagues demonstrated that lucid dreamers can signal the fact that they are dreaming directly from REM sleep (La Berge, Nagel, Dement, & Zarcone, 1981). During REM sleep, inhibition of postural muscles (REM muscle atonia) prevents the acting out of most dream movements (Peever, Luppi, & Montplaisir, 2014). Not all volitional movements are inhibited however; the rapid eye movements of REM sleep resemble waking state saccades (Aserinsky, Lynch, Mack, Tzankoff, & Hurn, 1985) and can be controlled during lucid dreaming. Thus, dreamers are able to communicate their lucidity to experimenters by performing eye movements in a predetermined pattern (LaBerge & Verified, 1990; Voss, Holzmann, Tuin, & Hobson, 2009). A number of studies have explored the limits of isomorphism between sleeping and dreaming bodily experiences. For instance, LaBerge and colleagues (La Berge et al., 1981) trained lucid dreamers to tap their initials in Morse code and had them repeat this while in a lucid dream state. The resulting EMG (electromyography, measure of muscle activity) signal showed detectable muscle twitches, corresponding to the Morse code movements. In another study, proficient lucid dreamers were asked to undertake physical exercises while in a lucid dream; physiological measures showed consequent increases in cardiovascular activity (Erlacher & Schreld, 2008). Similarly, in an fMRI study, relative activation of the sensorimotor cortex corresponded to dreamed hand movements during lucid dreaming (Dresler et al., 2011). In addition to these examples of dreamed movement “spilling over” into actual physical activity, body experiences play a special role in attaining and maintaining lucid dream states. Looking at one’s own hands and engaging in intense bodily activities, such as spinning or flying, are some of the techniques used by lucid dreamers to induce or stabilize the state of lucidity and avoid waking up (LaBerge & Rheingold, 1991).

In sum, some theories of dream embodiment, such as Windt's WPEH or Koopehele-Gossel's *mini-me*, point to the idea that body-as-object (experienced as explicitly having a body either by feeling/seeing it or through movement) is present in the dream in a rather schematic way, is not very sensitive to sleeping body distortions, and functions as a sort of a generalized site of the first-person experience. Some examples of intensified dream experiences, however, such as in case of lucid dreams, show that it is possible to have a direct and isomorphic relationship, albeit attenuated by muscle paralysis in sleep, between activities of the dream body and subtle expressions of autonomic arousal and muscle activity in the sleeping body.

1.2.4.3. Enactive dreaming: minimal self, affect and intensified dreaming

From an enactive embodied perspective, the absence of explicit references to the body or its parts in a dream report does not necessarily signify that the dreamer`s experience lacks all features of embodiment. In phenomenology and enactivism theory the very emergence of subjectivity is dependent on an active, embodied, sensorimotor engagement with the world. Thus, dreaming can be seen as akin to processes of imagination, which is based on memory of our engagement with the world (Thompson, 2014). Dreaming is lived from a first-person habitual perspective and incorporates body schema and affective engagement with the world, suggesting that qualities of embodiment may be altered but are not lost in dreams.

At a minimum, one might argue that the dreamer is embodied because all dream experience is lived from a first-person point of view (Windt, 2015), which is the view from somewhere (i.e., a spatial location, even if it is an uncertain one for the purpose of dream report), and appears to someone, has the *myness* quality (Zahavi, 2000). The dreamer has a particular spatio-temporal perspective on the dream experience. In that very minimalistic sense, even in dream experiences that are described as abstract, minimalist or unclear, the general structure of intentionality appears to be preserved almost by definition: the dreamer has a sense of the dream experience as *her* dream experience, whether or not she had a sense of involvement, was present as an observer or had a determinate location within the experience. Even in cases such as out-of-body experiences (OBE), where the dreamer can see their own body as if from the outside, there is still a first-person perspective, a particular location in space from which the scene is experienced. Further, we have no difficulty imagining our own bodies as outside observers (Thompson, 2015:211), since we already have a relationship to them as objects of awareness, enhanced through imagery we encounter via mirrors or photo-video documentation. Thus, in OBEs we experience an altered self-image, but it is still an experience from somewhere and for someone. De Warren too (2012) argues, from the point of view of Husserlian phenomenology, that the dreamer is pre-reflexively self-aware (not in the lucid dreaming sense, i.e. not aware of the fact that it is a dream), and moreover, has a certain sense that dream rules are not quite the same as waking life rules, considering that a nightmare does not quite reach the same level of fear and terror as a waking experience.

With regards to body schema, research on the dreams of amputees has revealed presence and use of missing limbs while dreaming (Alessandria, Vetrugno, Cortelli, & Montagna, 2011; Brugger, 2008; Mulder, Hochstenbach, Dijkstra, & Geertzen, 2008). Similarly, in paraplegic patients' dreams voluntary movements, such as walking, running and dancing, were found at a high rate (Saurat, Agbakou, Attigui, Golmard, & Arnulf, 2011). While these experiences are often interpreted as evidence for some form of a representation of a body schema that is invariant and stable in the brain, from an enactive view of dreaming as process of imagination, such dreams signify that, just as it is possible in wake to imagine oneself as missing a limb or having a different body, in dreams bodily and world affordances allow the mind to explore alternative ways of being (not only as in having a different body, but also in flying or being someone else).

1.2.4.3.1. Dream embodiment through emotion

The corporeal and irreducible nature of affect, emotion and experience has been proposed in a number of theories, such as psychoanalysis or the James-Lange theory of emotion (James, 1884) and is currently under consideration by scholars in affective neuroscience and affect theory in the humanities. The current affective neuroscience movement links affective and emotional states with processes of neuroplasticity, development, maturation, empathy and learning. Colombetti's work on affect and enaction

(Colombetti, 2013), Prinz's pure somatic theory of emotions (Prinz, 2004), and Pessoa's cognitive-emotional brain science (Pessoa, 2013) are all representative of current developments in the study of deep relationships between affect, cognition and the body. The nature of dream embodiment through affect was noted in particular by Freud. In the *Interpretation of Dreams* (Freud, 1900/2010) the latent source of dream formation is to be found in libidinal drives, repressed wishes and conflicts. At the root of these is the strong emotional charge that needs a form of expression in dream content that is safe and nonthreatening for the dreaming ego. In a similar vein, Rorschach and later Learner (Lerner, 1966, 1967) proposed that dream content is a form of kinesthetic fantasy: a somatic thought rooted in movement that creates dream imagery in other modalities, most typically in visual imagery.

Hartmann's theory of the function of dreams conveys the same theme, His theory is based on the notion of the Central Image, which is a condensed emotional locus of the dream (Hartmann, 1996, 2010b; Hartmann & Kunzendorf, 2007). The Central Image is a focusing, most salient element in the dream narrative that demands the dreamer's attention and involvement. Emotions in dreams are well-documented, with most dreams containing some kind of emotion (Hartmann, 2010b; Kahn, Pace-Schott, & Hobson, 2002; Nielsen, Deslauriers, & Baylor, 1991). The range and estimates of prevalence of negative and positive emotions in dreams vary between studies, as do the methodologies for sampling them (Domhoff, 2005). In one study, for example (Sikka, Revonsuo, Sandman, Tuominen, & Valli, 2017), dream emotional intensity differs for dreams collected early vs. late in the night, and in home dream diaries vs. laboratory-based awakenings, with the most intense dreams originating in home dream diaries and late REM sleep awakenings.

Intense existential dreams (Kuiken, 1995; Kuiken, Lee, Eng, & Singh, 2006; Kuiken, Rindlisbacher, & Nielsen, 1990) and nightmares (Nielsen & Lara-Carrasco, 2007; Nielsen & Levin, 2007) also illustrate the theme in that their content is structured around strong emotion. Evidence from the study of nightmares reveals an increase in sympathetic activity while in the dream state, as well as altered pattern of heart rate variability (Nielsen et al., 2010). Whether the body state is causally related to the intensity of the dream content in a top-down, experiential way is a question open to interpretation. In a recent laboratory study of nightmare sufferers (Carr, Blanchette-Carriere, Solomonova, Paquette, & Nielsen, 2016) that affect intensification was not restricted to dysphoric dreaming experiences, but was also characteristic of positive mind-wandering experiences. In addition, nightmare sufferers showed higher levels of bodily arousal in both dreaming and daydreaming experiences, suggesting a relationship between intense emotional dream experiences and heightened perception of bodily states.

1.2.4.3.2. Embodiment in parasomnias and intensified dreams

The embodiment inherent in intensified dreaming experience is richly illustrated in the anomalous sleep experiences referred to as parasomnias. These are often accompanied by vivid mentation and vigorous motor behaviours (Montplaisir, Gagnon, Postuma, & Vendette, 2011; Zadra & Pilon, 2011) and are sometimes described as disorders of arousal because they occur during transitions between sleep and waking. Accordingly, their electrophysiology is likely to show a state characterized at the same time by sleep- and wake-related activity. Some parasomnias, such as REM sleep behaviour disorder (RBD), sleep paralysis and dream-enacting behaviors attest to the direct connections that can occur between the sleeping and dreaming bodies. The acting out of intense and violent dreams in RBD (Manni et al., 2011; Montplaisir et al., 2011) is one of the most dramatic examples of an unwanted, possibly harmful bodily connection. Dream-enacting behaviours –non-pathological motor enactments of some of the aspects of dream experience common in the general population, including crying, talking, moving, etc.—(Nielsen, Svob, & Kuiken, 2009) are a more moderate expressions of this direct connection.

Sleep paralysis experiences, on the other hand, are a dramatic contrast to RBD enactments in that the dreamer *wants* to act, but is inhibited from doing so, and these feelings of inhibition aggravate an already unpleasant experience sometimes to the point of terror (Cheyne, 2005; Cheyne, Rueffer, & Newby-Clark, 1999; Solomonova et al., 2008). During sleep paralysis experiences, the dreamer is in a transitional state characterized by an overlap between REM sleep and wakefulness, cannot initiate volitional movements (is subjectively paralyzed by REM sleep muscle atonia), and may experience intense and frightening images, sounds and sensations, including a vivid sense of presence of someone or something sentient in the room (for a more detailed description of sleep paralysis experiences see Article II).

1.3. Sleep is a dynamic state, rich in subjective experiences

Sleep is a ubiquitous phenomenon in the animal kingdom, and is necessary for life (Rechtschaffen, Gilliland, Bergmann, & Winter, 1983). While its function(s) still remain(s) a mystery, most (if not all) physiological and psychological systems may well depend on sleep in some measure, and may be impaired by prolonged sleep deprivation. As for sleep's impact on the mind, a growing body of research converges on the idea that sleep is necessary for cognitive function in a number of ways that implicate expressions of embodiment during dreaming. Sleep is implicated in 1) memory encoding and consolidation (Abel, Havekes, Saletin, & Walker, 2013; Diekelmann & Born, 2010); 2) emotion regulation (Walker, 2009, 2010; Walker & Stickgold, 2010); 3) cognitive performance (Alhola & Polo-Kantola, 2007; Lehmann et al., 2010); 4) attention (Lim & Dinges, 2008), among others.

In the following sections, I will discuss several sleep-related factors of relevance to the current thesis that dreaming is an embodied experience; these will include some issues of pertinence for the sleep laboratory experiment reported in Article III. These include the basic principles of sleep neurophysiology, relationships between sleep and dreaming, varieties of dream experiences, and functions of dreams.

1.3.1. Sleep neurophysiology

To a casual observer, a sleeping individual may seem passive and immobile for the most part, and early views of sleep reflect this naïve position. Sleep was long considered to be a general state of oblivion, even a kind of mini-death. Invention of electroencephalography (EEG), by Hans Berger in 1920s (Haas, 2003) gave researchers a much closer, intimate view of sleep and marked the beginning of intensive empirical work by Kleitman and others. In 1953, EEG recordings helped lead to the discovery of rapid eye movement (REM) sleep (Aserinsky & Kleitman, 1953), which marked at one time the dawn of both modern sleep research and modern dreaming research. Since that time, there has been a steady linear growth in sleep research and a more sporadic growth in dreaming research up to the present day (Nielsen, 2011; Nielsen & Germain, 1998).

Currently, human sleep is typically separated into 2 main categories: non-rapid eye movement (NREM) sleep and REM sleep, which alternate on an approximately 90-minute ultradian rhythm throughout the night. NREM sleep is further subdivided into Stage 1 (or N1), Stage 2 (N2), and Stage 3 (N3: previously subdivided into Stages 3 and 4) slow-wave sleep (SWS). A typical sleep cycle early a night of sleep generally includes a sequence of N1 (first cycle only), N2, N3, N2 and REM. Subsequent cycles generally exclude N1 but may involve brief arousals with a return to sleep. Later in the night, sleep cycles may include only N2 and REM stages in alternation.

N1 sleep is typically considered a transitional period between sleep and wakefulness, normally occurring only at sleep onset (including in case of returning to sleep after nocturnal awakenings, commonly referred to as arousals), and is replaced by REM sleep starting with the second cycle of (normal) sleep (Iber, 2007; Rechtschaffen & Kales, 1968). Due to some similarities with REM sleep (rolling eye movements, desynchronized EEG with predominance of theta rhythms, and hypnagogic mentation), some researchers (Bodizs, Sverteczki, & Meszaros, 2008; Nielsen et al., 2005; Stenstrom, Fox, Solomonova, & Nielsen, 2012) consider N1 sleep closer to REM than to NREM sleep. Dream imagery in N1 has been described as abstract and fragmentary, but current research shows that it can very similar to REM sleep dreaming. The subjective dreamlike quality of N1 imagery increases with repeated awakenings (Stenstrom et al., 2012), and is more pronounced in participants who have been partially deprived of REM sleep the previous night (Nielsen et al., 2005). These findings suggest that the well-known pressure to replace lost REM sleep (REM pressure) may also be accompanied by a form of “dream pressure” that increases the subjective intensity (emotion, participation, vividness) of the dream experience. Memory sources for N1 dreams can be traced to as recent as the previous day experiences, and as distant as decades earlier (Stenstrom et al., 2012).

Later NREM sleep (N2, N3) is characterized by largely synchronous EEG waves (reaching their maximum synchrony in N3), high arousal thresholds, and relatively less recall of dream mentation. The microarchitectural EEG events that characterize NREM sleep are sleep spindles, K complexes and slow oscillations. N2 and N3 are differentiated primarily on the basis of what proportion of every 30-sec epoch is scored as containing delta in the EEG; <20% is considered N2; >20% is considered N3. REM sleep is differentiated from by virtue of episodes of rapid eye movements, combined with a desynchronized, almost wake-like, EEG and muscle atonia. The most vivid dreams and the most abundant dream recall occur after awakenings from REM sleep (McNamara et al., 2010; Nielsen, 2000).

While NREM and REM sleep are often viewed as discrete physiological states, there is evidence to suggest that they may be more fluid and overlapping processes. For example, sleep spindles and K complexes, characteristic of NREM sleep, may be present in REM, and, conversely, rapid eye movements may appear in NREM sleep. Based on such evidence, the Covert REM processes theory was proposed to account for the fact that dreaming can be reported from both REM and NREM sleep (Bodizs, Sverteczki, Lazar, & Halasz, 2005; Bodizs et al., 2008; Nielsen, 2000).

1.3.2. Sleep and dreaming

While dreaming has been reliably associated with REM sleep since the first characterization of that sleep stage (Aserinsky & Kleitman, 1953), it is now well established that many dream phenomena characterize NREM sleep as well (McNamara et al., 2010; Nielsen, 2000; Windt, Nielsen, & Thompson, 2016). Oneiric mentation is reported at sleep onset, from N2 sleep and even from deep N3 sleep. Furthermore, a variety of dream-like phenomena are associated with hybrid states, characterized by an overlap of REM or NREM sleep and wakefulness, such as acting out dreams (Godin, Montplaisir, & Nielsen, 2016; Nielsen & Kuiken, 2013; Nielsen et al., 2009; Valli et al., 2012), sleepwalking with recall of associated dreaming (Oudiette et al., 2009; Uguccioni et al., 2013), and sleep paralysis (Cheyne, 2005; Cheyne, Rueffer, et al., 1999; Sharpless & Barber, 2011; Solomonova, 2017). Such hybrid phenomena suggest that the relationship between sleep stage physiology and dream phenomenology is more nuanced and less deterministic than previously thought, and that the correlation between underlying neurobiology and lived experience may be weak.

Sleep mentation from NREM sleep and from parasomnia episodes, such as sleep paralysis or sleepwalking, has been referred to at times as hallucination rather than as dreaming, but many scholars agree that all types of mental activity in sleep are likely subserved by the same neurocognitive mechanisms (Cicogna, Cavallero, & Bosinelli, 1991; Nielsen, 2000). This does not imply that there are no significant phenomenological differences between, for example, REM sleep dreaming and dreaming during sleepwalking. There is a wide variety of possible experiences in sleep, just like there are many possible ways to be awake. Consider, for instance, experiential differences between daydreaming, writing, riding a bicycle, attending a religious ceremony, listening to music, or performing surgery: all these experiences are considered to be waking experiences, but it is clear that there are significant differences in vividness of experience, awareness of body or the environment, direction of attention, narrative complexity, emotional tone, and motivation.

Much of the neurocentric–i.e. equating consciousness with the activity of neurons – discourse focuses on dreams as hallucinatory phenomena: firmly located in the head, and epiphenomenal to sleep-dependent brain processes. Within this view, since dreams are *simulating* perception without any 'real' perceptual input, they are characterized as hallucinatory (Rechtschaffen, 1997). The hallucinatory view of dreaming gave rise to a number of theories equating dreaming with delusion and even proposing that rapid eye movement (REM) sleep and dreaming can be seen as a model for transient psychosis (Collerton & Perry, 2011; Gottesmann, 2006; Hobson & Voss, 2011; Limosani, D'Agostino, Manzone, & Scarone, 2011; Scarone et al., 2008). The dreaming-as-hallucination model is quite prominent and largely based on parallels in neurobiology of psychotic/delusional states and REM sleep, This idea is partially based on the relative deactivation of the dorsolateral prefrontal areas (DLPF) (Dresler et al., 2014), that coincide with the relative inability of the dreamer to appreciate that their dream is 'bizarre' or implausible in relation to waking life. Additionally, the fact that access to autobiographic memories is significantly weakened in dreaming, is often seen as further proof of dreaming-as-psychosis model, since the dreamer appears to lose a strong and coherent sense of self. Such a view sees dreaming as effectively disconnected from the dreamer's body, environment, context and memory. According to the AIM model (Hobson et al., 2000), all dream activity is epiphenomenal and dependent upon quasi-random "bottom-up" activation of the neocortex by REM sleep mechanisms. This view is a sharp contrast to the view of dreaming as embodied and enactive.

With regards to brain activity, work with the EEG consistently shows that specific patterns of brain rhythms, such as decreases in lower-frequency (delta) activity, irrespective of sleep stage, predicts the ability to recall a dream if a participant is awakened at that moment (Chellappa, Frey, Knoblauch, & Cajochen, 2011; Esposito, Nielsen, & Paquette, 2004; Scarpelli et al., 2017; Siclari et al., 2017). In other words, transient brain activity patterns, such as REM sleep and decreased delta activity, can be seen as strong enabling conditions for having and communicating a dream, possibly engaging attentional and memory capacities that are common to both sleep and wake. Furthermore, not recalling a dream upon awakening does not necessarily signify absence of experience, or of its phenomenal consciousness, but rather may mean that the experience was not available to access consciousness – the ability for metacognitive awareness (Block, 2005b). Moreover, the success of dream reporting depends on a number of factors: introspective capacity of the dreamer, attentional and motivational factors, and on what is considered as "dreaming" (likely referring to audio-visual immersive imagery) or "cognitive activity" (which would include thoughts, sensations and other phenomena) in a given culture (Foulkes, 1962; Nielsen, 2000). For instance, a trained individual, attuned to his/her oneiric life, could describe such experiences as white dreams (having dreamt but forget the content) or as an experience of pure subjective temporality in deep "dreamless sleep" (Windt, 2015b), or, even more radically, a sense of temporary "self-abstentation" or self-oblivion (de Warren, 2010). These latter non-imagistic kinds of experience escape the typical characterization of dreaming, and are typically disregarded as non-experiences or states of non-consciousness. Dreaming, therefore, has a potentially wide variety forms (like other conscious activity) and may not be reducible any distinct and sleep stage-bound neural correlate. It is even possible—albeit difficult to prove—that subjective experiences of some type continue throughout a night of sleep. Further, it may be that particular sleep processes facilitate recall and enhance specific sensory qualities of the experience. Windt proposes an inclusive approach, wherein the minimal requirements for dreaming are satisfied for as long as the experience is immersive and spatiotemporal (the immersive spatiotemporal hallucination model of dreaming) (Windt, 2010, 2015a).

In sum, sleep is a heterogeneous and dynamic process, characterized by a cyclical alternation of REM-NREM sleep stages. While REM and NREM sleep are characterized by different neurobiological signatures, they are both capable of supporting conscious experiences. Although dreaming has been traditionally associated with REM sleep, other sleep stages, especially N1 and N2, can also accommodate vivid and immersive sleep mentation. Furthermore, even from N3, claimed by many to be "dreamless sleep," it is possible to elicit reports of oneiric experiences that range from subtle sensations of "pure temporality" to complex sleepwalking experiences. Therefore, contrary to the widely accepted view, mental life in sleep cannot be isolated to a single sleep stage, i.e., REM sleep.

1.3.2.1. Sleep paralysis

Sleep paralysis is particularly relevant for the study of relationships between dreaming and embodiment for two principal reasons: 1) it is characterized by an overlap between dream mentation and waking consciousness, in particular, of REM-related muscle atonia during a wake-like state; and 2) its most striking subjective qualities are of a bodily nature, feelings of muscle paralysis, intense emotion and the nearness of other entities in particular. While Article II focuses in more detail on sleep paralysis experiences, the following section illustrates some of the most salient findings about paralysis in relation to dream embodiment.

Sleep paralysis is a vivid and a relatively prevalent experience occurring during transitions between sleep (at sleep onset or upon awakening) and during which the dreamer is unable to move. Sleep paralysis is a symptom of narcolepsy – a sleep disorder that involves REM sleep dysfunction, sleepiness and cataplexy. However, the most prevalent variant of sleep paralysis is a non-clinical presentation often referred to as isolated sleep paralysis (Sharpless & Barber, 2011; Terzaghi, Ratti, Manni, & Manni, 2012). During bouts of sleep paralysis, the individual is sometimes able to open the eyes and to be simultaneously aware both of her surroundings and of dream-like mentation. Sleep paralysis dream experiences may be accompanied by imagery in all modalities. Visual experiences range from ambiguous and unclear impressions to clear and vivid pseudo-hallucinations. Auditory experiences include mechanical or electric noises or human and animal voices; tactile experiences may occur in the form of unusual sensations (such as vibrations or pressure) or as feelings of touch or even assault (Cheyne, 2005; Cheyne, Rueffer, et al., 1999). However, the most impactful experience of sleep paralysis is felt presence – a distinct sensation that some animate entity (human or non-human) is present in the vicinity of the dreamer (Cheyne & Girard, 2007 ; Nielsen, 2007; Solomonova, Frantova, & Nielsen, 2011).

Felt presence experiences during sleep paralysis are often experienced as threatening and of supernatural origin (Hufford, 1989, 2005), and are typically interpreted within the cultural framework of the dreamer; they are often demons (Fukuda, Ogilvie, & Takeuchi, 2000), witches (Hufford, 1989), or even extra-terrestrials (McNally & Clancy, 2005). Accordingly, the most prevalent experience in sleep paralysis is that of fear (Sharpless et al., 2010). One interpretation of the link between paralysis and felt presence is a paranoid hallucination model, according to which the inability to move creates sensations of fear which, in turn, are externalized into extracorporeal space (Cheyne & Girard, 2007). Another is that felt presence is social imagery (sometimes accompanied by fear and sometimes not) that reflects a fundamental kind of spatial experience (Nielsen, 2007).

That the most studied variants of sleep paralysis are those containing fear and threat may be due to a self-selection bias by individuals who consult health practitioners or share these intense experiences with family and friends. Emotionally positive and neutral sleep paralysis experiences have also been reported but are understudied; however, a number of active online communities share and develop experiential tips on how to constructively use the opportunities afforded by being simultaneously asleep and awake and to transform them into lucid dreams or out-of-body experiences. Both of the latter are generally experienced as positive and even transformative, mystical experiences (Hurd, 2010).

In sum, sleep paralysis is an experience characterized by an overlap of waking and dreaming phenomenology and neurophysiology that is often accompanied by vivid bodily and social imagery, most notably the sense of being paralyzed, afraid and approached by a felt presence. sleep paralysis is one example of oneiric embodiment that illustrates some of the principles of the 4EA approach as applied to dreaming. In particular, the combination of oneiric mentation, altered sense of body and presence of reflective consciousness, allows some aspects of dream generation, especially those related to sense of space and intersubjectivity, to be studied in greater detail than in typical dream reports. I examine sleep paralysis in more detail in a review paper (Article II) which considers the current state of research on sleep paralysis neurobiology, precipitating factors, experiential attributes and available treatment strategies.

1.3.3. Functions of dreams

Discussions of embodiment are largely lacking from work on dream function. Despite the fact that research on dream function often evokes evolutionary/biological basis of dreams, most work on why we dream is focused almost exclusively on cognitive aspects, and not on bodily foundations of sleep mentation. Dreams have been linked to survival advantage, memory consolidation, emotion adaptation, and insight. Most of these cognitive-affective qualities have been addressed by work of 4EA theorists in the context of waking experiences, but not in dreams.

There is little scientific consensus regarding the question of whether or not dreams have a function. However, considerations of the issue fit roughly into two core contexts in contemporary cognitive science. First is evolutionary theory, wherein an organ or a cognitive capacity is thought to have been “designed” to a certain task as a result of natural selection, and as a response to environmental challenges (Downes, 2014). The brain, then, is a biological machine that runs different kinds of “software” adapted to the (ancestral) environment. This view corresponds to a position of biological and functional modularity, which endorses a decomposition of an organism or of the mind into smaller, specialized modules (Carruthers, 2006). Proponents of evolutionary theory have proposed a threat simulation theory of dreaming (Revonsuo, 2000; Revonsuo & Valli, 2008; Valli & Revonsuo, 2009) which posits that dreaming is a virtual simulation of threatening situations that allows the dreamer to rehearse responses to threat and thus to subsequently adapt to stressors in waking life. A more recent iteration of this view is the social simulation theory (Revonsuo et al., 2016), which proposes that dreams are primarily simulations of social relationships and that rehearsing responses to interpersonal situations enables adaptation to complex social landscapes in waking life.

Second is the functionalism position in philosophy of mind. This view does not assume biological modularity but rather emphasizes that explaining a mental process requires characterizing how it functions, i.e. what its role is in a larger system (Levin, 2016). This approach contrasts with the evolutionary modular view in emphasizing the *multiple realizability argument* (Bickle, 1998; Sober, 1999), i.e., the view that there is no one-to-one mapping of mental states onto physical substrates; the same mental states can be realized by different neural and physical events (Bickle, 2016). A functionalism approach to dream function is primarily focused on three interrelated domains: 1) memory consolidation, replay and reactivation; 2) emotional adaptation; and 3) creativity and insight. Each of these domains is considered in later sections.

A long-standing equation between dreaming and REM sleep has led many to conflate the functions of dreams with those of REM sleep. Most dream theories rely on the most current knowledge about REM sleep neurophysiology to explain the possible role of dreams in cognitive processing. While it is undeniable that experimental awakenings from REM sleep produce the most frequent, vivid, intense, bizarre and engaging mentation reports (Antrobus, 1983; McNamara, McLaren, & Durso, 2007; Nielsen, 2000), dream reports have been collected from NREM sleep as well, and are sometimes indistinguishable from those in REM sleep. Moreover, some daytime experiences, especially daydreaming, reverie and mind-wandering, have been described as phenomenologically similar to those of night-time dreams, and may depend on the activation of the so-called default mode network (DMN) (Domhoff, 2011c; Fox & Christoff, forthcoming 2017; Fox et al., 2013). Functions of the DMN are thought to include the production of spontaneous (task-independent) thought processes and large-scale functional brain organisation (Raichle, 2015; Raichle et al., 2001; Raichle & Snyder, 2007). Thus, the function(s) of dreaming may not be limited to functions associated with REM sleep but may extend to those associated with a cross-state neural structure (DMN) that governs production of spontaneous imagery more generally. The links between dreaming and DMN activity are speculative to date, and it is likely that neural substrates of dreaming are as varied and complex as neural substrates of waking perception, thought, imagination and other forms of mental imagery.

1.3.3.1. Memories play a role in dream formation

Relationships between memory and dreams have been discussed in two main ways: 1) the memory sources of dreams (how, when and which specific memories appear in dreams); and 2) the possible role of dreaming in memory consolidation (see section 1.4.3.2 and Article III for further discussion). While dream formation does appear to rely on autobiographic memory sources (Cavallero, Foulkes, Hollifield, & Terry, 1990; Horton & Malinowski, 2015; Malinowski & Horton, 2014; Nielsen & Stenstrom, 2005), with the exception of post-traumatic dreams and some neurological disorders, dreams rarely contain complete episodic replays, i.e., exact replays of temporally situated, autobiographical events (Fosse, Fosse, Hobson, & Stickgold, 2003; Hartmann, 2010a). Instead, dreams remix various episodic memory elements together with semantic information and other creative contents in novel, narratively organized, scenarios. The episodic elements often come from experiences lived the previous day, an effect known as day residue (Freud, 1900/2010; Harlow & Roll, 1992; Hartmann, 1968; Nielsen & Powell, 1992). Some memory elements also appear in dream content 5-7 days following the experience, a delayed incorporation phenomenon referred to as dream-lag (Blagrove, Fouquet, et al., 2011; Nielsen & Powell, 1989, 1992; Solomonova, 2011). Other research shows that episodic elements can appear in dream content from as recently as minutes before sleep to as long ago as early childhood (Battaglia, Cavallero, & Cicogna, 1987; Grenier et al., 2005; Stenstrom et al., 2012; Verdone, 1965). Memory elements that have the highest chance of being incorporated into dreams appear to be those that are most closely associated with current personally significant events and concerns, and/or are of an emotional nature (Blagrove et al., 2014; van Rijn et al., 2015).

1.3.3.2. Dreaming may facilitate adaptation to emotional disturbances

A role for dreaming in emotional adaptation has been discussed since Freud, who proposed that it is the eruption of repressed, emotionally charged libidinal wishes (Freud, 1900/2010). Today there is a growing consensus that sleep in general, and REM sleep in particular, plays a role in the regulation of emotions (Nielsen & Lara-Carrasco, 2007; Walker, 2008, 2009, 2010). One fundamental difficulty in studying this function of dreams, however, remains how to decouple what dream content does from what REM sleep or other sleep stages might do. Still, some evidence is suggestive (Cartwright, Luten, Young, Mercer, & Bears, 1998; Lara-Carrasco, Nielsen, Solomonova, Levrier, & Popova, 2009; Newell & Cartwright, 2000). For example, dreams are well-documented to respond to emotionally significant events. Studies of bereavement (Belicki, Gulko, Ruzycki, & Aristotle, 2003; Garfield, 1996; Kuiken, Dunn, & LoVerso, 2008; Wright et al., 2013) and divorce (Cartwright, Lloyd, Knight, & Trenholme, 1984) show that dreams respond dynamically to stressful and emotionally charged events. For example, stressful pre-sleep experiences, such as emotionally negative films (De Koninck & Koulack, 1975; Koulack, Prevost, & De Koninck, 1985), have a strong effect on subsequent dream content. In some conditions, however, excessive, emotionally negative dreaming may exacerbate levels of distress and impair processes of emotional adaptation and making sense of trauma; this is especially so in the context of depression (Cartwright et al., 1998), early history of adverse life events (Nielsen, 2017b) or post-traumatic stress disorder (Germain, 2013; Levin & Fireman, 2002).

1.3.3.3. Dreaming may facilitate creativity and insight.

Dreams have been linked to activities of creative and theatrical play. In cognitive dream research, work on embodiment as a metaphorical process can be traced back to Hall's cognitive theory of dreams (Hall, 1953), which postulates that dreaming is a creative process by which embodied thoughts and emotions are transformed into imagery.

Proponents of the cognitive theory of dreams have proposed that dreams are metaphorical (but not disguised) embodied simulated enactments of current concerns, thoughts and emotions (Antrobus, 1977; Domhoff, 2011a, 2015; Hall, 1953). More recently, Bulkeley proposed that dreaming is essentially a state of imaginative play in sleep (Bulkeley, 2016), an activity that contributes to continuous mental workout that stimulates the development of cognitive and emotional flexibility – prerequisites of culture and of our success as a species.

Many scholars see dreaming as hyperassociative (Carr, Blanchette-Carriere, Marquis, Ting, & Nielsen, 2016; Carr & Nielsen, 2015; Horton & Malinowski, 2015; Malinowski & Horton, 2014), i.e. a state of cognitive flexibility and fluidity, whereby loosely connected and weakly associated elements from waking memories are recombined in unusual ways to create novel dream experiences. In dream research, the idea of hyperassociativity is often linked with dream bizarreness, novelty, creativity (Globus, 1993; Hartmann, 1996; Llewellyn, 2013), and with evidence that REM sleep physiology (Cai, Mednick, Harrison, Kanady, & Mednick, 2009) is characterized by more widespread connectivity than NREM sleep (Massimini et al., 2010). Some of the proposed functions of this associative process are: 1) assimilation of novel experiences into larger autobiographic contexts (Cartwright, 2011; Levin & Nielsen, 2007), or the flexibility function of memory (as opposed to simply stabilization of memory traces); 2) development of insight, or extracting the "gist" of experiences (Stickgold, Scott, Rittenhouse, & Hobson, 1999; Walker, Liston, Hobson, & Stickgold, 2002).

In sum, approaches to functions of dreams can be divided into two main categories: an evolutionary account of why dreams were selected to play a role in increasing the organism's fitness; and a functionalist approach, which stresses the relationship between dreams and major cognitive processes. The three interrelated domains of research stemming from the functionalism approach to dream function provide context for the present work. Research largely supports the notion that dreaming functions include adaptations of concern to the embodiment perspective: memory consolidation, emotion regulation, and reorganization of memory traces in a way that creates novel experiences in dreams and fosters emotional and autobiographic insight.

1.3.4. Sleep spindles are involved in bodily aspects of memory

Much of recent efforts to unravel the intricacies of the relationship between sleep and cognition has focused not only on general contribution of sleep stages but also on more specific microarchitectural elements that punctuate sleep. The most common such events are sleep spindles (predominantly studied in N2 sleep), slow oscillations (1 Hz activity that occur in N3 sleep or "deep sleep"), and rapid eye movements (characteristic of REM sleep).

Sleep spindles are particularly relevant for the present work, since they have been consistently implicated in procedural memory consolidation, and thus can be conceptualized as neurophysiological markers of bodily memory. Sleep spindles are rhythmic oscillatory bursts of EEG sigma activity (11-16 Hz). Together with K complexes, they are defining electrophysiological markers of NREM sleep, especially N2 sleep (Silber et al., 2007). Sleep spindles are initiated in the thalamic reticular nucleus and modulated by thalamo-cortical networks (Lüthi, 2014; Steriade, 2006). Current models of sleep-dependent memory consolidations suggest that sleep spindles are involved in hippocampal-neocortical dialogue (Marshall & Born, 2007; Sirota, Csicsvari, Buhl, & Buzsaki, 2003) and, when phase-locked with sharp ripple oscillations, markers of thalamo-cortical neuroplasticity processes. Work on memory and sleep shows not only that spindle activity is associated with improvements on declarative and non-declarative tasks, but also that sleep spindles are involved in processes of integration of newly learned information into existing knowledge (Tamminen, Payne, Stickgold, Wamsley, & Gaskell, 2010).

1.3.4.1. Fast and slow sleep spindles may be differentially related to memory

On a methodological note, a number of distinctions between slow and fast sleep spindles have been proposed. First, topographic and temporal differences have been noted for slow and fast spindle occurrences, with slow spindles occurring predominantly during the first half of the night on frontal derivations and fast spindles during the second half of the night on primarily parietal derivations (Jobert, Poiseau, Jahnig, Schulz, & Kubicki, 1992). Second, one study reports that slow and fast spindles are differentially related to slow oscillations (<1 Hz), which are thought to drive some sleep-dependent memory consolidation processes; co-occurrences of fast spindles and slow oscillations are associated with enhanced learning of a word-paired associations task (Molle, Bergmann, Marshall, & Born, 2011). Third, a functional connectivity study (Zerouali et al., 2014) showed that fast and slow spindles may possess different connectivity patterns, with fast spindles being preferentially involved in short-range intra-hemispheric synchrony, and slow spindles in longer-range, intra-hemispheric connectivity. This suggests that the two types of spindles may play different roles in processes of neuroplasticity, activating different kinds of networks. Fourth, there is limited evidence to suggest that not only are fast and slow spindles different, they may have opposite patterns of relationship with some cognitive measures. To illustrate, our laboratory found fast spindles to be positively correlated with dream recall, nightmare recall and length of dream reports, while slow spindles were negatively correlated with these same measures (Nielsen et al., 2016). Similarly, in a study assessing contribution of spindles to consolidation of memory for faces, we found that fast spindles correlate positively with face recognition, while slow spindles were negatively correlated (Solomonova et al., 2017). Thus, in the present dissertation we separated sleep spindles into fast and slow types to investigate their relationship to procedural memory consolidation.

1.4. Memory functions of sleep

While there is now little doubt that sleep is involved in memory processing, the relative contributions to this function of sleep stages, microarchitectural sleep elements, circadian factors and individual differences are still largely inconclusive. So, too, are the many ways in which dreaming may be implicated in these sleep functions. And if the extent to which processes of embodiment in dreaming remain unexplored, their implication in sleep-dependent learning functions are even less well-appreciated. However, as emphasized in the previous section, sleep spindles have been identified as a crucial marker of the sleep-dependent processing of procedural (or ‘how-to’) memories in particular; this discovery has major implications for the current version of the embodiment hypothesis. In this section I will describe the human memory systems, and provide an overview of the current knowledge of sleep-dependent memory consolidation, with a specific focus on procedural memory as an expression of how embodiment is a major component of cognitive processing in sleep.

1.4.1. Memory is embodied

The idea that memory is not merely a representation of learned concepts about the world but is rooted in the wider lived experience of the body has its roots in both phenomenology and psychoanalysis. The phenomenologist Bergson introduced the concept of “habit memory” to refer to embodied actions that are conditioned by sensorimotor patterns of interaction with the world (Bergson, 1991). This idea was further developed by Merleau-Ponty (2012) in his formulation of the habitual body: the world is encountered through the manner in which individuals typically inhabit it. The body serves as a general point of anchorage in the world, i.e., “my habitual body structures the very appearance of the objects in my world and, from a pre-personal or anonymous level, animates a field of objects that appear to be manipulable in themselves” (Landes in Merleau-Ponty, 2012: xl-xli). This sentiment is shared by some contemporary philosophers. For instance, Casey proposed that memory is intrinsic to the body and that the process of remembering is a re-enactment of bodily memory. He uses the example of touching a broken tooth and immediately remembering the context of its breaking and the subsequent visit to the dentist in vivid detail (Casey, 2000).

The notion of bodily memory seems intuitively correct with regards to procedural memory, but recent research lends evidence to the idea that episodic and semantic memory also rely on sensorimotor patterns. Hand and arm gestures that accompany speech may help the encoding and recalling of spatial and conceptual information (Morsella & Krauss, 2004; Wesp, Hesse, Keutmann, & Wheaton, 2001), providing a gestural feedback that facilitates access to previously learned information. Body posture, movements and emotional states at the moment of learning may become part of the resulting memory trace (Casasanto & Dijkstra, 2010; Dijkstra, Kaschak, & Zwaan, 2007). Language acquisition itself may even rely on multisensory perception, including integration of somatosensory information and motor patterns (Macedonia, 2014; Piaget, 1976; Tomasello, 2005). Based on such empirical work, Barsalou and colleagues propose that conceptual learning is dependent on re-enactments of multimodal states that underlie memory formation (Barsalou, Kyle Simmons, Barbey, & Wilson, 2003). Embodied memory is context-dependent, and both declarative and procedural memory heavily depend on the cultural, social and historical scaffolding. The socio-cultural frameworks, then allow certain actions, gestures and concepts to emerge, and to be experienced, through bodily engagement, as explicit and implicit memories (Sutton & Williamson, 2014). Finally, the iconic couch of the psychoanalytic process, whereas the patient is in a reclining position, is designed to return the analysand physically as close as possible to the sleeping position, which may facilitate both dream recall and dream-like free-association process (Freud, 1900/2010; Friedberg & Linn, 2012).

In sum, while procedural memory, which involves motor and skill learning, is the most obvious connection between the theories of embodied mind and memory, all types of memory may have an important bodily component and can thus be seen at least partially as requiring enactive habits.

1.4.2. Human memory systems

In contemporary cognitive science, human memory is typically mapped onto two primary axes: 1) a temporal axis, which deals with sensory memory, short term and long term memory; and 2) a functional/qualitative axis of long-term memory, which is itself divided into two main systems: declarative (or explicit) and non-declarative (or implicit) memory (Squire, 2009). This separation between declarative and non-declarative memory is based upon the idea that the two systems are functionally and phenomenally dissociable (Cabeza & Moscovitch, 2013; Squire, 1998, 2004) and that declarative memory is accessible to conscious recall (Baars, 2002) while non-declarative memory—which includes procedural memory—is not. Further, since early work with the amnesiac patient HM (Corkin, 1984), declarative memory has been associated with medial temporal structures, especially hippocampus, while non-declarative memory is thought to be largely hippocampus-independent and is preserved to a certain extent even in cases of bilateral hippocampal damage. In the following section, main characteristics of declarative and non-declarative memory will be discussed, with a special emphasis on the latter, due to its special relevance to the present dissertation. Specifically, even though theories of embodied mind consider all cognition to be rooted in physical and bodily processes, procedural memory is most obviously so. Thus, procedural motor memory was selected as a learning process of interest for the present study, i.e., as a body-based target of more general neurophysiological and experiential processes of learning and memory.

1.4.2.1. Declarative memory

Declarative memory itself is typically subdivided into semantic and episodic memory types (Tulving, 1987, 1992, 2001, 2002; Tulving & Markowitsch, 1998). Semantic memory is factual memory or memory for general knowledge, such as "Ottawa is the capital of Canada: or "a whale is a mammal". Although a semantic memory is initially learned in a rich context and has episodic qualities, it eventually becomes dissociated from the autobiographical narrative and transformed into a relatively stable form of knowledge (Battaglia & Pennartz, 2011). For example, it is likely that one does not remember the episodic details (e.g, when and where) about first learning that a whale is a mammal. In contrast, episodic memory refers to memory for specific autobiographical events (Tulving, 2002) and is thought to be composed of three key components, summarized as "what" (elements of the event), "where" (spatial, hippocampus-dependent elements), and "when" (temporal qualities of the event); for example "I saw a fossilized whale in a Museum of Natural History in Ottawa a year ago with friends" illustrates an episodic memory. It has also been proposed that a main quality of episodic memory is "mental time travel" or the ability to vividly and compellingly imagine oneself in the past, almost to the point of re-living or re-creating all the "what, where, when" qualities of past experience (Suddendorf & Corballis, 1997; Wheeler, Stuss, & Tulving, 1997). Another proposed function of this highly evolved capacity is that the same neural mechanisms and experiential qualities that underlie episodic memory reactivation permit imagining future scenarios (Addis, Wong, & Schacter, 2008; Schacter, Addis, & Buckner, 2007).

1.4.2.2. Procedural memory

Non-declarative memory consists of procedural memory, priming, and classical and operant forms of conditioning (Squire, 2004, 2009). One important feature that differentiates non-declarative from declarative memory is that it operates largely unconsciously and is inaccessible to metacognitive reflection. This is also the case for procedural memory (including motor memory), which refers to a variety of skills, such as fine motor skills, complex sequential actions and target tracking (Squire, 2004). Procedural memory is thus sometimes referred to as “how to” memory and is typically acquired by repeating a complex motor activity. Understandably, a large number of tasks could be and have been used to investigate procedural memory. Since dream content is usually considered in audio-visual terms, for the purposes of investigating bodily, skillful and somatosensory aspects of embodiment in sleep and dreams, we will focus on the relationship between a full-body procedural memory task (a sensorimotor balance task on the Nintendo Wii Fit platform), sleep physiology and dream content. It is important to bear in mind that procedural learning is not completely independent of other types of memory and may have some episodic, semantic, or emotional characteristics. For example, learning to ride a bicycle happens in a certain context (episodic), with particular people (emotional), and in a particular place (episodic and semantic). While eventually the learned skill is largely dissociated (at least consciously) from the initial context, some associativity may persist. Furthermore, the assumption that procedural memory is necessarily unconscious has been challenged. Henke and colleagues, for instance, showed that both conscious and unconscious mnemonic traces may make up an integrated representation (Henke, Reber, & Duss, 2013) and a number of theories arguing for a single memory system, in lieu of a modular view, have been put forth (Bowers & Marsolek, 2003; Kihlstrom, Dorfman, & Park, 2007). Thus, procedural memory traces in dream content may not necessarily consist only of re-enactments of newly learned movements and skills, but could include context, emotional tone, and metaphorical manifestations of the procedural/motor memory. A number of early dream theories considered the importance of motor memory for dream formation. Lerner and Rorschach (Lerner, 1966, 1967), for example, considered dream imagery to be a form of kinaesthetic fantasy, i.e., imagined and transformed bodily movements made into visual or auditory imagery. Similarly, Hobson and McCarley hypothesized that stored sensorimotor information, i.e. patterns of embodied interactions with the world, is activated during dreaming and contributes to formation of the sequencing of dream scenarios (Hobson & McCarley, 1977).

1.4.3. Sleep plays a role in memory consolidation

Following initial learning some information is labile and may be forgotten due to interference (Barrouillet & Camos, 2009) or decay (Portrat, Barrouillet, & Camos, 2008). The process by which new memories avoid this fate and are transferred to long-term memory systems is known as memory consolidation (McGaugh, 2000). Some of the current controversy surrounding the role of sleep in memory consolidation has to do with the relative contributions of REM and NREM sleep stages. Much research assesses REM and NREM sleep stages separately and focuses on how these contribute differently to different kinds of memory. However, other work suggests that the two kinds of sleep contribute in concert to memory consolidation. This approach, too, is complicated by the possibility that memory systems are more integrated than they are modular (Bowers & Marsolek, 2003; Kihlstrom et al., 2007), thus making it difficult to categorically separate different kinds of learning.

As a result of this research, a more complex and nuanced picture is emerging of the overall role for sleep in memory consolidation. It is likely that sleep-dependent memory consolidation processes are less segregated in the types of memory they deal with, and are more related to a particular task's self-relevance, to the learning context, to a participant's prior skills, strategies and motivations, and other factors. Some studies illustrate this complexity. First, a recent proposal is that activity in the amygdala and mesolimbic dopaminergic areas in REM sleep promotes consolidation of memories with high emotional and motivational value, while hippocampal-striatal processes, characteristic of NREM sleep, strengthen specific memories for important events (Perogamvros, Dang-Vu, Desseilles, & Schwartz, 2013). Second, sleep may serve a "memory triage" process (Stickgold & Walker, 2013), selecting personally relevant information and discarding information that is not. Third, the interplay between REM and NREM sleep may be crucial in the complex sequence of consolidation, reactivation and reconsolidation: while NREM sleep may consolidate experiences, i.e. keep them distinct, REM sleep and its extensive activation of associative networks may reflect processes of integration of newly learned information into the larger context, thus enhancing cognitive flexibility (Cai et al., 2009; Carr & Nielsen, 2015; Sterpenich et al., 2014; Walker et al., 2002).

In sum, memory mechanisms in sleep serve to consolidate memories with personal relevance, even though REM and NREM sleep may process different features of these memories. From an embodied dreaming perspective, it is not yet clear how the consolidation mechanisms of sleep—and of REM sleep in particular—are related to the structure of dream experience. However, it may be that the rich and immersive experiences of REM sleep dreams are designed to bring to the foreground the bodily engagement of learning. In other words, a key feature of the vividness and immersion of REM dreaming may be the specific activation of motor and 'how-to' memory. And by this activation, somatosensory patterns of the relationship between the agent and the world may contribute to the widespread integration of new memories into memory networks. In this regard, it is noteworthy that the rate of fast spindles in N2 sleep—a purported marker of procedural memory—is correlated in a graded fashion with the recall of dream content from REM sleep (Nielsen et al., 2016). A closer examination of procedural memory in sleep further highlights this possibility.

1.4.3.1. Procedural memory consolidation in sleep

Both REM and NREM sleep stages and microarchitectural features of these stages have been linked to procedural memory consolidation. The kinds of tasks currently used to investigate sleep-dependent procedural memory consolidation are all relatively simple in nature, often requiring only a single movement repeated multiple times; these include: sequential finger tapping (Antonenko, Diekelmann, Olsen, Born, & Molle, 2013; Benedict, Scheller, Rose-John, Born, & Marshall, 2009; Debarnot et al., 2012; Doyon et al., 2009; Dresler, Genzel, et al., 2010; Dresler, Kluge, Genzel, Schussler, & Steiger, 2010; Genzel, Ali, Dresler, Steiger, & Tesfaye, 2011; Genzel, Dresler, Wehrle, Grozinger, & Steiger, 2009; Griessenberger et al., 2013; Herzog et al., 2012; Holz, Piosczyk, Landmann, et al., 2012; Van Der Werf, Van Der Helm, Schoonheim, Ridderikhoff, & Van Someren, 2009; Wamsley et al., 2012); serial-reaction time task (Ertelt et al., 2012; Galea, Albert, Ditye, & Miall, 2010; Prehn-Kristensen et al., 2011); motor sequence task (Manoach et al., 2010; Tucker & Fishbein, 2009); mirror-tracing task (Holz, Piosczyk, Feige, et al., 2012; Hornung et al., 2008; Javadi, Walsh, & Lewis, 2011; Kloepfer et al., 2009; Nissen et al., 2011; Puetz et al., 2011; Seeck-Hirschner et al., 2010; Smith, Nixon, & Nader, 2004; Voderholzer et al., 2011); button-box sequence (Wilhelm, Metzkow-Meszaros, Knapp, & Born, 2012); visuomotor adaptation task (Doyon et al., 2009); texture discrimination task (Cipolli et al., 2009; Gais, Rasch, Wagner, & Born, 2008); visual discrimination task (Suzuki et al., 2012), and others. More complex procedural tasks, such as the balance task used in the present study have not been studied extensively.

A number of studies report relationships between REM sleep neuromarkers and the learning of these simple procedural skills. REM eye movement density is positively associated with performance gains on a serial reaction time task in ADHD children (Prehn-Kristensen et al., 2011), as well as on a mirror-tracing task (C. T. Smith et al., 2004). And in obstructive sleep apnea patients, reduced REM density is associated with poor performance on a mirror-tracing task (Kloepfer et al., 2009). An association between improvement on a mirror-tracing task and REM-rich late sleep is also reported (Plihal & Born, 1997) while selective REM sleep deprivation disrupts procedural learning (Karni, Tanne, Rubenstein, Askenasy, & Sagi, 1994).

Some studies, however, do not find REM sleep to be implicated in procedural memory consolidation. For example, REM sleep deprivation did not lead to poorer performance on the sequential finger-tapping task (Genzel et al., 2009) and pharmacologically suppressing REM sleep did not lead to losses in procedural learning but, instead, improved performance(Rasch, Pommer, Diekelmann, & Born, 2009).

In addition to REM sleep, a growing literature suggests that NREM sleep plays an important role in procedural memory. NREM sleep duration and oscillatory events, such as sleep spindles, have been shown in both full night and nap-based studies to influence procedural memory. In a study of high-functioning adults with autism (Limoges, Bolduc, Berthiaume, Mottron, & Godbout, 2013), both patients and controls showed a relationship between spindle density and a procedural memory improvement, as well as a negative correlation between N3 sleep and gains on a sensory-motor procedural task. In a study involving mirror-tracing, EEG sigma activity (the sleep spindle band) and SWS both correlated positively with overnight improvement (Holz, Piosczyk, Feige, et al., 2012). Finally, amount of N2 sleep and sigma activity both positively correlate with improvement on a sequential motor task (Tucker & Fishbein, 2009).

In insomnia sufferers (Griessenberger et al., 2013), central sleep spindles were associated with susceptibility to interference for a finger tapping task. In a comparative study between healthy older controls and Parkinson's disease patients (Terpening et al., 2013), a relationship was found between improvement on a motor task and SWS duration in healthy controls. In schizophrenic patients, both an absence of overnight improvement on finger-tapping (Genzel et al., 2011) and motor sequence (Manoach et al., 2010) tasks and reduced spindle density and coherence were observed; this differed from matched healthy controls(Wamsley et al., 2012). In ADHD children, improvement on a serial reaction time task was associated with the amount of Stage 4 sleep (Prehn-Kristensen et al., 2011).

In a nap protocol, performance on a finger sequence task correlated with spindle density (Albouy et al., 2013). In another nap study, however, a 40-minute sleep in medicated schizophrenic patients did not produce any benefit for procedural learning (Seeck-Hirschner et al., 2010), as opposed to better performance in healthy controls and patients with remitted or moderate depression.

Some research groups have attempted to experimentally modulate sleep architecture in order to improve learning and consolidation of memory. In a number of transcranial magnetic stimulation (TMS) studies aimed at increasing the slow wave activity, no beneficial effect was found in healthy adults during an afternoon nap (Antonenko et al., 2013), or in elderly subjects (Eggert et al., 2013). A TMS study attempting to disrupt activity in areas subserving declarative memory consolidation, specifically in dorsolateral prefrontal cortex, showed benefits for learning of the sequential reaction time task (Galea et al., 2010). A number of experiments targeted potential memory reactivation with auditory cues (that were previously associated with procedural learning) during NREM sleep. Evidence points to not only benefits to motor learning, but also enhancement of sleep spindle density (Cousins, El-Deredy, Parkes, Hennies, & Lewis, 2014; Laventure et al., 2016; Schonauer, Geisler, & Gais, 2014).

Similarly, in a study that pharmacologically enhanced spindle density (Mednick et al., 2013) using zolpidem (a short-acting GABAA agonist hypnotic), no significant spindle-related improvement on a procedural task was found. In a clinical trial of D-cycloserine, a partial agonist of NMDA receptors, memory deficits specifically for procedural learning were observed (Kuriyama, Honma, Koyama, & Kim, 2011). Use of ecstasy/MDMA was not associated with deficits of procedural memory consolidation, although greater lifetime consumption of ecstasy/MDMA was associated with overall poorer procedural memory (Blagrove, Seddon, et al., 2011). In both patients with multiple sclerosis and major depression, administration of high-dose corticosteroid therapy (methylprednisolone) showed a marked overnight decrease in performance (Dresler, Genzel, et al., 2010). Finally, late night administration of the muscarinic receptor antagonist scopolamine and the nicotinic receptor antagonist mecamylamine (cholinergic receptor blockage agents) impaired motor memory consolidation in healthy young men (Rasch, Gais, & Born, 2009).

Lastly, REM and NREM patterns of sleep-dependent procedural memory consolidation may depend on individual characteristics of participants, on the level of mastery required or on the perceived complexity of the task. Smith and colleagues (Smith, Aubrey, & Peters, 2004), for example, showed that when a task was experienced as easy it had an effect on N2 sleep, including sleep spindles, but when it was subjectively more challenging there was a strong effect on REM sleep. In contrast, Fogel and colleagues (Fogel, Ray, Binnie, & Owen, 2015) showed that a newly learned procedural task enhanced N2 features, such as fast spindle density and sigma power; but when participants become ‘experts’ on the task, the relationship between performance and sleep shifted to REM sleep characteristics and to different features of N2 spindles, specifically, their amplitude and duration but not their density.

In sum, a substantial literature indicates that both REM and NREM sleep stages, and their microarchitectural elements—sleep spindles especially—are sensitive to procedural learning. The nature of the task, its perceived difficulty, individual differences in skill, and likely other, still unidentified variables (e.g., body awareness), can affect the relationship between learning, memory consolidation and sleep dynamics. Thus, it is possible that different aspects of bodily memory rely on different facets of the interplay between REM and NREM processes. Explicit and implicit qualities of embodiment in sleep, therefore, can be studied experimentally by manipulating the nature of the task and characteristics of participants. In our project, we chose to focus on the relationship between sleep stages, sleep spindles, and expertise in bodily self-awareness in relation to a full-body procedural task; differences in bodily self-awareness were assessed by comparing meditation practitioners who cultivate body awareness and matched controls who do not.

1.4.3.2. Dream content, memory traces and memory consolidation

One of the proposed functions of dreams is a possible role in sleep-dependent memory consolidation. Since dream content contains a seemingly unlimited variety of memory sources, and is sensitive to waking life events it seems intuitive to suppose that reactivation of memory traces in dreams is implicated in "offline" memory processing (Wamsley, 2014). Empirical research that attempts to link dream content with memory and learning has so far produced mixed results. There are two general ways in which dream content has been linked to memory consolidation: 1) dreaming is seen as an epiphenomenal correlate of REM sleep memory mechanisms; or 2) dream content plays a role in memory consolidation in its own right, i.e., independent of REM sleep mechanisms.

Recent work on animals and on memory cueing in humans suggests that neural replay, i.e. reactivation of newly learned memory traces in the brain, strengthens memory and protects it from decay (Feld & Born, 2017; Schouten, Pereira, Tops, & Louzada, 2017). Evidence points to neural replays, of hippocampal sequences in NREM sleep (Atherton, Dupret, & Mellor, 2015; Pavlides & Winson, 1989; Sara, 2017) and a growing body of work suggests that some replay events may also be present in REM sleep (Poe, Nitz, McNaughton, & Barnes, 2000). Further, REM sleep is well-documented to play a role in consolidation of procedural memory and of episodic emotional memory (Datta & O'Malley, 2013; Gilson et al., 2015; Nishida, Pearsall, Buckner, & Walker, 2009; Wiesner et al., 2015). In this context, dream content is seen as an experiential manifestation of these underlying REM sleep memory processes of replay and emotional memory consolidation (Smith, 2010).

However, experimental research on whether dreaming of a task enhances subsequent performance on that task has produced mixed results. One of the most striking examples for the relationship between dream content and memory comes from a study by Wamsley and colleagues (Wamsley, Tucker, et al., 2010) in which participants navigated a virtual maze before and after a nap (a design similar to that in Article III), and were awakened for dream report collection. Incorporating elements from that task into dream content was associated with significantly better performance upon awakening. Another example is a study that reports that dreaming in a new language is associated with enhanced learning of that language (De Koninck, Christ, Hebert, & Rinfret, 1990). Many studies, however, found no relationship between dream content and learning (Cipolli, Bolzani, Tuozzi, & Fagioli, 2001; Nguyen, Tucker, Stickgold, & Wamsley, 2013; Nielsen et al., 2015; Wamsley, Perry, Djonlagic, Reaven, & Stickgold, 2010). While dreams contain memory sources, they also almost never replay full episodic events (combining the what, where, and when qualities) (Fosse et al., 2003), suggesting that dreaming is not an experiential correlate or representation of sleep-dependent neural replays, but rather has a different, still unidentified, relationship to memory. It might be, for example, in creating associative and novel links between newly learned information and existing autobiographical knowledge (Carr & Nielsen, 2015; Hartmann, 1996; Horton & Malinowski, 2015; Malinowski & Horton, 2014).

In sum, while the importance of sleep for memory consolidation is now rarely disputed, the contribution of dreaming to memory remains unclear. On the one hand, there is evidence for neural replay in sleep in both REM and NREM sleep, but dream content only rarely includes full episodic memories, and likely plays an associative role, binding different elements of lived experience and general knowledge together in novel ways. On the other hand, research on mind-wandering and spontaneous cognition indicates the possibility that there is an underlying general process, possibly subserved by the default mode network, which enables generation of thoughts and imagery across wake and sleep states. Finally, experimental research has produced mixed results about dreaming's role in memory: few studies to date report strong links between dream content and learning, and many find no relationship between the two. Testing the relationship between sleep mentation and learning on a procedural memory task was one of the goals of Article III.

1.5. Mindfulness meditation practices: an overview

As indicated in the sections on learning and sleep, there is evidence that individual characteristics may be important in determining how sleep reacts to a newly learned task. Indeed, research on sleep, memory and dreams often includes "expert" groups of individuals who have developed a particular physical or cognitive expertise, or who share a particular characteristic. Some examples include recruiting athletes to study the virtual practicing of skills in lucid dreams (Erlacher, Ehrlenspiel, & Schredl, 2011), or pregnant women (Lara-Carrasco et al., 2013) to study how psychophysiological changes in pregnancy affect dream content. In the past two decades, experienced meditation practitioners have often been studied in projects designed to assess meditation's effects on specific cognitive skills. Research on attention, emotional reactivity, and various aspects of self-awareness has been conducted.

Contemporary contemplative science refers generally to practices influenced by the Indo-Buddhist meditation tradition as they are currently represented in the West. In very general terms, meditation practices aim at cultivating awareness of the present moment, with an ultimate goal of developing equanimity and, eventually, enlightenment (Analayo, 2004; Brown, 2003; Kerr, Sacchet, Lazar, Moore, & Jones, 2013). Historically, contemplative cognitive science and psychology can be traced to the popularization of meditation practices and development of a secular protocol known as mindfulness-based stress reduction (MBSR), which is still in wide use today (Crane et al., 2017; Kabat-Zinn, 1982).

Such meditation/mindfulness interventions have evolved over the years and are today commonly administered to patients with numerous conditions including cancer (Biegler, Chaoul, & Cohen, 2009; Carlson, 2016; Speca, Carlson, Goodey, & Angen, 2000), heart disease (Tacon, McComb, Caldera, & Randolph, 2003), pain (Hilton et al., 2017; Kabat-Zinn, 1982), mood disorders (Hofmann, Sawyer, Witt, & Oh, 2010; Qureshi & Al-Bedah, 2013), schizophrenia (Johnson et al., 2009), autism (Spek, van Ham, & Nyklicek, 2013), addiction (Brewer, Bowen, Smith, Marlatt, & Potenza, 2010; Khanna & Greeson, 2013), post-traumatic stress disorder (King et al., 2013; Lang et al., 2012; Simpson et al., 2007), and many others. Meditation programs targeting psychosocial health are also often administered to a variety of populations, such as health practitioners (dos Santos et al., 2016; Hevezi, 2016; Thimmapuram et al., 2017), women at risk (Dutton, Bermudez, Matas, Majid, & Myers, 2013), youth in shelters (Grabbe, Nguy, & Higgins, 2012), and prisoners (Auty, Cope, & Liebling, 2017; Lyons & Cantrell, 2016; Nidich et al., 2016; Ronel, Frid, & Timor, 2013; Simpson et al., 2007), among others.

In the current literature, mindfulness may refer to three different constructs (Lutz, Jha, Dunne, & Saron, 2015): 1) the cognitive skill of non-judgemental awareness that can be trained through meditation and, possibly, other activities; 2) a dispositional trait (Baer et al., 2008; de Bruin, Topper, Muskens, Bogels, & Kamphuis, 2012), and 3) a soteriological/spiritual path. Most empirical studies of meditation/MBSR interventions, including cross-sectional studies comparing meditators with non-meditating controls, have focused on the first sense of the term: mindfulness as a trainable cognitive skill with tractable and quantifiable effects. Examples of the outcomes of training in mindfulness are enhanced attentional abilities (Lippelt, Hommel, & Colzato, 2014), development of non-judgemental awareness, equanimity and cognitive flexibility (Moore & Malinowski, 2009), and a general sense of well-being or trait mindfulness (Montero-Marin et al., 2016).

The second sense of mindfulness is that mindfulness and its associated qualities of presence and awareness comprise a stable trait or predisposition (Creswell, Way, Eisenberger, & Lieberman, 2007). Research comparing trait mindfulness and state mindfulness in trained practitioners shows mixed results, with some studies reporting that trait mindfulness has similar neural and psychological correlates as meditation practice, and others (Antonova, Chadwick, & Kumari, 2015) showing no difference between experienced Buddhist practitioners and controls. As such, trait mindfulness is measured only by questionnaires, does not account for the temporal and dynamic nature of cultivating mindfulness as a skill (Lutz et al., 2015), and shows limited discriminant validity in relation to the various changes that meditation practitioners undergo in course of training (Goldberg et al., 2016).

Lastly, mindfulness as a soteriological or spiritual path refers to practices rooted in the Buddhist tradition (Kirmayer, 2015). It represents the practitioner's commitment to a particular way of life, a way aimed at decreasing suffering and promoting flourishing, and as such may differ significantly in intention from either mindfulness practiced as a wellness program or a clinical intervention, or mindfulness as a trait with no practical or intentional stance. Indeed, intentional and motivational factors (e.g. meditation as a well-being or therapeutic practice vs. meditation as a spiritual discipline) related to meditation practice may influence the experience and the outcome of the practice (Engen & Singer, 2016). Lutz and colleagues (Lutz et al., 2015), however, point to the idea that mindfulness in contemporary clinical and social settings is not entirely incompatible with the Buddhist tradition, citing a notion from an early Buddhist text suggesting that a contemplative way of life is a form of therapy, and comparing it to the contemporary mindfulness movement with its emphasis on mindful living (Williams & Kabat-Zinn, 2011).

1.5.1. Attentional and phenomenological families of contemplative practices

Meditation, like sport, is an umbrella term that refers to a wide variety of practices including solitary sitting, group sitting, walking, movement-based practices (Schmalzl, Crane-Godreau, & Payne, 2014), chanting, visualisation, and many others. Different meditation practices have different phenomenological (Kok & Singer, 2017b; Lutz et al., 2015) and neurological (Fox et al., 2016; Lippelt et al., 2014) signatures. Many practices, however, have overlapping elements, intentions and social contexts; it is therefore difficult to classify them as entirely different kinds of activities. Progress in meditation practices is often apparent as a decrease in the degree of effort required to maintain the desired attentional quality, a decrease in the stability of uninterrupted periods of practice (Lutz, Slagter, Dunne, & Davidson, 2008) and, eventually, the developing of insight and a capacity for non-judgemental awareness in the present moment. In the following section, the different aspects of contemplative training and their experiential and motivational characteristics will be reviewed. In the present work, we chose to solicit participation of Vipassana meditation practitioners in order to investigate the relationship between procedural learning, sleep and dreaming from the embodied cognition perspective. Vipassana was chosen due to its multifaceted quality of engaging numerous cognitive-affective qualities associated with different schools of meditation/mindfulness practices. In particular, Vipassana meditation consists of cultivating awareness of subtle bodily sensations – a skill that is known to improve body awareness and interoceptive precision.

One widely used classification method of meditation practices is based on the locus of attention, and distinguishes between 1) focused attention and 2) open monitoring (Lutz et al., 2008), some also include 3) self-transcending (Travis & Shear, 2010), and 4) loving-kindness/compassion forms of other-oriented meditation (Hofmann, Grossman, & Hinton, 2011; Hutcherson, Seppala, & Gross, 2008; Lee et al., 2012).

Focused attention meditation refers to a variety of practices characterized by developing a capacity for sustained attention on a chosen object, for example, breath, body sensations, or meaning of a *koan* (Japanese Zen practice of contemplating short, often paradoxical and poetic stories/expressions). This skill entails regulation of attention by noticing when one's focus wanders from the object and returning to it promptly (Lutz et al., 2008; Travis & Shear, 2010).

Open monitoring practices are often introduced after some progress in focused attention training. With this kind of meditation, practitioners are instructed to apply their skill of sustained attention to the monitoring of sensations or thoughts without explicitly focusing on any particular object of awareness (Lutz et al., 2008). The guiding principle behind the many open monitoring practices is the development of a capacity for insight – i.e., noticing habit patterns of reactivity to stimuli, developing a state of non-judgemental awareness, and de-automatizing maladaptive patterns of emotional, cognitive and behavioral reactivity (Kang, Gruber, & Gray, 2012).

Self-transcending meditation refers to the experience of and ambition for a state of awareness that erases subject-object distinctions and lets the mind rest in "pure consciousness" (Travis & Pearson, 1999; Travis & Shear, 2010). This practice is aimed at achieving insight into non-duality and the erasure of sharp subject-object distinctions.

Lastly, a group of other-oriented practices, such as *metta*, loving-kindness or compassion meditations, aims at cultivating feelings of benevolence, empathetic concern and wishes of well-being towards others (Hofmann et al., 2011; Hutcherson et al., 2008; Kok & Singer, 2017a). This form of meditation is aimed at increasing social connectedness and the realization of intersubjective and interpersonal dependence.

One of the more recent attempts at categorizing meditation practices proposes a new typology based not only on attentional style, but also on larger phenomenological and intentional regimes (Dahl, Lutz, & Davidson, 2015). Specifically, the authors propose that, rather than qualifying meditation practices based on their attentional locus, they be classified by family resemblances that take into consideration the overarching goals and global effects of practices. This grouping suggests three broad families: 1) attentional; 2) constructive; and 3) deconstructive.

The attentional family includes practices aimed at attention regulation and development of metacognitive abilities in order to de-enter or lessen "cognitive fusion" with the object of experience. These abilities are particularly helpful in development of self-awareness and are often used in therapeutic contexts to alleviate suffering associated with addiction (Brewer, Elwafi, & Davis, 2013), anxiety and depression (Bieling et al., 2012).

Practices in the constructive family involve cultivating perspective-taking, cognitive–affective reappraisal and the learning of prosocial and compassionate attitudes. These processes require an ability to become aware of and transform habitual patterns of reactivity to stimuli into wholesome and stable qualities. This family of practices is aligned with a particular value system and involves processes of habit formation (Vago, 2014). One example is the skill involved in transforming empathy (which can be maladaptive and create empathetic distress if not managed properly) into compassion (Singer & Klimecki, 2014) .

Finally, the deconstructive family is primarily characterized by an existential orientation towards self-inquiry and insight. These practices use attentional and habit formation skills to gain deep knowledge of the nature of the mind. This insight may produce an intense and transformative experience of a shift in the general understanding of the mind (Ding et al., 2015; Kounios & Beeman, 2014), a shift which may in turn stimulate a general reorientation of cognitive, affective and motivational processes. This focus on developing an insight into the nature of reality is rooted in the cultural and historical grounding of Buddhist practices as paths to liberation, i.e. the general Buddhist ambition at achieving enlightenment (Welwood, 2002).

Experiences and effects associated with meditation practices vary according to the level of the expertise of the practitioner. Trajectories of experience with mindfulness practices are often divided into early, middle and advanced practice depending on the amount of effort required to enter and maintain the desired state (Tang, Holzel, & Posner, 2015; Tang, Rothbart, & Posner, 2012). Moreover, temporal shifts in the quality of meditation practices have been proposed to take place on four levels (Lutz et al., 2015): changes in 1) aperture or scope of attention; 2) in clarity of experience, increasing in vividness as practice progresses (Namgyal, Kunsang, & Rinpoche, 2004); 3) in stability of practice; and 4) in degree of effort, ranging from effortful early practice to effortless advanced practice (Brefczynski-Lewis, Lutz, Schaefer, Levinson, & Davidson, 2007). All these dimensions change both the lived experience of the practice and its neural correlates.

In sum, meditation practices are classified according to a number of basic dimensions, either related to the attentional locus (focused attention, open monitoring, self-transcendence, loving-kindness), or based on a principle of family resemblance according more general attentional/phenomenological regimes (attentional, constructive, deconstructive). While there is no single, widely agreed-upon taxonomy, most of them distinguish bodily-oriented focusing as a major foundational factor. The choice of Vipassana meditators for the present study is thus representative of a very large class of meditators, combining elements from all attentional styles (starts with focused attention, continues with open monitoring, favors self-transcendence and ends with loving-kindness), and sharing some characteristics with all the three families (starts with attentional practices, aims at deconstruction and insight, and incorporates a strong constructive element).

1.5.2. Effects of meditation practice

There are many reported effects of meditation practice, and the literature is mixed with respect to both which practice leads to what specific effects, and what level of expertise is required for these effects to be most pronounced. Crucially for the present work, many cognitive functions that are sensitive to meditation practice are also associated with dreaming. For example, meditation improves general cognitive functioning (Gard, Holzel, & Lazar, 2014), emotion regulation (Desbordes et al., 2012; Guendelman, Medeiros, & Rampes, 2017), social connectivity skills including empathetic concern and altruistic behaviour (Kok & Singer, 2017a; Weng et al., 2013), and creativity (Horan, 2009; Lippelt et al., 2014). Such studies might lead us to expect that the dream experiences of meditators would differ in important respects from those of non-meditating controls.

Little is known about the potential negative effects of meditation practice. A single qualitative study examining the variety of effects of meditation practice (Lindahl, Fisher, Cooper, Rosen, & Britton, 2017) has found subjective effects to range from fleeting to enduring, and from very positive to very severe, highlighting a need for a more careful and thorough approach to mindfulness and meditation research. A complete review of the many meditation effects is beyond the scope of the present dissertation (for reviews see (Fox et al., 2016; Fox et al., 2014; Lutz et al., 2015; Sedlmeier et al., 2012; Tang et al., 2015), and the following sections will focus on the variables of most interest for the present study: body awareness, effects associated specifically with Vipassana meditation, and the relationship between meditation practices, sleep and dreaming.

1.5.2.1. Meditation is fundamentally embodied

One dimension characterizing the effects of meditation practices that is of central interest to the present work is body awareness. In classic Buddhist texts, body awareness is an integral part of mindfulness and a starting point in the development of insight. Kerr and colleagues proposed a neurophysiological framework, aligned with these Buddhist principles, which suggests that, because mindfulness meditation enhances alpha rhythm regulation in the somatosensory cortex, meditation practices may increase top-down control of thalamocortical processes and thus allow practitioners to notice alterations in their somatic state more quickly (Kerr et al., 2013). This, in turn, is hypothesized to be the basis of other cognitive improvements commonly associated with sustained meditation practice, including metacognition and emotion regulation. Cultivating interoceptive awareness is proposed to be beneficial to a number of conditions, such as cancer (Targ & Levine, 2002), mood disorders (Pollatos, Traut-Mattausch, & Schandry, 2009), disordered eating (Myers & Crowther, 2008), addiction (Goldstein et al., 2009) and others. As discussed earlier, according to embodied mind positions, a coherent sense of self may depend on interoceptive awareness (Craig, 2003; Seth, 2013; Varela et al., 1992). A number of studies (see below) tackle the question of whether or not meditation practitioners are better than non-meditators in sensing and discriminating between different body sensations.

In a 3-month long study of four different kinds of meditation (the ReSource Project), a large sample of participants (N=1076) practiced breath meditation and body scanning meditation (Bornemann, Herbert, Mehling, & Singer, 2014). Tests on a number of aspects of interoceptive awareness, including the noticing of bodily sensations, revealed that individuals with the lowest interoception scores at the outset improved the most at re-test. Similarly, Fox and colleagues report higher interoceptive precision in Vipassana meditators (Fox et al., 2012). Other aspects of proprioceptive and somatic awareness have also been improved by meditation. For example, respiratory accuracy increased in meditation practitioners (Daubenmier, Sze, Kerr, Kemeny, & Mehling, 2013; Krygier et al., 2013) while heartbeat perception accuracy was improved for meditators (Bornemann & Singer, 2017; Khalsa et al., 2008; Nielsen & Kaszniak, 2006; Parkin et al., 2014). In general, mindfulness practice over time is thought to cultivate a trait-like capacity for increased bodily awareness by altering cortical structures such as insula and temporoparietal junction that are typically associated with the processing of interoceptive information (Holzel, Carmody, et al., 2011; Holzel et al., 2008; Lazar et al., 2005).

1.5.2.2. Vipassana meditation: a focus on body awareness

In our empirical study of sleep and dreaming in meditators (Article III), we solicited help from Vipassana meditation practitioners in the S.N. Goenka tradition (Goenka, 1997; Hart, 1987) for two main reasons. First, a defining characteristic of this meditation style is the practice of body scanning; practitioners slowly and systematically learn to notice body sensations with ever increasing levels of subtlety. This practice, while non-verbal by design, likely leads to increased interoceptive accuracy (Daubenmier et al., 2013; Fox et al., 2012) and to better awareness of somatic states that are usually unavailable to reflective consciousness. Thus, Vipassana meditators may be seen as an expert group of individuals who are unusually attuned to their bodily sensations. A second reason for choosing Vipassana as the target practice group is that a wide variety of meditation practices are popular and available today in Canada and we wished all participants to follow the same steps and receive the same instructions. Vipassana practitioners in Goenka's tradition are all required to complete at least one 10-day full-time silent retreat, during which they receive specific, standardized practice instructions that are identical in all Goenka centers around the world (dhamma.org).

While Vipassana meditation draws upon elements of all four types of meditation (open monitoring, focused attention, self-transcending, and loving-kindness), its focus is clearly on bodily awareness. Practitioners typically start with mindfulness of breathing (focused attention), then gradually progress to alternating between body scanning and monitoring of bodily states (focused attention and open monitoring). Only later in the sequence of steps does the individual engage in *metta* (loving-kindness) meditation, and, ultimately insight (self-transcendence) into the conditioned and non-dual nature of reality.

1.5.2.2.1. Effects of Vipassana meditation

Overall effects of Vipassana meditation are generally the same as those reported for other schools of contemplative practice. In general, Vipassana meditation decreases subjective feelings of stress (Szekeres & Wertheim, 2015), improves psychological well-being (Montero-Marin et al., 2016), generates greater perceptual clarity, decreases automated reactivity to stimuli (Cahn, Delorme, & Polich, 2013; Cahn & Polich, 2009; Delgado-Pastor, Perakakis, Subramanya, Telles, & Vila, 2013), and decreases anger, hostility and depressive symptoms (Kasai et al., 2015). Other studies report improved psychological and cognitive flexibility (Kasai et al., 2015) and increased heart rate variability, a marker of autonomic nervous system health (Krygier et al., 2013). Vipassana meditation also improves attention; for example, after an intensive 3-month retreat (Slagter et al., 2007) significant improvement was found on an attentional blink task. In another study (Delgado-Pastor, Perakakis, Subramanya, Telles, & Vila, 2013), Vipassana meditators showed greater amplitude in event-related potentials than did controls, suggesting that this form of mental training may alter one's ability to allocate attentional resources.

Some of the effects of Vipassana training that reflect the practice's experiential elements include increased somatosensory awareness, more spontaneous body movements, increased trait mindfulness, and the development of equanimity or the ability to adapt to extreme changes in lived experience (Kornfield, 1979). Since Vipassana meditation often involves elements of other-oriented practices, such as loving-kindness, its effects also extend beyond the immediate effects of cultivating sensory acuity to involve broader positive consequences on personal and social life. For instance, Vipassana interventions in prison settings improved social relations, generated a more positive atmosphere in a difficult environment, created a context for overcoming ordeals (Ronel, Frid, & Timor, 2011) and diminished rates of substance abuse (Simpson et al., 2007).

In sum, Vipassana meditation was chosen for the present study primarily because of its focus on practices of encouraging bodily-oriented awareness, including its effects on attentional processes, sleep and body awareness. Contrasting the sleep and dreaming features of Vipassana meditators with non-meditating controls thus provides an excellent opportunity to examine embodied characteristics of mind in wake and in sleep. Specifically, we will study the interplay between procedural learning, sleep and dreaming.

1.5.2.3. Meditation is beneficial for memory

Considering the mounting evidence that meditation practices are beneficial for cognitive function, including for attentional skills and cognitive flexibility, it is reasonable to suppose that meditation should have beneficial effects on learning (Jha, Krompinger, & Baime, 2007; Valentine & Sweet, 1999; Zeidan, Johnson, Diamond, David, & Goolkasian, 2010). However, few studies to date have examined the effects of meditation practice on memory. Kirtan Kriya meditation was shown to improve performance on a declarative memory task (Innes, Selfe, Khalsa, & Kandati, 2017). Albers and Thewissen examined the effects of mindfulness on emotional declarative memory for words with negative and positive valence (Alberts & Thewissen, 2011). The group that received brief mindfulness training correctly recalled fewer negative words and the same number of positive words as an untrained control group. This suggests that effects of meditation practice may be less related to improved memory retention and more to selective remembering; this may be due to changing of one's attentional pattern and developing of a bias against engagement with negative experiences. In contrast, another study reports only a few differences between long-term meditation practitioners (including Vipassana meditators) and non-meditating controls; meditators showed better performance on short-term and free recall long-term memory (Lykins, Baer, & Gottlob, 2012) but not on working memory or long-term cued-recall task. Other studies report superior working memory in meditation practitioners (Mrazek, Franklin, Phillips, Baird, & Schooler, 2013), including in a military cohort (Jha, Stanley, Kiyonaga, Wong, & Gelfand, 2010), and a group of adolescents (Quach, Jastrowski Mano, & Alexander, 2016). Similarly, short meditation training was reported to enhance working memory and decrease worry in novices (Course-Choi, Saville, & Derakshan, 2017).

With respect to procedural motor memory specifically, one study assessed the contribution of training in meditation to memory consolidation (Immink, 2016);

experienced yoga *nidra* meditation practitioners showed post-training memory benefits on a sequence tapping task. In a second study (Yadav & Mutha, 2016), a group that practiced deep meditative breathing exercises improved significantly more on a hand-eye coordination motor task than did a control group.

In our study (Article III), we used a full-body task (as opposed to a hand only or a hand-eye coordination task as are commonly used in procedural memory research) to test differences between Vipassana meditators and controls. Our rationale was based on the fact that, because Vipassana meditators possess a particular expertise in body awareness, they will show better initial performance levels on the task and will improve more as a function of an intervening sleep opportunity than will a control group.

1.5.3. Meditation and dreaming

Few studies to date have examined relationships between dream content and meditation/mindfulness practices. Most existing research has focused on the cross-state continuity idea, suggesting that cognitive skills cultivated by engaging in contemplative practices, especially waking reflective awareness, are reflected either in dream qualities (such as reflectiveness and control) or in an increased incidence of lucid dreams. For example, in one study Lee and Kuiken (2015) report that waking trait mindfulness was positively associated with dream reflectivity and, conversely, that dream mindfulness, especially when present in impactful/transcendent dreams, predicted changes in waking self-reflection. Similarly, another study reports a positive relationship between waking mindfulness and dream mindfulness (Rider, 2012).

The idea that daytime meditation practices and development of awareness influence different qualities of sleep, and especially the frequency of lucid dreams, has been emphasized by many contemplative practices and is most explicitly present in the Tibetan Dzogchen tradition, commonly referred to in the West as Dream Yoga (Holecek, 2016; Norbu, 2002; Wallace, 2012). Lucid dreaming refers to dreams in which the dreamer is aware of the fact of dreaming, and may develop a certain degree of control over dream actions and construction of the dream environment (LaBerge, 2009; LaBerge & Rheingold, 1991). A few studies have reported on relationships between meditation practices and lucid dreams, most commonly showing elevated levels of dream lucidity and dream control in meditators (Gackenbach, Swanston, & Stark, 2015; Hunt, 1988). In a recent online questionnaire study (Stumbrys, Erlacher, & Malinowski, 2015), a higher than average (73% vs. 50% in general population) frequency of lucid dreams was reported for meditation practitioners, and lucid dreaming frequency was positively correlated with trait mindfulness. Similarly, middle of the night meditation practice increases dream lucidity, and, when combined with pre-sleep dream reliving exercises, increases the qualities of constructive engagement and reflectiveness in dream content (Sparrow, Thurston, & Carlson, 2013). Finally, an early study (Faber, Saayman, & Touyz, 1978), reports a higher frequency of dream recall, longer laboratory dreams and marginally longer home dreams in Yoga meditation practitioners as compared to non-meditating controls; there was also a higher incidence of "archetypal" themes in the dreams of meditators, i.e., themes characterized by mythological references, emotionality, irrationality and remoteness from everyday life.

Further, trait mindfulness may play a protective role against dysphoric dreams. , A questionnaire study of undergraduate university students (Simor, Koteles, Sandor, Petke, & Bodizs, 2011) found that trait mindfulness was inversely related to disturbed dreaming, including nightmares and night terrors, and was associated with lower dream anxiety. While there are no studies to our knowledge that used meditation/mindfulness-based interventions for treating nightmares, both meditation (King et al., 2013; Lang et al., 2012; Simpson et al., 2007) and lucid dreaming training (Been & Garg, 2010; Mota-Rolim & Araujo, 2013; Spoormaker & van den Bout, 2006; Zadra & Pihl, 1997) have beneficial effects on post-traumatic stress disorder, a condition characterized by intense and recurrent nightmares. Meditation practices that cultivate non-judgmental self-awareness may be particularly beneficial for alleviating the distress of sleep paralysis nightmares. Increased awareness of the present moment, including of bodily sensations, may help patients in developing a non-attached awareness of their disturbing dream; chanting and visualization practices may allow them to become more familiar with how the mind conjures vivid and intense imagery, thus generating insight into how troubling dreams and nightmares are formed.

In sum, literature on the relationships between meditation, trait mindfulness and dream content is limited. Available results generally converge on the notion of a cognitive and affective continuity between waking and dreaming in that skills of awareness and reflexivity cultivated through meditation also become characteristic of dream experiences. Accordingly, some studies suggest higher levels of dream awareness (lucidity) among meditators. Additionally, mindfulness may function as a mechanism of protection against dysphoric dreams, although research on this question is sorely needed. Research on the impact of Vipassana meditation on dream content is also lacking. To further research on meditation and dreaming, the present study focuses on clarifying relationships between Vipassana meditation experience, body awareness, and dream content.

1.5.4. Meditation alters sleep architecture and sleep quality

Our present focus on the dreams of Vipassana meditators provides an opportunity to also study their sleep patterns. While embodied theories of mind may be silent on questions of how sleep impacts body awareness, there is evidence that meditation has a beneficial effect on sleep (see below). To further study of this important topic, we opted to compare our meditating and non-meditating groups on standard measures of sleep architecture.

Current knowledge about the influence of meditation on sleep points to two complimentary effects (Britton, Lindahl, Cahn, Davis, & Goldman, 2014). On the one hand, meditation practices, including a mindfulness-based therapy for insomnia (Ong, Shapiro, & Manber, 2008, 2009), may promote relaxation (Lazar et al., 2000), improve sleep (Britton, Bootzin, et al., 2010; Shapiro, Bootzin, Figueredo, Lopez, & Schwartz, 2003), and reduce insomnia (Garland, Zhou, Gonzalez, & Rodriguez, 2016). On the other hand, a growing literature that is both qualitative, in the form of first-person reports (Kornfield, 1979), and empirical in nature suggests that meditation practice promotes vigilance and results in shorter total sleep times (Kaul, Passafiume, Sargent, & O'Hara, 2010).

1.5.4.1. Meditation, sleep quality and insomnia

A number of mindfulness-based interventions for insomnia have recently been employed (for review see (Garland et al., 2016)). Results suggest that their efficacy is mixed and likely dependent on insomnia etiology (primary vs. secondary), population type (adolescents, adults, cancer patients, depressed individuals, and others), and the kinds of cognitive alterations implicated in particular sleep problems (rumination, hypervigilance, etc.). Trait variables may also be involved since dispositional mindfulness is associated with subjectively better sleep quality (Brisbon & Lachman, 2017). Overall, mindfulness-based interventions may be particularly effective when improvement in sleep quality is their primary target (Garland et al., 2016).

The variability of results among studies can be partly explained by the heterogeneity of meditation practices employed and differences in practice expertise. For example, in one study of a mindfulness-based sleep intervention (Britton, Bootzin, et al., 2010), sleep duration increased with short bouts of weekly meditation practice (< 1h/week) but decreased with longer bouts (>3h/week). Similarly, an experienced Shamatha meditator reports that her sleep duration increased to about 8 hours per night at the beginning of an intensive 3-month retreat (12+ hours of meditation per day) and subsequently decreased to as little as 1.5-3 hours per night as the retreat progressed (Britton et al., 2014).

1.5.4.2. Polysomnographic characteristics of sleep in meditators

Few studies to date have focused on sleep PSG characteristics in meditation practitioners, and results are again mixed. Three studies of long-term meditation practitioners (Berkovich-Ohana, Glicksohn, & Goldstein, 2012; Cahn, Delorme, & Polich, 2010; Ferrarelli et al., 2013), including Vipassana practitioners (Berkovich-Ohana et al., 2012; Cahn et al., 2010), revealed a pattern of increased parietal-occipital EEG gamma (25-40HZ) power in NREM sleep which correlated with meditation expertise and with resting state wake EEG characteristics. In Vipassana and loving-kindness meditation novice practitioners, however, intensive meditation training periods provoked an increase in low-frequency EEG oscillations (7-8 Hz) in prefrontal and left parietal derivations in NREM sleep (Dentico et al., 2016). This suggests that meditation practice may engender long-term cross-state changes in brain activity which may engage a variety of neural networks associated with thought, cognition, imagery and attention, including the default-mode, salience, and self-referential networks.

With regards to sleep architecture, several studies have compared meditators and matched controls. First, alterations in REM sleep have been reported. These include lower REM density in transcendental meditation (Mason et al., 1997) and Vipassana meditation (Maruthai et al., 2016) practitioners, longer duration of REM sleep (Maruthai et al., 2016; Pattanashetty et al., 2009; Sulekha, Thennarasu, Vedamurthachar, Raju, & Kutty, 2006), and altered REM sleep organisation (Maruthai et al., 2016). Lower N2 sleep was also observed in Vipassana practitioners (Sulekha et al., 2006). In one study, however, a lower proportion of REM sleep in yoga meditation practitioners was reported (Patra & Telles, 2009). Higher SWS was reported in older Vipassana practitioners (Pattanashetty et al., 2009; Sulekha et al., 2006), and in yoga meditators (Patra & Telles, 2009). In a cohort of medicated depressed patients in partial remission (Britton, Haynes, Fridel, & Bootzin, 2012) an 8-week MBSR intervention improved subjective sleep quality and showed changes in polysomnographic sleep characteristics, specifically, an improvement in sleep continuity (less total wake time). However, in non-medicated, partially remitted, depressed individuals undergoing an 8-week MBSR intervention, more awakenings, higher percentage of N1 and less SWS were induced (Britton, Haynes, Fridel, & Bootzin, 2010); these characteristics increased with amount of meditation practice in a linear fashion.

Studies on sleep spindle characteristics in meditation practitioners are lacking. The only study to my knowledge that included spindle activity in analysis of sleep reports an increase in sigma (spindle band) activity early in the night following short and intense meditation training (Dentico et al., 2016). However, this study did not investigate spindle density, localisation or other parameters.

In sum, studies reveal several effects of meditation on sleep. Some of these findings are consistent with findings on dreaming, especially in demonstrating improvements in REM sleep as a function of meditation. It may be that the more frequent, longer REM periods produced by regular meditation lead to more vivid, less dysphoric dreaming including, especially, more lucid and archetypal dreams. In the present study, our assessments of the polysomnographically recorded sleep of meditators will allow us to check on the replicability of these findings and to test the hypothesis that global cognitive changes brought about by Vipassana meditation practice include improvements in bodily awareness and change in sleep characteristics. The study will also allow us to determine if meditation-induced changes extended into the domain of sleep-dependent learning and dream alterations.

2. Objectives and Methods

The overarching goal of the present dissertation is to situate the mind in sleep within the framework of embodied mind. This will be accomplished through a set of three objectives:

1. to outline a theoretical framework that describes the embodied dreaming position and proposes practical avenues for exploring relationships between waking and dreaming phenomenology (Article I and section 1.2.4 of the Introduction);
2. to review the phenomenology, neurobiology and treatment of one waking/dreaming overlap phenomenon–sleep paralysis—that illustrates the distinctive nature and variety of bodily dream imagery (Article II);
3. to conduct an empirical study that tests the notion that the practice of Vipassana meditation, characterized by enhanced interoceptive and bodily awareness, changes the neurobiological and experiential qualities of sleep- and dream-dependent memory consolidation of a procedural balance task (Article III)
   a. additional objectives of the study were to investigate how somatosensory stimulation in sleep affects dream content (Discussion section 6.3.7) and whether meditation practitioners have significantly different dreams (Discussion section 6.4.8).

2.1. A Theoretical framework for an embodied and enactive approach to dreaming

While cognitive science does not generally include sleep and dreaming within the framework of embodied experiences, phenomenological work provides important insights into the fundamental features of imaginal life and, to a lesser extent, dreaming. The embodied dreaming proposition will make use of phenomenological traditions of Merleau-Ponty and Husserl, the philosophy of enactivism and the embodied mind, and the cognitive science of sleep and dreaming to advance the argument that dreaming is an embodied and intersubjective process of imaginary sense-making in an oneiric world.

In addition to discussing dream life from an embodied perspective, the present dissertation aims at outlining a practical approach to study the variety of dreaming experiences. Specifically, I argue for an integrative neurophenomenological framework that is complimentary to existing philosophical and cognitive neuroscience approaches. My intent is to expand the scope of existing approaches to include dream phenomenology and the assessment of quantifiable formal dream qualities (what I refer to as the "breadth" or the *what* of dreaming). By elaborating such a first- and second-person inquiry, subtler and more fundamental elements of oneiric formation (what we propose to be the "depth" or the *how* of dreaming) may be uncovered.

By situating dreaming on a continuum of skilful, engaged and embodied sensorimotor experiences, I also challenge the strong separation between dreaming, imagination and perception as distinct "states" of consciousness. Instead, we propose that qualities of waking perception are present in dreaming, albeit often in an altered form, and qualities of dreaming and imagination may also spill over into the waking mind. One of the guiding goals of the present dissertation is to provide some ground for fitting the wide variety of dreaming experiences into the larger matrix of mental experience and to clarify the intricate interrelatedness between the habits and skills lived when awake and those lived during dreaming.

2.2. Sleep paralysis as a case study of embodied cognition in sleep

In Article II I discuss the current state of knowledge of the phenomenology, neurobiology, and current treatment strategies for sleep paralysis. More precisely, I approach SP from the embodied mind perspective and discuss it as part of a continuum of oneiric experiences. I argue that SP is best understood as a form of an intensified dream experience (as opposed to a delusional or paranoid hallucination) in which bodily experiences become especially salient. SP is thus particularly relevant to the present discussion of the embodied and enactive cognition. Due to its overlap between dreaming and waking experiences and to its salient bodily experiences, SP provides a vivid example of spontaneous, affective, intersubjective and spatial process of sense-making, grounded in the social and cultural milieu of the dreamer. SP can thus be explored and assessed through observational, empirical and contemplative methods.

2.3. Embodied sleep, dreaming and memory in Vipassana meditation

Finally, the embodiment of mental experience in sleep will be probed in an empirical study that compares patterns of sleep- and dream-dependent procedural memory consolidation in Vipassana meditation practitioners and non-meditating controls. We expect that processes of neuroplasticity, associated with sustained Vipassana meditation practice, extend into larger-scale changes in styles of memory processing and dreaming. This study has a number of sub-objectives:

1. To assess whether Vipassana meditators outperform non-meditating controls on a procedural balance task;
2. To test whether Vipassana practitioners and controls differ in the sleep-dependent style of memory consolidation;
3. To evaluate whether meditators incorporate a procedural task into dream content to a greater extent than do controls, and whether dreaming about the task is related to improvement on that task;
4. To assess whether the sleep architecture of meditators differs from that of controls.
5. To investigate how somatosensory stimulation delivered during sleep alters dream content;
6. To explore whether dream qualities of Vipassana meditators reflect their mental styles and the aspirations of their practice: namely, whether meditators have longer dream reports, show more empathetic interactions with dream characters, and are more lucid in their dreams;

Objectives 1-4 are discussed in Article III. Preliminary results concerning objectives 5-6 are presented in sections 6.3.7 and 6.3.8 of the Discussion

2.3.1. Methodology of the empirical study

The empirical study was approved by the Sacre-Coeur Hospital's ethics board; all participants signed an informed consent form and were advised that they were free to withdraw from the study at any time without penalty. They were financially compensated for their time ($ 120). Vipassana meditation practitioners in S.N. Goenka's tradition and matching controls were recruited via advertisements on university online forums and by word of mouth.

2.3.1.1. Study protocol

Participants arrived at the at the Dream and Nightmare Laboratory (at the Center for Advanced Research in Sleep Medicine, Sacré-Coeur Hospital, Montreal) at approximately 9:00 am. They signed an informed consent form and had an opportunity to ask any questions about the experiment. They then completed the procedural learning task and had electrodes installed. The latter was a standard PSG setup with F1, F2, C3, C4, O1, and O2 EEG, chin, leg and arm EMG, and horizontal and vertical EOG channels. A somatosensory stimulation apparatus (see below) was then installed on the right ankle. Vipassana meditators (MED group) meditated for about 30 minutes prior to the nap, and non-meditating controls (CTL group) relaxed in bed for the same amount of time. Participants then took a nap in a private room equipped with video and audio monitoring. They were awakened for dream collection first at sleep onset (N1 sleep), and then during REM or N2 sleep after approximately 1.5 hours of sleep had elapsed. A stimulation group had the somatosensory stimulation device inflated first at sleep onset and then during REM sleep. Participants in the stimulation group, who did not reach REM sleep by the end of their nap, did not have the cuff inflate before awakening. Awakenings were conducted after 5 minutes of continuous stimulation maximum using an 80-decibel tone and semi-structured dream interviews were conducted (see Appendix 1). If participants showed signs of arousal or awakening, stimulation was either suspended, or they were awakened immediately for dream collection. After the final dream interview, the electrodes were removed and participants had an opportunity to shower before completing the procedural task once more.

After this, they were debriefed and left the lab (see Figure 1 for the schematic representation of the study design).

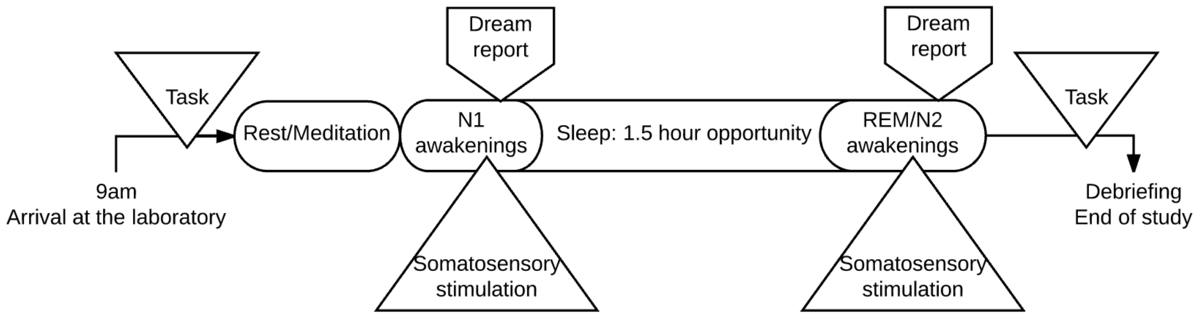

Figure 1. Study protocol. Upon arrival, participants completed a procedural learning task (Wii Fit, Bubble Balance game); then the control group rested for 30 minutes while meditation group meditated. N1 (Non-rem sleep, stage 1) awakenings were effectuated after 5 seconds of theta activity had elapsed, followed by awakenings for dream reports. Participants then had a sleep opportunity of 1.5 hours. They were then awakened either from REM of from N2 sleep for dream reports. Some participants (stimulation group) underwent somatosensory stimulation of the right ankle prior to N1 and REM awakenings.

2.3.1.2. A novel procedural task

For the purposes of this study we used a novel procedural task: a Nintendo™ Wii Fit™ system Bubble Balance game. The task was performed on the Wii Fit balance board projected on a 72-inch, flat-screen television set. In the game, the participant is represented on the screen as a small avatar inside a bubble, which they must navigate along a river without hitting obstacles or the river's edge, bursting their bubble and ending their run (see Figure 2 for a screenshot of the game). Participants had an initial 2-minute training session during which they became acquainted with the apparatus and game mechanics. They then had a total of 5 minutes to move their avatar as far as possible along the virtual river, restarting every time they burst their bubble.

This task was chosen due to the fact that it requires using the whole body to navigate an environment. Thus, it is more immersive than tasks usually used to investigate procedural memory, and involves more than hand-eye coordination to complete (as opposed to, for example, a mirror tracing task or a rotor pursuit task).

Figure 2. A screenshot of the Nintendo Wii Fit "Bubble Balance" game. Participants rely on shifting their balance on a force platform to navigate the avatar downstream without bursting the floating bubble on obstacles or the river edge. (Image source: Ign.com website: http://wiimedia.ign.com/wii/image/article/864/864050/wii-fit-20080402033441054_640w.jpg)

2.3.1.3. Polysomnography

Participants slept in a quiet bedroom under continuous audio-visual monitoring with a two-way intercom. A standard polysomnographic (PSG) montage was used: 6 EEG channels (F3, F4, C3, C4, O1, O2) referenced to A1 and re-referenced to A1+A2 offline; four electrooculography (EOG) channels (horizontal and vertical), and three electromyography (EMG) channels (chin, wrist, leg). Acquisition of EEG signals was done using an M15 Grass Acquisition System (−6 dB filters with cut-offs at 0.30 and 100 Hz) and Harmonie v6.2b software (Natus Medical Incorporated, Pleasanton, CA, USA). Sleep stages were scored according to standard criteria (Iber, 2007) by an experienced technician and standard sleep variables were calculated using in-house software.

Sleep spindles were detected on artifact-free sleep epochs recorded from F3, F4, C3, C4, O1 and O2 derivations by an in-house detector. The full detection algorithm is described by Nielsen et al (2016) and by O'Reilly and Nielsen (2014). Spindles were separated into slow (10.00-12.99 Hz) and fast (13.00-16.00 Hz) types and densities calculated as the number of spindles of each type divided by time in seconds elapsed in N2 sleep.

2.3.1.4. Somatosensory stimulation protocol

To test whether somatosensory stimulation is incorporated into dream content differentially for meditators and non-meditators, participants were fitted with a blood pressure cuff on the right ankle. Prior to bedtime, the cuff was inflated to habituate the participant to the stimulation apparatus. An individual threshold for discomfort was established (in mm/hg), and the experimental stimulation pattern was set below that value, which was close to 160-180 mm/hg, a typical pressure applied when measuring blood pressure. Participants were then randomly assigned to either the experimental or the control group. The experimental group had the cuff inflated to below discomfort threshold 1) at sleep onset according to the Hori scoring system sub-stage 4 or 5, after at least 5 seconds of theta EEG activity had elapsed, and 2) after 10-15 minutes of sustained REM sleep had elapsed or after about 1.5 hours of sleep had elapsed, whichever came first. The cuff was inflated for about 5 seconds at sleep onset, and for about 5 minutes during REM sleep. The exact duration of stimulation varied according to whether the participant showed EEG signs of arousal (e.g. alpha activity, muscle tonus); if so, the cuff was deflated and the participant was awakened for dream report collection.

2.3.1.5. Dream report collection and analysis

Participants were awakened by an 80 decibel, 500-Hz tone, and remained in bed for the duration of the semi-structured dream interview. They were first asked to report anything that they remembered and then to respond to a series of questions (see Appendix 1). These exchanges were recorded and subsequently transcribed verbatim.

Preliminary analyses tested whether the dreams of Vipassana meditation practitioners were qualitatively different from the dreams of controls in length, emotional tone, quality of interpersonal relations, and metacognitive awareness (see Table 2). To measure dream lucidity, we used criteria developed by Voss and colleagues (Voss, Schermelleh-Engel, Windt, Frenzel, & Hobson, 2013), including measures of lucid insight, degree of control, logical thought, and bizarreness. Dreams were scored by two trained research assistants blind to group (meditators, controls) and experimental condition (stimulation, no stimulation). Preliminary results of these analyses are presented in 6.3.8 of the Discussion.

Table 2. List of variables used for scoring of dream qualities

Variable	Measurement method
Length of the dream report	Total word count in number of words
Emotional tone	1-9 Likert-type scale: 1=negative, 5=neutral; 9=positive
Dreamt locus of control	scored on 1-9 Likert-type scale: 1=internal; 7=external locus of control over the dream environment
Friendly interactions with dream characters	scored on a 1-9 Likert-type scale: 1=hostile; 5=neutral; 9=friendly interactions
Compassionate interactions with dream characters	scored on a 1-9 Likert-type scale: 1=selfish; 5=neutral; 9=compassionate interactions
Indications of lucidity/metacognitive awareness in the dream:	
Lucid insight	scored on a 1-5 Likert-type scale: 1=no insight; 5=explicitly states having insight into the fact that this is a dream
Degree of control over the dream	scored on a 1-5 Likert-type scale: 1=no control; 5=full control of own movements and dream scenario
Logical thought during the dream	scored on a 1-5 Likert-type scale: 1=not logical; 5=very logical and appropriate to the dream
Bizarreness	scored on a 1-5 Likert-type scale: 1=not bizarre at all; 5=very bizarre

3. Article I: Exploring the Depth of Dreaming

Exploring the depth of dream experience: enactive framework and methods for neurophenomenological research

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Published in: *Constructivist Foundations*

Contribution of authors:

Elizaveta Solomonova: took the lead on development of the theoretical framework, wrote the manuscript, revised the manuscript

Sha Xin Wei: contributed to theoretical framework, manuscript writing and revision

Structured Abstract

Paper type: conceptual (philosophical-argumentative support)

Background(s) – cognitive; epistemological; philosophical; psychological; sociological

Perspective –enactive cognitive science

Context – Phenomenology and the enactive approach pose a unique challenge to dream research: during sleep one seems to be relatively disconnected from both world and body. Movement and perception, prerequisites for sensori-motor subjectivity, are restricted; the dreamer's experience is turned inwards. In cognitive neurosciences, on the other hand, the generally accepted approach holds that dream formation is a direct result of neural activations in the absence of perception, and dreaming is often equated with 'delusions'.

Problem – Can enactivism and phenomenology account for the variety of dream experiences? What kinds of experiential and empirical approaches are required in order to probe into dreaming subjectivity? Investigating qualities of perception, sensation and embodiment in dreams, as well as the relationship between the dream-world and waking-world requires a step away from a delusional or altered state framework of dream formation and a step toward an enactive integrative approach.

Method – In this paper we will focus on the 'depth' of dream experiences, i.e. what is possible in the dream state. Our paper is divided into two parts: a theoretical framework for approaching dreaming from an enactive cognition standpoint; and discussion of the role and strategies for experimentation on dreaming. Based on phenomenology and theories of enactivism, we will argue for the primacy of subjectivity and imagination in the formation of lived experience.

Results – We propose that neurophenomenology of dreaming is a nascent discipline that requires rethinking the relative role of third-, first- and second-person methodologies, and that a paradigm shift is required in order to investigate dreaming as a phenomenon on a continuum of conscious phenomena as opposed to a break from or an alteration of consciousness.

Implications – Dream science, as part of the larger enterprise of consciousness and subjectivity studies, can be included in the enactive framework. This implies that dream experiences are not passively lived nor functionally disconnected from dreamer's world and body. We propose the basis and some concrete strategies for an empirical enactive neurophenomenology of dreaming. We conclude that investigating dream experiences can illuminate qualities of subjective perception and relation to the world, and thus challenge the traditional subject-object juxtaposition.

Constructivist content: This paper argues for an interdisciplinary enactive cognitive science approach to dream studies.

Key Words – dreaming, enaction, first-person research, consciousness, neurophenomenology.

Introduction

Dreams have traditionally occupied a marginal place in cognitive science. Like most philosophy of mind, cognitive science largely has been concerned with awake and alert subject of experience, interacting with her world and with others. First-person reports have commonly been approached with suspicion by behavioral scientists, as they are prone to error, to confabulation and to temporal and factual uncertainties. Dreaming, then, is an even more difficult subject to study, as it requires not only attention to ongoing mental experience, but also maintaining that attention despite a change in psychophysiological state (from sleeping to wakefulness).

Recent years, however, have seen an important rise in the scientific interest in the study of subjective experiences, and radical skepticism regarding the trustworthiness of first-person reports (Nisbett & Wilson, 1977) is gradually being replaced by a variety of interview methods, taking seriously both neurophysiological 'objective' data and phenomenology of the concurrent experience (Petitmengin, 2007; Petitmengin & Bitbol, 2009, Overgaard, Gallagher & Ramsay, 2008). In dream research, even though the first-person data has always been taken seriously, a number of researchers and philosophers have challenged the trustworthiness of dreamers' reports and even the status of dreaming as a real-time lived experience (Dennett, 1976). Currently, however, due to increasing research on lucid dreamers and on populations with high dream recall, the first-person accounts of oneiric experiences are mostly taken at face value, and researchers are encouraged to collect subjective reports to complement sleep data, assuming that dream content is 'transparent' and accessible to the subject of experience, and therefore trusting study participants to report to the best of their ability their dream (Windt, 2013, 2015).

Depth and breadth of dreaming

Dream research today is a heterogeneous and vibrant field, combining researchers from neuroscience, psychology, cognitive science, philosophy and other fields. Each field has approached dream processes and dream content using its own frameworks and tools, and therefore the questions asked depend on the place that dreaming occupies in a particular field of study. In this paper we will focus specifically on the fundamental and methodological aspects of studying the 'depth' of dream experience. By 'depth' we mean the fine-grained investigations of rich qualities of dream content. Investigating depth of dream experiences would imply studying more than just formal qualities of dream content, including temporal dynamics of dream formation, affective qualities of dreaming, and phenomenology of how dream appears to the dreamer. We contrast 'depth' to 'breadth', by which we mean a range and a variety of experiences in a formal sense. In general terms, we propose that breadth of dreaming refers to the study of what is typical for dream content in a given population, while depth of dreaming would probe what is possible in the dream state (Solomonova, Fox & Nielsen, 2014). In this sense, we follow Petitmengin (2006) and Gendlin (1986) in an attempt to shift focus from the 'what' - the breadth of dream experiences, to the 'how' - the depth of dream experiences. Uncovering the depth of dreaming involves changing research question from 'what are you dreaming of' to 'how do dream elements appear/feel to you'. For example, researchers interested in 'breadth' of dreaming would quantify the many different kinds of dream characters: family members, friends, work relations, TV personalities, etc. To study 'depth' of these dreams one would instead ask detailed questions about the qualities and the feel of dream characters: how did they appear to the dreamer, when and how did the dreamer know who they were, what emotion did the characters elicit in the dreamer, what was the context for their appearance, etc. In other words, by 'breadth' we mean expanding quantifiable categories of dream elements, and by 'depth' we mean zooming in on dream elements in order to explore their manner of appearance in temporal, spatial and affective terms. While investigating depth of dreaming may seem to sacrifice the quantitative aspect, by looking closely at qualities of dream experience it is possible to discover complex processes and expand the list of formal quantifiable categories of dream characteristics and their attributes.

A number of formal approaches, focused on the 'breadth' of dreaming, currently exist. Most methods used in cognitive neuroscience of dreaming consist of scoring dream reports for presence/absence of particular dream elements (settings, characters, objects, animals, friendly/aggressive interactions, etc.). The most used method is known as Hall and Van de Castle content analysis (Bulkeley, 2014; Hall & Van de Castle, 1966; William

Domhoff & Schneider, 2008), which consists of lists of categories and sub-categories of dream elements, settings, interactions, etc. A number of studies used this method in the context of the continuity hypothesis – the idea that dream content reflects elements and concerns of the current situation of the dreamer (Schredl, 2010; M. Schredl & Hofmann, 2003). Other studies have employed similar formal content analysis methods, scoring dream content for specific elements of interest, appearing in the dream, such as maternal representations (Lara-Carrasco, Simard, Saint-Onge, Lamoureux-Tremblay, & Nielsen, 2013), animals (Lewis, 2008), and others. Such quantitative methods for investigating the frequency of appearance of formal categories in dream content are representative of the 'breadth' approach to dream experience and show a number of age, gender (Nielsen, 2012; Waterman, 1991), and clinical (Bugalho & Paiva, 2011; Khazaie et al., 2012) differences (such as dreaming in schizophrenia or in Parkinson's disease) in dream content that provide normative information about typical dream content of a given population.

Another line of research targeting breadth of dreaming, but with the addition of certain qualities of the depth, aims at elucidating temporal patterns of memory source incorporations into dreams by tracing elements from either participants' own dream diaries (Blagrove, Henley-Einion, Barnett, Edwards, & Heidi Seage, 2011) or from target experiences in the laboratory, such as unusual films (De Koninck & Koulack, 1975), video games (Wamsley, Perry, Djonlagic, Reaven, & Stickgold, 2010) or virtual reality ([reference deleted by the editors]). By tracing concrete elements in dreams (such as salient elements from a disturbing film or specific places/characters from virtual reality), patterns emerge, showing that dream content reacts to lived experiences in a dynamic temporal manner, incorporating salient and personally important elements into the dream content on the first night – the day residue phenomenon (Freud, 1900; Hartmann, 1968) – and then re-incorporating some elements 5-7 days later – the dream-lag effect (Blagrove et al., 2011; Nielsen, Kuiken, Alain, Stenstrom, & Powell, 2004; Nielsen & Powell, 1989). In these studies not only the formal qualities of dreaming are assessed, but also the temporal qualities of memory sources, which not only contribute to elucidating the fundamental processes of dream formation, but also relate to more difficult questions of individual sense-making and processes of production of meaning of the lived experience. The depth of dreaming, however, has not been investigated systematically by contemporary empirical cognitive sciences.

This paper is divided into two parts. In the first part we will present our view of inseparability of imagination processes from perception and describe the role of dream experiences within the enactive framework. Our argumentation is grounded in some of the contemporary enactive approach (Thompson, 2007; Varela, Thompson & Rosch, 1991, Steward, Gapenne & Di Paolo, 2010; Colombetti, 2013; Noe, 2004), and in the phenomenological tradition (Merleau-Ponty, 2010; 2012). We will present an embodied and enactive view of dreaming as a process of imagination grounded in embodied subjectivity and motivated by affect. In the second part we will present possible interdisciplinary empirical strategies for neurophenomenological investigation of dream experiences. We will first discuss potential methods of eliciting detailed dream reports and training participants to be aware of their dream experiences; second, we will provide an overview of laboratory-based brain imagery methods used for dream neurophenomenology, and thirdly, we will discuss avenues for a second-person experimental dream science, which would rely on researchers-practitioners skillfully interacting with participants experienced in dream practices.

Enaction and the depth of dreaming

Phenomenology in the tradition of Husserl and Merleau-Ponty, proposes that subjectivity entails a process that moves away from Cartesian separations between mind-body and subject-object, seen as problematic, unnecessarily obscuring the nature of lived experience. In Merleau-Ponty's Phenomenology of Perception the being-in-the-world (être au monde – also being-of-the-world) entails an embodied and motivated subject, co-creating meaning through oriented interactions with the world and with others, and who, by virtue of intentionality and affect, are geared towards the world rich with meaning (Merleau-Ponty, 2012). He gives body and mind equal claims to creating the lived experience through an "indivisible consciousness" (Merleau-Ponty, 1945; 2012: 122). The body, according to this position, is the locus and the subject of the lived experience.

The enactive approach, which is at the center of this paper, is based upon the idea that individuals are autonomous agents who are, in the process of living within their socio-cultural and physical environments, actively enacting and maintaining their identities. This developmental process of identity and sense-making depends on the sensorimotor and affective coupling/interaction between the individual and her world. Enaction as a theoretical and practical stance in cognitive science was first proposed by Varela, Thompson and Rosch[2] (1992). More than twenty years later, enaction, as cognitive science and philosophy of mind program, is gradually becoming more accepted as both theoretical and empirical ground for consciousness studies.

The enactive framework allows for an integrative view of the dream experience (Thompson, 2014; Bogzaran & Deslauriers, 2012). On one hand, enaction takes into consideration the latest advances in neuroscience and in cognitive science, on the other hand, enactive approach takes first-person experience, in its own right. One central tenet of enactivism is that consciousness is not restricted to brain activity, but rather is a process, a developmental achievement of a living being, affectively linked with her biological and socio-cultural environment.

In our view, and in accordance with Thompson (2014), dreaming, as an enactive process, is more like a performance than like a hallucination, a delusion. It is creative and theatrical but also performative[3] ([reference deleted by the editors]): embodied, spatio-temporal, intersubjective and metaphorical. As a performative activity, dreaming can be seen as a process of enacting and sense-making of the subjectivity textured by memory traces and motivated by affect. In the following section we will present specific qualities of enactive cognition in relation to the depth of dreaming research program:

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[2] "We propose as a name the term enactive to emphasize the growing conviction that cognition is not the representation of a pregiven world by a pregiven mind, but is rather the enactment of a world and a mind on the basis of a history of the variety of actions that a being in the world performs" (Varela, Thompson & Rosch, 1991: 9)

[3] We develop our view of dreaming as a performative process in a manuscript under preparation: [reference deleted by the editors]

(1) relationship between imagination and perception; (2) embodiment; (3) its sense-making, process-oriented nature; and (4) intersubjectivity and importance of affect.

Imagination, perception and delusion

While perception and imagination are often seen as two sometimes overlapping but qualitatively distinct kinds of subjective experiences, phenomenology and enactivism cast strong doubts on such a sharp separation. Perception is not seen as a passive reception of the ready-made outside physical world, but rather is actively co-construed by an engaged subject, with her developmental, affective and conceptual history. Additionally, perception is seen as not a passive information-processing, but rather as an active and engaged process (Noe, 2006; Noë, 2004), which involves the whole motivated, affective organism.

In *Institution and Passivity*, Merleau-Ponty raises the question of the status of imagination in perception and of the role of dreaming in these processes (Merleau-Ponty, 2010). He writes: “The distinction between perceptual and imagining consciousness is clear as far as a sensible object, or, a living body is concerned: observable - non-observable. But neither the dream nor the waking world is made up of that. They are made up of behaviours, events, anecdotes. (...) Our real life, inasmuch as it is addressed to beings, is already imaginary. (...) Thus, there is an oneirism of wakefulness and, conversely, a quasi-perceptual character of dreams” (Merleau-Ponty, 2010: 147). Because one can observe an intimate link between dream content and the dreamer’s life events, concerns, preoccupations and bodily affective states, Merleau-Ponty argues that sleep and wakefulness are not discreet or disconnected states, instead: “To sleep is neither immediate presence to the world nor pure absence. It is being in the divergence” (Merleau-Ponty, 2010: p.148). This sentiment is echoed by Maturana who discusses this possibility in light of complex dynamic systems and phenomenology (Maturana, 2008), and points to the problem that the “distinction between perception and illusion, or between virtual and non-virtual realities pertain to the operations of the observer” (Maturana, 2008:112), and thus are not the properties of the lived experiences as an ongoing consciousness state.

In relation to dreaming, the perception-imagination debate has a long history. Proponents of the dreaming as a perception view often rely on the idea of the equivalency of subjective processes in wake and in dreaming (for a detailed review see Windt, 2015a). This view has led to one extreme view of dreaming as a temporary and transient delusion/hallucination (Hobson, 2004; Gottesmann, 2006), whereas the dreamer is unable to appreciate the bizarreness or the implausibility of the dream scenario and is therefore somewhat cognitively deficient, as opposed to her waking state. Thompson rejects this claim, pointing out that: "when you hallucinate, you seem to perceive something that's not there. (...) When you imagine, you evoke something absent and make it mentally present to your attention" (Thompson, 2014: 179).

Perception is a relationship between private subjectivity and the world, colored by imagination and constrained by affective, attentional and developmental processes. Dreaming imagination, seen from this point of view, is a spontaneous or intentional (in case of lucid dreams or dream incubation practices) subjective process that may not be synchronously constrained by the demands of the world but is nevertheless rooted in bodily sensations of sleeping and sensory qualities of the environment.

Studying dreams as processes of spontaneous thought puts oneiric phenomena on the continuum of creative imagination or active processes of consciousness and takes a step away from the hallucination/delusion deficiency-based model. Recent research has demonstrated a wide variety of spontaneous thought/image/sensation processes (Fox & Christoff, forthcoming 2016), which include such processes as task-independent mind-wandering, states of reverie/daydreams, focused attention, contemplative experiences, experiences facilitated by psychoactive substances, as well as oneiric phenomena from different stages of sleep. Is has been proposed that dreaming can be seen as an intensified form of mind-wandering (Fox et al, 2013), and that positioning dreaming on the continuum of variants of spontaneous thought may be the most empirically sound strategy if one wanted to remain agnostic regarding the perceptual-imaginary debate (Windt, 2015a).

Approaching the depth of dreaming through the prism of enactive imagination allows for a fine-grained investigation of oneiric experience in its own right, and rejects the view that dreams are hallucinations or are delusional in nature. The bizarre/impossible scenarios that often characterize dream content can be seen as a kind of creative imagination processes and not as failures to recognize the implausibility of their occurrence. This creative dimension has been noted by a number of dream theorists it has been recently proposed by Hartmann that dream process can be seen as a basic creative mechanism by which lived emotionally significant experiences are 'translated' into dream images/situations. The same mechanism, coined thymophor (Hartmann, 2013-2014), is at play in other associative creative processes, such as literary, performance or fine art practices.

Embodiment

The first fundamental position of the enactive approach is the view that the mind is strongly embodied: consciousness is not the property of the brain, but of the whole organism with its nervous system, sensory and life-regulation processes. The body, then, is not an object of inquiry (although it can be objectified in a pragmatic sense and talked about in terms of body parts, body position and my vs. other body), but rather a subject of experience. Within the enactive view, perception, sensation and cognition are not computational processes that presuppose pregiven internal states and independently existing external reality, but rather are developmental achievements that come to being through sensori-motor coupling between the individual and the world. Cognition, in a large sense of the word, is a "form of embodied action" (Thompson, 2005b). The 'embodiment' position stands in sharp contrast to the 'embrainment' idea, prevalent in contemporary neuroscience, which essentially reduces all mental phenomena to brain processes and treats body as a "dumb machine" (Morris, 2010). Merleau-Ponty argues for sleep as an active embodied process. He writes: "...the body, as perceptual focusing in general, as relation to dramatic situations is the subject of dreams, rather than the 'imagining consciousness'. Sleep is not the same as dreams but the return to the dedifferentiated body. Symbolism, compromise between active body and dedifferentiated body, is not simply collapse of the intention-Erfüllung structure, absence of the real world." (Merleau-Ponty, 2010: p.148)

Recently, Windt (2015a) presented a view of dreaming which is weakly functionally-phenomenally embodied, allowing the dreamer to have an impression or an illusion (rather than a hallucination) of moving around and being active within the dream, while maintaining some degree of connection to the sensations experienced by the sleeping body. Her approach is a promising middle ground between the positions viewing dreaming either 'disconnected' from body (Rechtschaffen, 1978; Hobson, 2000) or entirely dependent on bodily processes. Studying relative contribution of neurophysiological and subjective imaginary processes to changes in the sense of self as a bodily situated subjectivity with a perspective, affect and point of view, is key to the neurophenomenological dream research program (Thompson 2014, 2015b).

Investigating embodiment in dreams, therefore, involves strategies beyond simply naming body parts that are present in the dream, but rather ones that are focusing on the qualities of the embodied experience. The depth of embodied experience in dreaming will then be concerned with the way that the body is experienced differently in various oneiric contexts, with how some phenomena allow for a seemingly 'disembodied' or out-of-body states, which are nevertheless embodied in terms of having a definite perspectival location (Thompson, 2014); and with the way in which sensations of the sleeping body, sensing and monitoring the physical environment, change the dream scenario. These changes can be both direct incorporations of physical sensations into the dream content, and, most importantly, changes that present themselves in a non-isomorphic manner: i.e. when changes in body state catalyze changes in something other than the body in the dream. Such changes can concern the perception of space, emotional state, change in the tone of interpersonal interaction with dream characters, or a scene shift, to name a few possibilities. Such an approach would allow for non-pathologizing research of such states as sleep paralysis, dream enactments, sleepwalking, and other intense oneiric phenomena. Focusing on the "how" question instead of the "what", would allow to probe for affective and somatosensory experiences in greater detail, and to elucidate microdynamics of how sensations of the sleeping body affect and modulate various aspects of oneiric formation, on both diachronic and synchronic levels of analysis. Such detailed descriptions of phenomenology of waking lived experience have been obtained using a method known as explicitation interview (Petitmengin, 1999; 2006).

Consciousness as a skillful process of sense-making: dreaming is something that we do, not something that happens to us

According to the enactive view, consciousness is not a passive computational process, nor is it an epiphenomenal feature of the brain activity. Rather, consciousness is a dynamic temporal process of sense-making (Thompson & Stapleton, 2009), which involves the whole embodied organism, its relationship with the world, intentionality (the aboutness of consciousness), and the way in which subjectivity is geared towards certain features/qualities in the world in a meaningful way. In addition to consciousness being a dynamic temporal process (Thompson, 2014; Noe, 2009), it is also a developmental and skillful activity. Sense-making depends crucially upon the perceptual/conceptual mastery of the individual, developed over her lifetime. Consider the case of wine tasters or astronomers. Sensory organs, trained in close coordination conjunction with meaningful concepts (wine taste properties; understanding shapes and luminosity of stars and galaxies when looking through the Hubble telescope) allow us to recognize meaningful properties in our experiential world, which may not be available for the untrained mind.

Dreaming, however, is often seen as a passive process, epiphenomenal to sleep-related spontaneous brain activation, in which the dreamer has no choice but to live whatever experience is thrown at her, without much choice or say in the matter. Indeed, ‘this is just a dream’ attitude, typical of many current traditions, underlines the generally dismissive attitude toward oneiric experience. A notable exception, lucid dreaming, a trainable skill of becoming aware during dreaming, is increasingly being studied as an antidote to the overly passive view of dreams (LaBerge, 2009; LaBerge, 1990). In recent years, lucid dreamers have been the preferred ‘expert’ group of research on dreaming and on the limits of the dream experience - having an ability to signal the state of lucidity directly from the sleep state, they can also perform specific tasks during the dream, for example, physical exercise (Dresler et al., 2011; Voss & Hobson, 2015). In addition to lucid dreams, non-lucid dreams can also be seen as skillful activities. It is well-documented that keeping a dream diary increases dream recall, and dreams are often used as a source of problem-solving and insight in therapy settings (Crook & Hill, 2003; Fischbein, 2011; Knox, Hill, Hess, & Crook-Lyon, 2008), in healing dream practices (Stranahan, 2011), and for personal pragmatic reasons (Edwards, Ruby, Malinowski, Bennett, & Blagrove, 2013). Dream incubation, i.e. intention-setting to dream about a certain kind of scenario or to receive an intuitive answer to a pressing question in the dream, also has long history of both traditional and contemporary oneiric practices (Barrett, 1993). In therapy settings, however, as in many traditional contexts, such as in practices of dream yoga (Norbu, 2002; Wallace, 2012), skillful engagement with the dream world and with contents of own spontaneous thought, is emphasized.

Approaching dreaming as a temporal, skillful process of sense-making allows for probing the depths of subjective engagement with the dreamworld. The depth approach allows for rethinking strategies of dream interpretation, individuation and making sense of rich and creative dream experiences. Depending on research questions, the relative emphasis on the breadth or depth as a methodology can facilitate moving between the quantitative aspect of the typical attributes of elements associated with various dream practices, and the qualitative characteristics of how are these practices temporally, affectively, and bodily lived in the dream.

Intersubjectivity and affect: dreams are about interactions with others

The classic phenomenological example of opacity of the experience of touching and of being touched (the sentient-sensible distinction in Merleau-Ponty, the body that is simultaneously the one that touches/speaks/sees and the one that is touched/heard/seen), or the reversibility of the experience as a subject or as an object, is often used to illustrate the fundamental role that intersubjectivity plays in dynamics of the formation and maintaining of individuated subjectivity (Merleau-Ponty, 2012: 219. 230). In this example, it is impossible to distinguish with absolute certainty what characterizes the feeling of touching and what characterizes the feeling of being touched. Yet, an individuated self manifests itself through this interaction. Maclaren suggests that it is through touch the one develops the primordial, intercorporeal intimacy with the world, which is the underlying condition of possibility of intersubjectivity (Maclaren, 2014). Zahavi's account of 'we-intentionality' offers a point of view on the self as an interdependence of experiences of selfhood and alterity though processes of second-person perspective and empathy (Zahavi, 2014, 2015).

From an enactive cognition perspective, the interactive brain hypothesis (Di Paolo & De Jaegher, 2012) states that since cognition, including social cognition, is embedded in and extended into the world in a meaningful way, the relational nature of subjectivity can be seen as a process of participatory sense-making. The authors propose that individual neural processes both evolve developmentally through social interactions and are characterized by ongoing dynamical processes, embedded in the social world.

The intersubjective/intercorporeal dimension of subjectivity is inseparable from the affective and emotional one. Empathy, emotional attachment, compassion, shame - all these and other affective/emotional states characterize the way in which an individual experiences herself in relation to the social world. A growing number of scholars is challenging the textbook separation between cognition and emotion. In his recent book, Pessoa argues for a research program that would conceive of a brain as a dynamic cognitive-emotional system (Pessoa, 2013). An emergent field of enactive affective neuroscience (Colombetti, 2013) is bringing together neuroscience, theories of emotions and affect, and work on embodied cognition. Collapsing cognitive vs. emotional (just as mental vs. physical) dualism into a non-reducible embodied affective cognitive dynamic system provides ground for investigating a range of experiences, such as prodromal dreams (dreams announcing progression in a disease), frightening nightmares, sleep paralysis, precognitive experiences, and other phenomena.

The self-other dynamic, central to awake consciousness, is equally at the center of the oneiric subjectivity. Despite the surface view that dreaming is a solitary experience, the dreamer is rarely alone, and the dream world is rich with interactive elements that orient and motivate the dreamer. The Social Simulation Theory of dream function (Revonsuo, Tominen & Valli, 2015) postulates that dreaming about others is the essential characteristic of the oneiric subjectivity, reinforcing fundamental qualities of social bonds and training social skills. Similarly, an earlier theory has proposed that the intersubjective dimension of dreaming facilitates and promotes attachment (Zborowksi & McNamara, 1998). The intersubjective, affective dimension of dreams is probably what makes dream experiences so realistic, compelling and impactful: the dreamer is interacting with other characters, makes decisions and ethical choices, and, conversely, the dreamt characters' behavior has an important impact on the dreamer. The most intense examples of the interpersonal effect of the dream is the case of nightmares: in some cases nightmares can have a lasting effect on the daytime wellbeing of the dreamer, creating a state of distress (Levin & Nielsen, 2007).

Dream characters are not the only oneiric elements that motivate the dreamer: the whole of the dream environment can be conceptualized as interactive and in direct dialogue with the dreamer, since it is rarely neutral in tone. The dream as a whole is a motivating and engaging force which provides the dreamer with particular affordances and engage them to respond to external conditions. The self-other dynamics in dream research has rarely been investigated. In one study we have introduced the concept of Dream Locus of Control (Solomonova et al, 2015), which is a scoring scale between external and internal predominant influence on the progression of the dream scenario: by the internal locus of control we mean the extent to which the dreaming self is affecting the dream events, and by the external - the extent to which the rest of the dream, dream characters, objects, settings, environments, etc., has influence over the unfolding of the narrative. This relational force of dream formation has been conceptualized as the dream's 'central image' (Hartmann, 2008; 2010) - the most intense, personally significant locus of emotional power of the dream: the dream elements (characters, settings, qualities of dream environment), external to the dream self, that drive, motivate and challenge the dreamer.

Approaches focused on the breadth of dreaming have uncovered a variety of typical dream characters and their prevalence in different populations (Bulkeley, 2009; Domhoff and Schneider, 2008). Family members (Barrett & Loeffler, 1992), partners (Cartwright et al, 2006), strangers, aggressors, animals, friendly and hostile interactions, among others, have all been well-documented in empirical dream research. Research focusing on the depth of interpersonal experiences in dreaming would then probe into the qualities of how the characters appear to the dreamer, what kind of affective reaction they provoke, how does the dreamer know who the character is or what their intentions are, and how other characters' presence motivates and changes the dreamer's own behavior.

Neurophenomenology of dreaming: probing the depth of the embodied, intersubjective processes of sense-making

Neurophenomenology has been proposed as one possible remedy for the 'hard problem' (Chalmers, 1995) of consciousness, also referred to as the 'explanatory gap' (Block & Stalnaker, 1999), the fundamental question of how subjective experience emerges from or is connected to the brain electrophysiological and metabolic processes. Mutually constraining third-person objective and first-person subjective data should inform us, in a non-reductive way, of the dynamic qualities of the experience. Proposed by Varela, neurophenomenology is a method combining third-person objective measures (brain imaging, physiological measures such as heart rate, respiration, galvanic skin response, etc.) with detailed first-person accounts of subjective experiences (Lloyd, 2002; Lutz & Thompson, 2003; Varela, 1996, Thompson, 2014, 2015). Rather than simply looking for neural correlates of consciousness, neurophenomenological investigations emphasize the dynamic and personal nature of brain activity-experience relationship, and thus employ third- and first- person measures as mutually constraining and co-informing.

As proposed by Hut and Shepard (1996), most iterations and reactions to the 'hard problem' start with the relationship between the matter (brain cells, electricity, metabolic processes) and then move up to the more complex or emergent phenomena such as consciousness and awareness. Subjective experience is then implicitly seen as causally secondary to or emergent from neurochemical processes in the brain (even if it may not be reducible to the brain and even the whole embodied and embedded organism). Instead Hut and Shepard propose that as scientists of the mind we take a radically phenomenological turn and, in accordance with the positions of Husserl, Merleau-Ponty, Gibson and James, start with the unquestionable and obvious ongoing first-person experience and then work our way to asking such questions as "how nonphysical conscious experience could arise in this physical world; why it would arise only from some particular physical processes and not from others that from the outside appear to be entirely equivalent; and how it could act back on – or play a functional role in – the physical world" (Hut and Shepard, 1996: 9). This inversion of the point of view can be particularly helpful to tackle the case of dreaming consciousness, as it does not presuppose, from the outset, any particular relationship between the mental activity, the brain (with the body) and the world (which has limited influence, compared to waking consciousness). The experience as it presents itself to its subject seems like a good place to start, before inferring causal relationship with the neural processes. More recently, due the rising interest in neurophenomenology, Bitbol proposed that one way to read Varela's program for research is not to see it as a theoretical framework, providing a solution to the 'hard problem', but instead as a stance towards the very practice of science (Bitbol, 2012). The 'hard problem' is then softened by phenomenological/contemplative mind training, and by a "... completely renewed and broadened conception of science" (Bitbol, 2012: 171), which aims at dissolving the neuro-materialist bias, rather than at building yet another theoretical and conceptual bridge between the neural and the experiential.

Neurophenomenology as a method for investigating contents of consciousness is uniquely suited for the challenge that dreaming poses to enactivism in particular and to cognitive science in general ([reference deleted by the editors]). The sleeping subject, behaviorally, looks static and unresponsive/unconscious to an observer. Apart from some micro-awakening, intermittent body movements or, in some cases, sleep-related behaviors such as sleepwalking, night terrors or dream-enactments, in most cases the sleeping individual is motionless between bedtime and awakening. EEG recordings, however, paint a very different picture of sleep: as an incredibly dynamic process, cyclically alternating between patterns of relatively fast desynchronized brain activity (theta range) and low frequency, synchronized periods (0.5-2 Hz) of 'deep sleep'. Neurophenomenology has been tacitly used in dream research since 1960s, with a number of studies aiming at linking varieties of subjective experiences in sleep with concurrent electrophysiological activity. Studies linking rapid-eye-movement (REM) sleep and its qualities with different kinds of oneiric experiences were made possible by the increasing accessibility of electroencephalogram (EEG) – a non-invasive method of monitoring brain activity, allowing individuals to sleep and to move in their sleep without disrupting data acquisition.

In accordance with the enactive view of dreams, neurophenomenological investigations of dream experience would address issues such as the temporal structure of the dream formation, and the three proposed qualities of enactive cognition: embodiment; dynamic process of sense-making/dreaming as a skillful activity; and affective intersubjectivity (self-other/world distinction). These qualities are closely intertwined and dependent on one another - subjective experience is not reducible to any of these categories. It is possible, however, to study specific aspects/qualities of enactivism through the prism of dream experiences.

Systematic neurophenomenological research program on dreams will then depend on successful integration of three elements: (1) the appropriate and best available neurophysiological apparatus; (2) disciplined and detailed first-person reports; and (3) adoption of the second-person perspective/taking a phenomenological stance from within the scientific practice.

Using best available and most appropriate neurophysiological measures.

A variety of neuroimaging methods exist today and are successfully used to generate important insights in the functioning of the human brain and its relationship to concurrent mental processes. Sampling live neuroimagery in sleep, however, faces unique challenges: the trade-off must be made between the inconvenience of sleeping in the laboratory, in the scanner or with attached sensors; and the likelihood of the research participant of having 'normal' sleep, being relaxed and comfortable enough to experience vivid dreams, hypnagogic experiences and thoughts during sleep. The most common choice of imaging apparatus has historically been electroencephalography (EEG), which is non-invasive and permits the study participant to move reasonably freely in bed, sleeping in any position that she chooses. There are, however, limitations to laboratory-based EEG monitoring, including changes in sleep architecture in a strange new place, known as the ‘first-night effect’ (McCall & McCall, 2012), and excessive incorporations of laboratory settings into dreams collected during the experiment (Domhoff & Schneider, 1998; Schredl, 2008; [reference deleted by the editors]). Home-based monitoring is could be a preferred setup, and as consumer-grade EEG setups are slowly getting on the market, new possibilities will be available. This will not, as of now, allow for any fine-grained investigation, but may be sensitive enough to detect sleep stages and prompt experimental awakenings (for example, by playing a sound). Some desiderata for future developments would be using the best available tools that facilitate fine-grained live dynamic analysis of spectral components (theta/alpha ratio, for example); improved temporal-spatial integration that permits dynamic whole brain analysis (Thompson & Varela, 2001); high density EEG, facilitating better localization of brain rhythms; analysis of EEG coherence; sleep microarchitecture (eye movements during sleep, sleep spindles, delta waves) known to be involved in processes of memory consolidation, emotional adaptation and other dream-related processes.

Additionally, constraining the neurophysiological measurements with the first-person reports of concurrent experience may lead to rethinking of the way that sleep is currently classified: current sleep staging norms and conventions may be too crude to allow for fine grained analysis of neural correlates of conscious states. For example, dreaming was thought to be confined to REM sleep exclusively (Hobson & McCarley, 1977), however, changes in interview techniques (changing questions to allow for more nuanced answers), allowed for discovery of a whole range of oneiric processes that are possible in all sleep stages (Nielsen, 2000), and some parasomnia, such as sleepwalking and night terrors, which often have strong experiential quality, also tend to arise from non-REM (NREM) (Oudette et al, 2009). One conceptual problem with some recent practices in neuroscience that endorse the enactivist position in some form is that on the level of actual scientific practice, the “Cartesian prejudice” often remains tacitly accepted (Morris, 2010), and brain processes are still viewed as correlative/casual to subjective experience even if modulated by the body: brain and body are considered as two independent, albeit intimately linked, phenomena. As Morris suggests, the remedy to the ‘hard problem’ is not simply taking both physiological and subjective data seriously, but more specifically, to take a phenomenological turn and to consider, through careful investigation of the flow of experience, how phenomena of mind appear in temporal terms within the sensorimotor/kinaesthetic engagement with the world.

Disciplined and detailed first-person reports.

And what about the 'phenomenology' aspect of the whole enterprise? While in cognitive science and psychology the word 'phenomenology' is often used as synonymous with any kind first-person data, neurophenomenology, as a research program (Bockelman, Reinerman-Jones, & Gallagher, 2013; Lutz, 2007; Thompson, 2005a; Varela, 1996) relies on disciplined self-observation techniques based on the phenomenological tradition in continental philosophy (especially on work of Husserl and Merleau-Ponty) and on Hindu and Buddhist contemplative practices (Thompson, 2006, 2014). This type of self-observation rests on the principles of training the mind in order to facilitate metacognitive awareness and to decrease biases: with help of phenomenological reduction/epoche, introspective techniques, or, as it is in case of meditative training, by cultivating specific kinds of focused, diffuse or transcendental awareness (Josipovic, 2010; Travis & Shear, 2010; Lutz et al, 2015). Studying various groups of trained populations has implications for the processes of attention, learning of new cognitive skills and for understanding of neuroplasticity (Slagter, Davidson, & Lutz, 2011).

While most existing dream scoring methods rely on extensive lists of various dream characteristics, we propose that successful neurophenomenological investigation of dreaming should privilege content analysis approaches that focus of depth of dream experience instead of breadth. This would imply taking a phenomenological turn and asking not what appears in the dream, but rather how elements (for an example of a dream interpretation technique see Gendlin (1986), settings, characters, objects, etc. appear to the dreamer within the dream. Researchers would have to take into consideration temporal structure of appearance/disappearance/change of dream elements; spatial aspects of where these elements are located with respect to the dreamer; and affective/bodily feel that dream characteristics produce within the dreamer: in other words, the research question would be not so much what do people dream about, but rather how they are moved, motivated, challenged by their dreams.

One way to facilitate detailed dream reports lies in selecting ‘expert’ dreamers as participants in neurophenomenological studies of dreaming. These target populations depend upon the research objective and at the very minimum include individuals who have good dream recall and are able to report on their subjective experiences in an articulate way. Individuals with high dream recall, lucid dreamers for their metacognitive abilities in dream state, athletes (Erlacher, Stumbrys & Schredl, 2012), and dancers as movement experts, possessing a certain kind of gestural vocabulary; wine tasters for their nuanced gustatory and olfactory capacities; experienced meditators (Thompson, 2014) - all are candidates for targeted neurophenomenological research, depending on specific research questions. Finally, considering that dream recall and metacognitive access are both trainable skills, soliciting help from contemplative practitioners may elucidate various aspects of dream formation. For example, research has shown that vipassana or insight meditation may improve accuracy in identification of somatic stimulation (Fox et al., 2012) – an aspect of awareness that may be of interest to research focused on bodily sensations in dreams.

Training participants in reporting dream content is another way of getting around the poor introspective capacity or poor dream recall. It has been thoroughly documented that the longer one keeps a dream diary at home, the more often she recalls dreams and the more detailed these dream reports become over time. Including additional training elements, such as asking specifically to report on emotional states or bodily experiences, can help further illuminate these often-obscured aspects of implicit embodied experience. One pilot study, aimed at training participants in reporting their dreams, has shown that, compared to the control group which has received no additional instructions as to how to keep a home dream diary except for reflecting on their dream, the training group increased not only the total word count of their dream reports, but specifically, used more words (gave more details) to describe their perceptual movements and inner reactions during their dream experience ([reference deleted by the editors]). A third method is to employ phenomenological interview methods, such as focusing method (Gendlin, 1982; Gendlin, 1986), elicitation interviews (Petitmengin, 2006; Petitmengin & Bitbol, 2009). When applied to dreaming, these methods may help untrained participants uncover meaningful details of their experience, and elucidate both the breadth and the depth of dream content, including temporal and structural aspects of unfolding of the dream scenario.

Researchers-practitioners, second-person perspective

We believe that the potential for truly interdisciplinary investigation of consciousness contents in sleep lies in effective coupling between first- and third-person methods, informed by the phenomenological perspective, and carefully constructed scientific apparatus, allowing researchers to adopt a second-person perspective and to become discovery-oriented research participants in concert with informed (as opposed to naive) research study participants (Depraz, Varela, & Vermersch, 2003; Thompson, 2001; Varela & Shear, 1999). The insight generated by scientific practice is located in the third space between the scientists' subjectivity and participants' articulation of their lived experiences. Giorgi, the proponent of a phenomenological psychology, made a methodological call for a special sensitivity to the phenomenon investigated: the researcher would simultaneously practice phenomenological reduction and be attuned to the object of her research (Giorgi, 2012). Returning to the question of intersubjectivity, De Jaegher, Di Paolo and Gallagher have proposed that study of engagement in social interaction, the feeling of connectedness and of shared experience, can be used as an object of study of social cognition (De Jaegher, Di Paolo, & Gallagher, 2010). Only in that shared third space, between the agents of action, can a truly interpersonal neurophenomenology emerge. Depraz and Cosmelli (2013) write: "We propose to take seriously the multifarious varieties of second-person involvements within the whole process of validation. In the long term, we aim at understanding how scientific objectivity is in the last instance radically founded on and determined by such intersubjective practices" (Depraz & Cosmelli, 2013: 164).

Additionally, a contemplative attitude is not only a desired skill of 'expert' research participants, it is also an empirical strategy of engaged researchers, adopting a phenomenological stance toward the relationship between neurophysiological data and concurrent first-person reports. Researchers-practitioners have been fruitfully participating in studies of contemplative practices, such as meditation (Desbordes & Negi, 2013). For the research program concerned with the 'depth' of dreaming, as opposed to 'breadth'; it seems important that the experimenters themselves be practitioners of skillful dreaming, i.e. having experienced a kind of phenomenon would give one sufficient perspective, insight and intuition into the variety of questions/experimental procedures that may elucidate qualities of dreaming.

We propose that the move that involves methodologies beyond the subject-object, and body-mind dualities, needs not only to shift from 'embrainment' to embodiment, but also possibly to enlarge the notion of the brain: beyond the confines of the skull. When the brain activity is addressed and analyzed in context of the larger nervous system, including autonomic and peripheral processes, afferent and efferent sensory systems as well as direct contact with the world, it can be seen not as a representation of an information-processing within the head, but rather as a marker of dynamic processes involving the whole embodied subjectivity, embedded in the world, and affectively interacting with others. In Thompson's words: "when neuroscientists say the dreaming mind reflects the sleeping brain, they are not wrong, but they get only half the story, for the opposite is equally true - the sleeping brain reflects the dreaming mind" (Thompson, 2014: 110). And the dreaming mind may reflect the somatic, unconscious, associative, creative spontaneous cognition processes, which are still poorly understood and which may be elucidated through rigorous neurophenomenological strategies.

One oneiric phenomenon particularly well suited for a fine-grained neurophenomenological investigation is the hypnagogic state: images, sensations, sounds that occur at sleep onset (Stage 1 NREM sleep), during the transitional period between wake and sleep. As it rarely happens in research on neural correlates of consciousness, hypnagogic images are reliably 'caught' in the laboratory, as their formation tends to coincide with a dramatic observable to the naked eye change in the EEG pattern (Tanaka, Hayashi & Hori, 1997) from alpha state (8-12 Hz) to predominance of theta activity (4-7 Hz). Waking a participant from this state, almost invariably, and in some studies in 100%

of participants (Nielsen et al, 2005; Stenstrom et al, 2012), coincides with very short intrusive hypnagogic mentation . This state can be seen as satisfying the some of the ideal reporting conditions (Windt 2015a: 196): since hypnagogic images often last only for a few seconds, they constitute a manageable amount of content; the temporal proximity to the awakening in the laboratory is nearly perfect; and hypnagogic mentation is possible to study almost any time of the day.

One other example of a promising avenue for such an investigation is the study of so-called ‘dreamless sleep’ (Thompson, 2015b), or deep/delta/slow wave sleep experiences (Stage 3 NREM), which are typically seen as lacking any conscious content (Thompson, 2014). Growing evidence, however, challenges this perception, as some kinds of dream reports are possible even from NREM sleep (for review see Nielsen, 2000). Additionally, in a recent study it was reported that experienced mindfulness meditators have higher gamma activity during NREM sleep, which suggests a possibility of some kind of metacognitive activity even in deep sleep (Ferrarelli et al, 2013). Furthermore, ‘dreamless’ sleep may be characterized as having some phenomenal qualities (Thompson, 2015), being an experience of ‘pure subjective temporality’ (Windt, 2015b), or even a “kind of consciousness without object”, familiar to some contemplative traditions (Thompson, 2014). It is possible, therefore, that some kind of spontaneous mental activity is ongoing at all times, even in deep ‘dreamless’ sleep (Nielsen, 2000; Thompson, 2014, 2015), and that various states of vigilance and arousal facilitate and support different kinds of subjective experience, which modulate one’s sense of self, of environment and of qualities of interaction with the world.

Another, more clinically-oriented direction for the neurophenomenological dream research is studying oneiric disorders. Training participants in noticing the subtle structural and temporal qualities in the way in which their nightmares or sleep paralysis attacks unfold can have concrete practical applications ranging from distress-reducing strategies to neurophenomenological investigations of dreaming disorders in the laboratory. Investigating the depth of dream experience within a neurophenomenological framework will allow for detailed investigation of synchronic and diachronic qualities of lucid dreams, non-lucid dreams (given that participants are well-acquainted with their dream world, have good dream recall and are able to provide detailed reports), oneiric experiences associated with such marginal experiences as sleep paralysis attacks, REM sleep behaviour disorder, prodromal dreams and somnambulism, among others.

Conclusion

We propose that neurophenomenological paradigm is a fruitful and challenging approach to the study of oneiric experiences. While dreaming has been mostly excluded or only marginally treated by the majority of phenomenological and enactive work, studying the depth, in addition to breadth, of dream experiences through the prism of embodied, processual, sense-making, intersubjective and affective subjectivity may uncover temporal and structural elements of dream formation.

An enactive neurophenomenological framework allows for new kinds of investigations of dream experiences by going beyond the entrenched perception vs. imagination; cognition vs. affect, and mind vs. body Cartesian dichotomies in order to fully appreciate and study oneiric subjectivity in its own terms. Such methodologies facilitate study of experiences that lie beyond the typical range of waking lived experiences without inscribing them into a delusional/hallucinatory/unreal domain. Treating dreaming as spontaneous thought (Fox et al, 2013), or, following Thompson (2014), as spontaneous imagination, makes room for altered experiences of body, self, relationship with others and with the world, as well as of unusual and rich affects.

Taking the phenomenological attitude towards lived experiences during sleep requires adopting non-reductive methodologies, such as disciplined self-observation/elicitation/training techniques as well as a second-person perspective. Dreaming, as a subjective experience with no or minimal behavioural correlates, may be the perfect candidate for neurophenomenological challenge to brain-centric science. Taken as a locus of investigation of enactive cognition, insights from disciplined study of creative and imaginative dream experiences can then be used to inform the larger study of consciousness and also as starting point of more ambitious intersubjectivity and enactive cognition neurophenomenological research.

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4. Article II

Sleep Paralysis: phenomenology, neurophysiology and treatment

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To appear in: *The Oxford Handbook of Spontaneous Thought: Mind-Wandering, Creativity, Dreaming, and Clinical Conditions*. Fox, K & Christoff, K. Eds. 2017.

Abstract

Sleep paralysis is an experience of being temporarily unable to move or talk during the transitional periods between sleep and wakefulness: at sleep onset or upon awakening. Feeling of paralysis may be accompanied by a variety of vivid and intense sensory experiences, including mentation in visual, auditory, and tactile modalities, as well as a distinct feeling of presence. This chapter discusses a variety of sleep paralysis experiences from the perspective of enactive cognition and cultural neurophenomenology. Current knowledge of neurophysiology and associated conditions is presented, and some techniques for coping with sleep paralysis are proposed. As an experience characterized by a hybrid state of dreaming and waking, sleep paralysis offers a unique window into phenomenology of spontaneous thought in sleep.

Introduction

"I had a few terrifying experiences a few years ago. I awoke in the middle of the night. I was sleeping on my back, and couldn't move, but I had the sensation I could see around my room. There was a terrifying figure looming over me. Almost pressing on me. The best way I could describe it was that it was made of shadows. A deep rumbling or buzzing sound was present. It felt like I was in the presence of evil... Which sounds so strange to say!" (31 year old man, USA)

Sleep paralysis (SP) is a transient and generally benign phenomenon occurring at sleep onset or upon awakening. Classified as a rapid-eye-movement (REM) sleep-related parasomnia, SP represents a psychophysiological state characterized simultaneously by qualities of both sleep and wakefulness, wherein the experiencer can open her eyes (Hishikawa & Kaneko, 1965), can be aware of her physical environment but is unable to move and may start seeing, hearing, feeling or sensing something.

While documented instances of SP seem to be very consistent across cultures, SP's lived qualities, phenomenology, and interpretation as a meaningful experience varies depending on the cultural and religious background. Rooting SP in a particular belief system may either help the experiencer recognize that SP is common and transient, or amplify negative qualities of SP by giving more concrete shape to an already terrifying experience of a supernatural assault.

The emotional experience of SP is often one of fear, terror and panic. Threatening presences, the vulnerability of being in a paralyzed state, uncontrollable visions - all these elements contribute to intense, predominantly dysphoric, negative affect. Some qualities of spontaneous thought associated with felt presence during SP can be seen as paranoid (Cheyne & Girard, 2007), spatial, or interpersonal/social (Nielsen, 2007, Solomonova, 2008). The vast majority of SP experiences are associated with intense feelings of realism, and are most often characterized by fear and distress, which may carry-over into wakefulness and create a vicious cycle of negative emotional association with sleep, including aversion to going to bed, and even, in extreme cases, can result in symptoms reminiscent of post-traumatic stress disorder (McNally and Clancy, 2005). Yet, some SP experiences are described in positive terms, especially vestibulo-motor phenomena that include out-of-body experiences (OBE), or sensations of flying or floating. While the intuitive and immediate reaction to SP is typically negative, as will be discussed in the section on practical considerations, there are numerous reports of neutral/positive SP. Furthermore, there is a possibility of harnessing the power and potential of the dissociative/overlapping state in order to take active charge of one's experience and to use the opportunity presented by the simultaneity of waking and sleeping cognition - a potential for entering into a lucid dream state or for contemplative self-observation.

Neurophysiologically, SP is currently understood as a state dissociation or a state overlap between REM sleep and wakefulness (American Academy of Sleep Medicine, 2014). During SP one can open her eyes, look around the room, become aware of her environment and simultaneously experience REM sleep-related paralysis (muscle) as well as intense and realistic imagery[4] of all sensory modalities - a nightmare spilling into the real world. Normally, during REM sleep, skeletal muscle atonia blocks most motor output, effectively preventing the sleeper from acting out her dreams (Peever, Luppi, & Montplaisir, 2014). SP can also occur in the context of narcolepsy (Sharpless & Barber,

[4] In this chapter I will use the terms 'imagery' and 'mentation' interchangeably to refer to visual, auditory, somatosensory and even social experiences during SP. The term 'imagery' here is therefore not restricted to the visual domain. I prefer 'imagery' and 'mentation' to 'hallucination' in order to emphasize the dream-like process of spontaneous imagination that takes place during SP, and to de-emphasize the association with delusional thought and pathologies, associated with the term 'hallucination'.

2011; Terzaghi, et al, 2012), but the majority of those who experience SP report it in its isolated form (often referred to as Isolated Sleep Paralysis), without known medical or neurological association.

In current medical and neuroscientific literature, SP is discussed in terms of its presentation and negative factors: SP-associated mentation is generally seen as a non-desirable effect of REM sleep intrusion into waking. In this chapter I propose that situating SP experiences as a dream phenomenon within the framework of embodied mind and enactive cognitive science, including contemplative approaches to consciousness, is an alternative that accounts for the phenomenology of SP as a lived experience, allows for rich and detailed cultural framing of the experience, and offers avenues for a cross-cultural social neurophenomenology of SP.

First, I will discuss the phenomenology and neurophysiology of SP experiences. I will present SP in general, without distinguishing between its isolated and narcolepsy-related form, unless such a separation is warranted. I will start by presenting the current state of knowledge of SP prevalence, as well as the varieties of imagery accompanying SP and their cultural significance. I will then discuss SP in terms of a REM sleep parasomnia and outline its precipitating and enabling factors, as well as sleep and dream characteristics of those who experience SP. Finally, I will examine SP in light of various cultural and shared practices, including preventative measures, and practices aimed at interrupting and transforming SP experiences.

The experiential examples of SP used in the present chapter are all derived from an Internet-based study of SP (Solomonova et al, 2008). Our research group collected 193 responses from people with recurrent SP experiences, using a modified version of the Waterloo Unusual Sleep Experiences Questionnaire (Cheyne, Newby-Clark, & Rueffer, 1999). Our participants were recruited online, using word of mouth, and via advertising on SP-related forums, information and support.

Definitions and prevalence

Idiopathic SP (SP not associated with narcolepsy, and without known cause) is a benign and transient parasomnia (Howell, 2012), occurring during transitions between wake and sleep: at sleep onset or upon awakening. The Diagnostic and Statistical Manual of Mental Disorders (DSM-5) classifies isolated SP accompanied by fearful mentation as an instance of a nightmare disorder (American Psychiatric Association, 2013). During an episode of SP, characteristics of REM sleep intrude upon seemingly awake consciousness: thus the person experiencing SP, while having an impression of being awake and aware of her environment, is unable to initiate voluntary movements (i.e., experiences REM sleep muscle atonia/paralysis), and may also experience intense and realistic sensations in any sensory modality - REM sleep-related mentation (American Academy of Sleep Medicine, 2014). SP should be distinguished from night terrors – early night awakenings with feelings of panic/terror, typically associated with somnambulism-spectrum arousal from slow wave (Stages 3 and 4) non-REM (NREM) sleep. Night terrors are characterized by sudden awakening in an agitated state, anxiety, body motility and general amnesia with regards to underlying cognitive experience (Szelenberger, Niemcewicz & Dabrowska, 2009).

Prevalence estimates of SP range widely, and may depend on geographic and cultural factors. A systematic review of SP prevalence has revealed that studies report SP lifetime prevalence from as low as 1.5% to possibly 100% in the general population (Sharpless & Barber, 2011). The authors indicated that about one in five individuals may have experienced SP at least once in their lifetime (of 36,533 persons in their review). Prevalence estimation of SP is difficult due to numerous factors such as ethnicity and cultural background, including variable familiarity with the phenomenon and in the wording of questions (Fukuda, 1993). For example, in a cross-cultural study, Fukuda and colleagues (2000) reported that while it is unclear whether SP is equally prevalent in Canada and Japan, the lack of familiarity and of a normative cultural framework for SP in Canada may contribute to the fact that many Canadian, but not Japanese, respondents qualified SP as a kind of a dream, and would not have, therefore, readily recognized SP in a prevalence study. An additional reason for under-diagnosis of SP in the West may be the fact that those who experience SP may be misdiagnosed as having psychiatric disturbances (Hufford, 2005). The developmental trajectory of SP is traditionally associated with an onset during adolescence, which may indicate a process associated with sleep architecture maturation (Wing, Lee & Chen, 1994). However, in one study of older adults, a bimodal onset pattern was reported, with a second pattern of onset of SP episodes after the age of 60 years old (Wing et al, 1999), suggesting a possibility that SP may have a variety of onset conditions.

Neurologically and phenomenologically SP is situated on the REM-sleep based dream/nightmare continuum. In this chapter, I will approach SP experiences as a variant of intensified or disturbed dreaming, and will situate them within a framework of embodiment and enactivism.

The 4EA cognition and oneiric mentation

Recent years have seen the development of a paradigm shift from a strictly neurocentric view of the mind, a position that can be stated as "embrained" (Morris, 2010), to a diverse family of approaches that consider the mind embodied (Varela, Thompson & Rosch, 1991; Gallagher, 2005), enactive (Noe, 2004; Thompson, 2005; Stewart, Gapenne & Di Paolo, 2010), extended into and embedded in the physical and social world (Clark & Chalmers, 1998; Menary, 2010), and affective (Colombetti, 2013; Pessoa, 2013). While these approaches are in many respects quite different, they have sometimes been labeled as 4EA (embodied, embedded, extended, enactive, affective) cognition, with a common theme of offering a robust alternative to computational, connectionist, and neuro-reductionist views of the mind (Wheeler, 2005; Protevi, 2012). These theories attempt to situate cognition, brain activity, and psychophysiology within the larger contexts of lived subjective experience, by emphasizing the roles of developmental sensorimotor attunement to the world, as well as of the active and motivated processes of perception and sense-making, the importance of the social and cultural milieu, and the role of emotion and affect.

Sleep and dreaming phenomena have been only rarely addressed by 4EA theorists (with the exception of Thompson 2014, 2015a,b), and the prevailing view of the sleeping mind today situates sleep mentation as being firmly constrained within the brain (Rechtschaffen, 1978; Hobson, Pace-Schott & Stickgold, 2000; Revonsuo, 2006). As Revonsuo states: "The conscious experiences we have during dreaming are isolated from behavioral and perceptual interactions with the environment, which refutes any theory that states that organism-environment interaction or other external relationships are constitutive of the existence of consciousness" (Revonsuo et al, 2015: 3). Alternatively, situating dream mentation within a framework of 4EA approaches implies that the dreaming subject is not entirely isolated or disconnected from environmental and somatic stimuli, and that her experiential self retains affective, social, sensorimotor and sense-making qualities. Dreaming then is not passively lived as a purely mental simulation (Revonsuo et al, 2015), but can be seen as a process of active imagination (Thompson, 2014) rooted in the dreamer's physical, social and affective world (Solomonova & Sha, 2016). I propose that SP experiences, by virtue of their special kind of overlap between and simultaneous presence of both waking and dreaming cognition, are perfect candidates for neurophenomenological research on spontaneous thought in sleep, which would help illuminate particular qualities of dreaming cognition that may otherwise be inaccessible to reflective consciousness upon awakening from a dream.

Phenomenology of sleep paralysis experiences

Figure 1. A representation of sleep paralysis experience[5]. The sleeper is awakened suddenly and sees a menacing shadowy creature on top of him. He experiences the sensation of being pushed into the bed, while the bed itself is swirling

[5] Excerpt from the dreamer's account: "The transition between wake and sleep is a crucial moment to enter into the world of dreams. During this transition on countless occasions I would awaken suddenly not being able to move. During this experience it seems that the very essence of fear permeates my consciousness. Eeriness goes through my soul, freezes my blood and interrupts all substantial notion of my being. No words can describe that visceral sensation, and in parallel, no words can come out of my mouth. Aware of the lack of muscle tonus, I try to escape this inevitable Machiavellian *black beast*, that materializes in my head

in a sort of a tornado. The two faces of the dreamer represent the "double" consciousness during sleep paralysis: he is simultaneously terrified of the supernatural attacker and also knows that if he does not resist the experience and allows himself to drift back into sleep he may have a lucid dream (this lucid consciousness is represented as a sleeping face with a colorful brain, denoting vibrant possibilities of lucidity. Artist: Benjamen Samaha, Montreal, Canada 2016. Reproduced with artist's permission.

In addition to transient experience of muscle paralysis, the most dramatic quality of SP is its sensory content, characterized by vivid, intrusive audio-visual and somatosensory imagery. The experience of SP can be extremely realistic, have a quasi-perceptual and wake-like quality, and may be accompanied by tactile and kinesthetic sensations. Reflective thought processes, self-awareness and metacognitive abilities seem to be relatively preserved during SP experiences, and people who have had multiple SP experiences may develop a "feel" for recognizing SP imagery.

SP-associated experiences are typically referred to as hallucinations (hypnagogic, when occurring at sleep onset, or hypnopompic, when happening upon awakening), since these occur during otherwise seemingly awake consciousness (Liddon, 1967; American Academy of Sleep Medicine, 2014). This entails that a person who experiences SP sees something that is not there, something that is distorted or false. Such a view presupposes that during SP one is effectively awake and is misinterpreting her experience. Another way of looking at SP is to situate it within the spectrum of dream mentation and dreaming imagination. While dreaming too has been seen as a delusional/hallucinatory activity, an alternative view, in line with embodied mind theories and enactive approach, has also been proposed: "When you hallucinate, you seem to perceive what is not there. (…) When you imagine, you evoke something absent and make it mentally present to your attention" (Thompson, 2014: 179). In this chapter I adopt this latter view and will refer to SP

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before my eyes and on my chest, slowing down my breathing. Moreover, my senses are grabbed by an impression of fighting a hurricane that may drag me out of my body. This cyclone, that has a black hole in lieu of an eye, forces me to fight it, and this fight seems crucial to my survival (…) In addition, there are auditory experiences, an amalgam of petrifying words and vibrations that feel like sudden gusts of wind in the eardrums. All this happens when by body feels like a statue, without a possibility of screaming.
(…) On occasion, with determination and *lucidity*, I can have power over this swirl of stillness. (…) I take back some control of my imaginary hands, and then I hold them out to *Morpheus* for a dazzling and colorful dance in a deep and enlightened night". (Male SP sufferer, also diagnosed with narcolepsy. Montreal, Canada. Account translated from French).

experiences as variant of spontaneous thought/mentation or mental imagery, rather than hallucinations or delusions.

Kinds of sleep paralysis experience

A factor analysis by Cheyne and colleagues (1999) showed that SP mentation typically falls into three general categories. The first category is *Intruder,* and it is characterized by a felt presence, fear, as well as auditory and visual imagery. The person who experiences SP feels that someone is in the house or in their room. This experience is sometimes accompanied by seeing or hearing someone or something sentient move around the house. The second category of SP experiences is known as *Incubus*, in which the felt presence is interpreted as a supernatural assault and is often accompanied by a sensation of shallow breathing, a feeling of being smothered, pressure on the chest, or pain. In this case, the sleeper often sees and feels the maleficent being on top of her. The third category, *Unusual Bodily Experiences*, appears to be a separate, less well-known, and a qualitatively different kind of SP experience: these are often described as positive events, such as sensations of floating, out-of-body experiences (OBEs), and feelings of bliss. Both *Intruder* and *Incubus* categories typically include the experience of felt presence – a distinct sensation that someone sentient is in the immediate vicinity of the sleeper (Cheyne, 2005).

Most literature on SP focuses almost exclusively on the first two kinds, *Intruder* and *Incubus,* possibly due to their particularly intensified felt presence imagery, which contributes to distressing SP experiences (Solomonova et al, 2008; Cheyne, 2013). However, neutral and positive instances of SP have also been described, and the third category, *Unusual Body Experiences*, or vestibulo-motor experiences, is often characterized by pleasant sensations and a spirit of exploration, accompanying sensations of flying, out-of-body experiences, or autoscopy (observation of one's own body from an unusual/novel point of view) (Brugger, Regard & Landis, 1997).

Felt Presence

"Just before going to sleep or if awoken suddenly I feel as though a presence, usually a dark shadow figure is standing over the bed staring down at me, or pacing back and forth." (22 year old, gender not reported, USA).

Among all SP experiences, felt presence, the distinct sensation that another sentient being, human or not, is present in the extracorporeal space of the experiencer, is arguably the most salient, terrifying, and rich.. Felt presence is consistently reported as the most common SP-associated experience – about 80% of episodes (Cheyne et al, 1999), which produces most fear and SP-related state of distress (Solomonova et al, 2008). One salient feature of felt presence experiences during SP is the fact that it is a distinct sensation, and may occur in the absence of visual, auditory, or tactile imagery. Felt presence experiences during SP have been classified as a paranoid delusion (Cheyne & Girard, 2007), an expression of spatial social imagery (Nielsen, 2007), and as a variant of basic intersubjective experience of the world (Solomonova, Frantova, & Nielsen, 2010).

Felt presence experiences are often interpreted within the cultural framework available to the experiencer (see the following section on the cultural neurophenomenology of SP), but some basic characteristics seem to be common across cultures and ages (Cheyne, 2001): 1) felt presence often manifests from ambiguous stimuli: it is often described as "shadowy", and its physical characteristics are often unclear; 2) the experiencer may report a distinct sensation of being watched, and that the presence has some intentions towards the dreamer; these range from some vague interest to full-blown assault; 3) felt presence is usually accompanied by intense emotions (often fear when the presence is interpreted as threatening), sometimes to the point of a distinct feeling of dread, imminent death, or being in the presence of evil. Positive emotions, however, are also possible, especially when the experience is understood as visitations by deceased relatives or visions of the divine.

Intruder

Consider the following examples of felt presence experiences of the *Intruder* type: A 26-year-old man from the United States reports: “It felt as if someone was watching me but silently standing behind me”. In this example the presence is felt in a distinct and clear way, but not seen or heard, yet the experiencer knows where in space the presence is located. Similarly, a 29-year-old woman from USA regularly experiences the malevolent presence without ever seeing it: “…feeling of evil that is watching or monitoring; never able to actually see this "evil entity". Even in the absence of direct visual, auditory or tactile imagery she feels that she is observed and that the presence is “evil”. The ambiguous qualities of the physical attributes of SP visitors can be illustrated by the following two examples. A 39-year-old man from USA writes: “The "presence" is a tall black/darkest grey shadow of a human form without any features. It stands in the doorway to my bedroom waiting to be "noticed". Likewise, a 30-year-old woman experienced various ways in which the presence was manifesting during her SP attacks: “Once it seemed a shadow was leaving the room. One other time the shadow seemed to have "wild" hair or if it doesn't have hair at all, it looked as some sort of black something”.

Incubus

The *Incubus* experience happens when the *Intruder* physically oppresses the sleeper, sometimes in a rather dramatic way. In words of a 52-year-old man from the United States: “My worst experience was being choked by a man who burst into my bedroom. The experience was so real and frightening that I was very afraid of my SP for many months after.” The *Incubus* takes many forms, including human, supernatural and more rarely, animal: “I often hallucinate creatures like large cats - lions or tigers, … wrapping themselves firmly around me and crushing my body” writes a 20-year-old woman from England.

Some of the most dramatic and potentially traumatic SP *Incubus* experiences are instances that are lived as sexual assault or alien abduction. Consider the following example, reported by a 40-year-old man from the United States: “When it is a "Dark Man" episode, he most likely touches me. Either by laying across my body, in a sexual way or in the beginning, he would grab me and drag me. I always felt that if I let go, he would pull me out of my body". Similarly, a 29-year-old woman from Spain describes her distressing SP experience: "…extreme terror, the feeling that air is dense and darker, that shadows boil and take shape… I hear some low tone noises, voices, tactile feeling of grabbing, of naked cold skin, and, very rarely, a presence. Very dark with round eyes, spider-like fingers, that laughs, messes up the bed, and makes me feel terror, with some sexual approaches…". In a study linking reports of space alien abduction to SP episodes McNally and Clancy present this case: "…female abductee… was completely paralyzed, and felt electrical vibrations throughout her body. She was sweating, struggling to breathe, and felt her heart pounding in terror. When she opened her eyes, she saw an insect-like alien being on top of her bed" (McNally & Clancy, 2005: 116).

Positive felt presence experiences and doubling

While most easily recognizable and most commonly documented cases of felt presence during SP have to do with a threatening and ominous "visitor", some evidence suggests, however, that the presence is not always understood as hostile. Such experiences include perception of friends and family; visitation from deceased relatives or benevolent spirits; and erotic encounters where the sense of presence is comforting. A 20-year-old SP sufferer from the United States writes: "Once or twice I have thought that my friend or roommate was standing over me. I was confused but not afraid." Similarly, encountering deceased family members in visions or in dreams can be experienced as a positive spiritual event, and possibly play a healing role in processes of bereavement (Garfield, 1996; Belicki et al, 2003).

Finally, another rare kind of SP-related felt presence episode involves first an experience of "someone there", and then a doubling of the dreamer's own body, a self-projection into the extracorporeal space. Some individuals report that the felt presence entities are becoming an externalized view of themselves: "Sometimes I feel that the presence is myself, that I can watch myself", reports a 21-year-old man from Jamaica; "I switch to another world and I myself become a presence", writes a 19-year-old man from Russia.

Body experiences in sleep paralysis

Most (if not all) SP episodes are defined by an altered experience of the body. These include simple experience of muscle paralysis; sensations associated with supernatural assault, including touch, pressure on the chest, or even choking; feelings of unusual vibrations or falling into a vortex; and out-of-body experiences, including flying, falling, or moving around one's house.

One of the most salient features of SP is the REM sleep-related muscle atonia. The inability to move is a striking and unusual experience for most individuals, and the mismatch between sensing the body and the loss of voluntary control over the body's movements may contribute to a range of somatosensory experiences. As discussed above, some of the most intense SP episodes may involve a feeling of being assaulted or touched by a supernatural entity. For instance, a 34-year-old man from USA describes the following experience: "Felt my arms pinned across my chest in a strait jacket hold, felt hands on my chest pinning me against a wall". Perception of not being able to fully breathe, often accompanied by feeling of pressure on the chest, may be prevalent in as much as 57% of SP episodes (Sharpless et al, 2010).

Although most accounts of and research on SP experience have centered on paralysis accompanied by terrifying mentation and by felt presence, not all SP experiences are characterized by imagery and many are simply experiences of transient body paralysis during the transition between sleep and wakefulness, without any other accompanying mental activity (American Academy of Sleep Medicine, 2001). Additionally, SP episodes may be predominantly somatosensory in nature: Cheyne (1999) characterizes these experiences as *Vestibulo-Motor* mentation.

Autoscopy, out-of-body experiences, vibrations, floating, falling and body doubling experiences (Cheyne, 2002) are all possible within the SP framework due to its reliance on dream-supporting REM sleep mechanisms. During a dream, especially a lucid dream (wherein one is aware of the fact that she is dreaming), it is possible to have simultaneous experience of one's dream body and real body at the same time. Thompson (2014) distinguishes between the dreaming self (I the dreamer) and the dream ego (I as dreamt) as two coinciding modes of self-experience, which may sometimes be experienced in parallel. The dreaming self is the sleeping self, it is the “I” of the waking life, now engaging in the practice of sleep and dreaming. The dream ego, on the other hand, is the experiential self, immersed in the dream scenario. The I as dreamt is the temporary “I” that takes on the first-person perspective as a subject (and sometimes an object) of the dream world. Seen from this point of view, SP episodes may represent an intense experience of the dreaming ego, lacking a dream body and temporarily “stuck” within her immobilized sleeping body of the dreaming self/I the dreamer while experiencing dream-like mentation. This feeling of being stuck, coupled with awareness of the overlap between states of vigilance, may then transform itself into a situation of perceptual doubling of body imagery.

Contrary to most SP episodes with a felt presence component, some bodily experiences are described in quite positive terms. For instance, a 20-year-old woman from England describes this characteristic of her typical SP episode: “Generally, the experiences start with a low, pleasant vibration that moves through my body in defined waves, from the feet up. I feel them most strongly in the throat and in my eardrums”.

Out-of-body experiences are also relatively common in SP – as much as 39% of SP experiencers have had one at some point (Cheyne, 2002). A 39-year-old woman from the United States writes: “I floated out of my bed into the kitchen. But, as I floated over my bed, I saw like this beast figure crouched over on the front of my bed. I floated over it down to the kitchen. That is where I saw this beautiful kaleidoscope-like leaves. They were so vibrant … I then floated back to my room into my body”. In this example there is a combination of various SP characteristics: dream-like mentation superimposed onto the environment, a nocturnal visitor, and an altered sense of the body.

SP experiences are also sometimes accompanied by false awakenings—dreams where one has a vivid and realistic feeling of waking up in their own bed and engaging in usual activities only to realize that they are still asleep (Buzzi, 2011). While false awakenings are typically characterized as dream experiences, their phenomenology in terms of realism and possible state overlap is to a degree similar to SP. In Cheyne’s report (2002), 58% of people who experience SP also experienced false awakenings at least occasionally. Additionally, false awakenings are often associated with feelings of dread, anxiety, and oppression (Green & McCreery, 1994; Nielsen and Zadra, 2011), similarly to SP. The following two examples from our Internet-based sample illustrate such cases: a 24-year old man from the United States reports: "… sometimes I think I have moved... sometimes even gotten up and walked around only to find that I never got up at all." In a similar vein, a 21-year old man from Jamaica describes his experience: "I will wake up into another dream inside my bedroom and think I am awake and realize I am still sleeping minutes later and the same procedure repeats several times".

Emotions

*…Extreme anxiety and fear, mind is awake, but body is asleep. I feel as though I am trapped and cannot communicate with those around me. (*23-year-old woman, USA*)*

The most prevalent emotion associated with SP experiences is fear. Indeed, the most natural reaction to waking up unable to move is panic, and the sensation of constricted breathing (consistent with REM sleep physiology) may increase the state of distress. Sharpless and colleagues (2010) introduced the term *fearful isolated sleep paralysis* to denote SP experiences characterized by an intense state of distress.

As much as 90% of reported SP episodes are described as fearful (Cheyne, Rueffer, & Newby-Clark, 1999). Similarly, in an Irish University students' sample, fear was found to be the most prevalent emotion, with 82% of respondents stating that they have experienced fear at some point during a SP episode (O'Hanlon, Murphy, & Di Blasi, 2011). Moreover, nightmare frequency was previously reported as a predictor of SP occurrence (Liskova et al, 2016). This data suggests that SP, or at least the *Fearful* form of SP, can be seen as an intensified form of a nightmare: a recent study by Robert and Zadra (2014) reported that about 65% of nightmares and 45% of bad dreams are characterized by fear.

One approach to classify the affective and personal impact of SP experiences is to assess not only frequency or intensity of SP episodes, but also *distress* associated with SP experiences (Solomonova et al, 2008; Cheyne & Pennycook, 2013). To what extent is the individual affected by SP? To what extent do negative emotions carry-over from an SP episode into waking life? Do SP experiences promote a negative relationship with sleep? These questions have been successfully examined in previous research on nightmares (Belicki, 1992; Blagrove, Farmer & Williams, 2004), showing that the individual impact of negative and intense dream experiences depends more on a trait-like reactivity, sometimes referred to as affect distress (Nielsen & Levine, 2007). This trait is thought to represent a general dysfunction of affect regulation network, and it has been shown to be a better measure of how much nightmares influence waking life emotional well-being than frequency or intensity of self-reported nightmare occurrence. Furthermore, affect distress mediates reactivity, negative interpretation and degree of negative reaction to nightmares (Belicki, 1992; Levin & Fireman, 2002). According to Nielsen and Levine (2007; Levine & Nielsen, 2009), dreaming helps regulate emotional memory consolidation and emotional reactivity via fear extinction. Nightmares, therefore, represent a case of problematic/dysfunctional processes of fear extinction. In combination with other factors, affect distress is likely to play a role in formation, experience and interpretation of SP.

Positive emotions associated with SP are much less studied, and it is not possible to accurately estimate their prevalence. One possible reason for this is lack of appropriate screening (SP is often diagnosed as an unpleasant phenomenon) and lack of medical/psychiatric concern: patients are not very likely to describe such experiences to their health practitioner, since they are not bothered by them. In addition, the current diagnostic criteria for a recurrent isolated SP as listed in the latest edition of the *International Classification of Sleep Disorders – 3d edition* (American Academy of Sleep Medicine, 2014), include that the episodes must cause “clinically significant distress including bedtime anxiety or fear of sleep”. Such a provision would effectively exclude all possible positive and non-distressing SP phenomena from investigation and/or diagnosis. Nonetheless, in a web-based SP study Cheyne (2002) reports that in addition to anger (30% of respondents) and sadness (23%), bliss (17%) and erotic sensations (17%) are also sometimes present in SP.

Visual and auditory experiences

Felt presence is the most prevalent, the most emotionally disturbing, and the most salient SP-related experience. Therefore, it is unsurprising that most visual and auditory mentation during SP usually has something to do with these unwelcome visitors. The entities, however, while *felt* in a very distinctive and concrete way, are often described visually as rather general and vague shadowy beings. Visual experiences are reported to occur in 54%– 56% and auditory experiences in 55%-60% (Solomonova et al, 2008; Cheyne, 2002) of SP sufferers.

SP may be accompanied by auditory experiences, ranging from abstract and mechanical sounds, such as electric sounds and sounds of buzzing, to vivid auditory imagery, consistent with SP experience of an *Intruder* or an *Incubus*. Sounds of footsteps and of voices are often reported (Cheyne, Rueffer & Newby-Clark, 1999; Cheyne, 2002; Solomonova et al, 2008).

Cultural grounding of SP

While sleep paralysis is a lesser-known sleep phenomenon in the West, it is quite prevalent and is well-described in many other cultures. Due to the lack of general awareness of SP in the West, it is rarely discussed in the context of family medicine or psychology. Cross-cultural work on SP revealed that it is rooted in a variety of religious beliefs and cultural schemas, including interpretations of the experience and techniques to engage with the nocturnal visitors. Some of the common qualities of SP across cultures (Adler, 2011) include: 1) sensation of being awake; 2) perception of the environment; 3) paralysis; 4) feeling of fear and dread; 5) felt presence; 6) chest pressure/breathing difficulties; 7) supine position; 6) various unusual body sensations. These apparently culturally-invariant qualities of SP-related occurrences of the experience of a supernatural attack have been at the center of the phenomenological and cross-cultural cognitive research on SP.

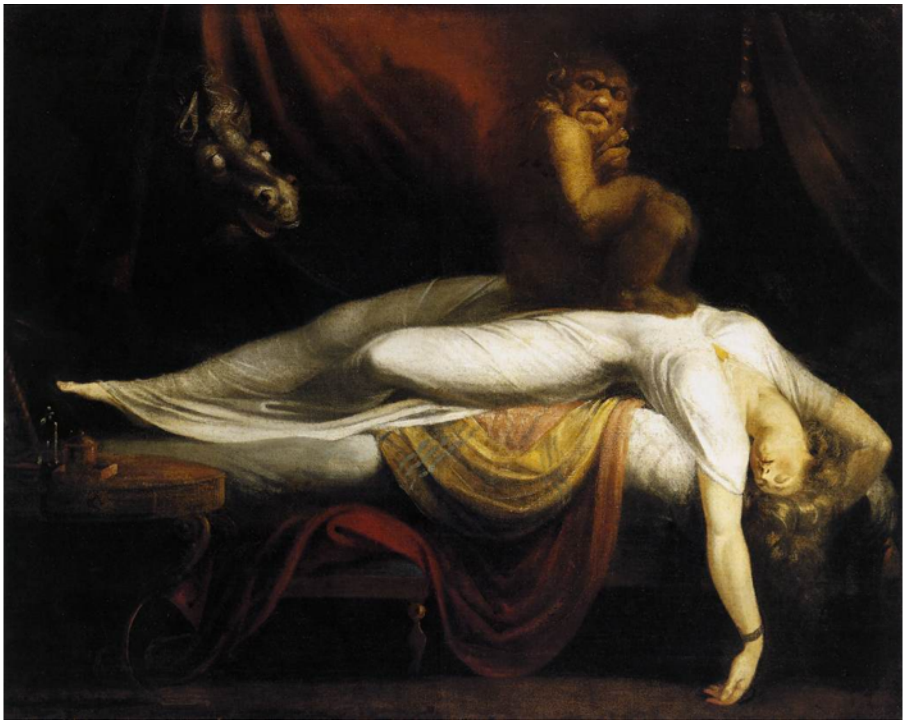

Figure 2. Henry Fuseli. The Nightmare. 1781. Detroit Institute of Art. Public Domain image: https://commons.wikimedia.org/w/index.php?curid=15453518

Figure 2 is a reproduction of an eighteenth-century work by Henri Fuseli entitled *The Nightmare*. It represents a sleeping woman in a supine position being oppressed by a maleficent creature sitting on her chest and with an ominous presence of the *night-mare*. It is likely that the early use of the English term *nightmare* was to describe intense SP (Orly & Haines, 2014). Culture-specific presentations of SP-related felt presence experiences typically involve a maleficent supernatural being, such as a witch or an evil spirit. Some examples found across cultures include the *kanashibari* demon in Japan (Fukuda et al, 1987; Arikawa, Templer & Brown, 1999); *kokma* in the West Indies (Ness, 1983); "old hag" in Newfoundland (Hufford, 1989); *pandafeche* in Italy (Jalal, Romanelli & Hinton, 2015); *uqumangirniq* among the Inuit of Baffin Island (Law & Kirmayer, 2005); and many others (for a comprehensive list of terms for SP experiences see Adler, 2011). Figure 3 illustrates a possible SP representation (Orly & Haines, 2014): a Japanese demon *Yamachichi* oppresses and inhales the breath of the sleeper.

The first systematic cultural exploration of SP was done by Hufford (1989): he described a phenomenon specific to Newfoundland – the "old hag" witch attack. In his book, Hufford discusses the tension in situating SP experiences somewhere between the 'cultural source hypothesis', wherein cultural interpretations and framing influence how an experience unfolds, and the 'experiential source hypothesis', where some invariant lived experiences, such as SP, may influence the development of a spiritual interpretation and formation of cultural beliefs (Hufford 1989, 2005). Similar to this notion, McNamara and Bulkeley (2015) proposed an experiential hypothesis to describe how dreams and other dream-associated experiences, including visions and transcendental experiences, can be seen as a cornerstone and a source of religious belief (McNamara & Bulkeley, 2015). According to this view, a number of cultural, religious and paranormal beliefs are shaped primarily by direct experience and then framed within a particular tradition, which imbues them with existential and metaphysical meaning, a notion that is reminiscent of William James' grounding of mystical experience in the phenomenology of lived experience (James, 1985).

The effect of framing such intense subjective experiences within a cultural tradition can have at least two kinds of potentially opposing effects. On the one hand, many cultures provide not only supernatural explanations of SP, but also remedies and protective rituals against it (some of which are described in the later part of this chapter), thus rooting the SP in a framework which allows for shared narrative and for practical interventions. On the other hand, intense and fearful SP, when interpreted as supernatural assault, has a potential for traumatizing the sleeper, thus creating a vicious circle of anxiety, aversion to sleep, facilitation of future SP episodes (Hinton et al, 2005; Sharpless et al, 2010), and increasing the level of distress via "cultural fear priming" (Ohayon et al, 1999; Jalal, Romanelli, & Hinton, 2015). For instance, the *Incubus* experience, when seen as part of the Christian tradition starting with the late Antique period, according to Gordon (2015), gained additional stigmatizing power, with a connotation of an illicit supernatural sexual experience. Not only were SP victims living through a waking nightmare of an encounter with a demonic assailant, they were also seen as responsible for having summoned it due to their own sinful predisposition/thoughts/impurities.

It is important to note that while SP can include a range of experiences, such as positive experiences, neutral emotions, vestibulo-motor phenomena, out-of-body experiences, and others, most cultural interpretations of SP deal specifically with overlapping aspects of Intruder and Incubus.

Figure 3. Takehara Shunsen. *Yamachichi*. Public domain image: https://commons.wikimedia.org/w/index.php?curid=2074508

Neural basis, associated conditions, and precipitating factors

Human sleep is typically divided into two kinds: REM sleep and NREM sleep. Healthy adults alternate between NREM and REM in cycles lasting about 90 minutes, for a total of 5-6 cycles over a night of sleep. While it is possible to experience dreaming in all stages of sleep, REM sleep is typically characterized by the most vivid, realistic, bizarre, and emotionally intense sleep mentation (Nielsen, 2000). Other vivid dream experiences, such as nightmares (Nielsen & Levin, 2007) and lucid dreams (LaBerge, Levitan & Dement, 1986), are also typically associated with REM sleep.

Within the context of narcolepsy, sleep paralysis is a part of the diagnostic tetrad, alongside daytime sleepiness, cataplexy, and hypnagogic hallucinations (Thorpy, 2016). There is not sufficient data to assess whether there are significant differences in phenomenology between narcolepsy-associated SP and the isolated form.

SP episodes are characterized by simultaneous presence of waking thought and of REM sleep psychophysiology (Mahowald & Schenck, 1991, 2005; Terzaghi et al., 2012), and the sleeper can often open her eyes and become relatively aware of her environment, while REM sleep-related spontaneous mentation - vivid dreaming - superimposes onto otherwise awake consciousness. This imagery may occur at sleep onset (hypnagogic) or upon awakening (hypnopompic). Other characteristics of REM sleep, such as airway occlusion and rapid shallow respiration (Gould et al., 1988) may contribute to the feeling of being suffocated or the perception of shortness of breath often reported by SP sufferers. Additionally, in one study obstructive sleep apnea was found to be a possible precipitating factor for ISP (Hsieh et al, 2010).

Little research has been done on the sleep characteristics of SP sufferers. Some preliminary data suggests that the SP sleep profile may be similar to that of frequent nightmare sufferers (Nielsen et al, 2010), in that SP participants appear, paradoxically, to exhibit less REM sleep pressure, have more “skipped” REM sleep periods, and show no increase in eye movement density (as opposed to healthy controls) throughout the night (Solomonova, et al, 2012). SP participants also show higher delta power during sleep than non-SP controls (Marquis et al, 2015), which suggests alteration of processes of wake-NREM-REM regulation.

Some of the vestibulo-motor characteristics, such as autoscopy, out-of-body experiences, and feelings of physical transformation, may stem from disturbances in right parietal regions (Jalal & Ramachandran, 2014): the mismatch between intended motor movement and inability to move may contribute to unusual physical sensations.

SP may be experimentally elicited in laboratory settings, but only using an arduous protocol of repeated sleep interruption. For example, SP episodes were experimentally induced by letting participants sleep uninterrupted for the first NREM period, thus eliminating most of the slow-wave sleep pressure (a tendency of slow-wave NREM sleep to take precedence and occupy a large proportion of early night sleep), and then repeatedly awakening participants after 5 minutes of REM sleep have elapsed, thus augmenting REM sleep pressure and facilitating sleep-onset REM periods (SOREMPs). SOREMPs may be seen as a facilitating factor in a REM-wake state dissociation thought to characterize SP experiences. It should be noted, however, that even within such controlled settings and demanding protocols, rates of SP were relatively low: 6 episodes total in 16 participants who already had a tendency toward recurrent isolated SP (Takeuchi et al., 1992), and 8 episodes from 184 sleep interruptions in 13 SP sufferers (Takeuchi et al, 2002). These results suggest that incidence of SP at sleep onset may signify an individual's propensity to enter into REM sleep directly upon falling asleep. This further supports the idea that SP may result from alterations in wake-REM-NREM regulation patterns, resulting in state overlap.

Associated conditions

Little is known about the epidemiology of SP, but growing evidence points to a combination of genetic and experiential factors. The only study to date to examine genetic factors associated with SP has reported moderate heritability and that this effect was associated with factors known to contribute to disrupted sleep cycles (Denis et al., 2015). Sleep fragmentation and disruption in wake-NREM-REM regulation are an important factor facilitating SP occurrence, but it is uncertain whether all types of SP can be explained by a propensity for sleep fragmentation. Some ethnic groups seem to be more likely to experience SP than others. The Hmong population in Wisconsin, for instance, had a significantly higher incidence of SP than a non-Hmong cohort (Young et al, 2013), with as much as 31% of interviewed Hmong participant reporting at least weekly occurrence of SP episodes. Individuals of African descent also seem to have elevated rates of SP (Bell et al, 1984; Friedman & Paradis, 2002).

Links between affective disorders, especially depression and anxiety, and SP have also been reported. A relationship have been found between SP and depression magnitude and anxiety **(**Szklo-Coxe, Young, Finn, & Mignot, 2007**)**, social phobia and panic disorder (Paradis & Friedman, 2005; Otto et al, 2006; Sharpless et al, 2010) and social anxiety (Simard & Nielsen, 2005), especially with the sensation of being observed (Solomonova et al, 2008). Changes in REM sleep regulation are often found in mood disorders, especially in depression (Arargun & Cartwright, 2003; Nofzinger et al, 1994)

The relationship between trauma, especially post-traumatic stress disorder (PTSD), and SP has been noted by a number of researchers. McNally and Clancy found that there was a higher proportion of SP reports in participants with a history of childhood sexual abuse (McNally & Clancy, 2005a), and Abrams and colleagues (2008) reported that sexual abuse survivors report more distressing and more frequent SP incidence. In addition, higher rates of SP were found in Hmong population in relation to traumatic Vietnam War experiences (Young et al, 2013), as well as in Khmer (Hinton et al, 2005a) and Cambodian refugees (Hinton et al, 2005b). Similarly, Sharpless and Grom (2013) report that some cases of SP onset in adolescents begin after the loss of a family member. Considering that SP may be conceptualized as a nightmare spectrum experience, this relationship may represent the same dysfunction in the affect regulation network (Levin and Nielsen, 2007; Nielsen & Levin, 2007) as the one that has been proposed to be involved in nightmare production. PTSD-related sleep disturbances have been extensively documented (Spoormaker & Montgomery, 2008; Germain, Buysse & Nofzinger, 2008), including REM sleep dysregulation and increased nightmares (Melman et al, 2002; Germain, 2013), which in itself may contribute to altered REM sleep pressure, in turn facilitating occurrence of SP episodes.

Since SP is often associated with intense, detailed, and troubling visions, a link between SP and psychiatric disorders has been hypothesized. Research, however, shows no consistent relationship between psychiatric conditions and SP, with the exceptions of PTSD, panic disorder, and social anxiety. In one study a number of links between SP and psychiatric conditions were found (Ohayon et al., 1999); these findings,were challenged, however, by an internet-based study (Solomonova et al., 2008), with a larger sample size, in which no strong links between psychopathology and SP were described. However, while isolated SP often presents itself in the absence of psychopathology, higher rates of hypnagogic and hypnopompic experiences (dream experiences occurring during the transition between sleep and wake: at sleep onset or upon awakenings, respectively), some of which may be associated with SP, are often found in psychosis (Plante and Winkelman, 2008).

Precipitating factors

In their recent book, Sharpless and Doghramji (2015) list a number of plausible precipitating factors for SP occurrence in susceptible individuals. Sleep fragmentation and insufficient sleep are among the most obvious factors. REM sleep deprivation has been shown to increase REM sleep pressure contributing to REM rebound effect and intensified dreams at sleep onset (Nielsen et al, 2005). Poor sleep quality with frequent awakenings and disruptions may also facilitate REM-wake overlap, creating fruitful conditions for the occurrence of SOREMPs (Takeuchi et al, 1991, 2002; Spanos et al, 1995). Shift work, jet-lag, use of sleep disrupting medication, stress, anxiety – all these factors affect sleep and may facilitate a SP episode. Alcohol consumption was also reported to promote SP (Golzari & Ghabili, 2013; Munezawa et al, 2011), probably due to its effect on altering sleep architecture (Roehrs & Roth, 2001). Sleeping in a supine position also appears to enhance the risk of a SP episode (Sharpless et al, 2010).

Neurocognitive considerations

A return to felt presence

While undoubtedly felt presences are a hallmark of SP, especially of the intense and frightening episodes, presence experiences are not restricted to this parasomnia and are reported in a variety of conditions, thus possibly representing a more general and basic social imagery process (Nielsen 2007, Solomonova, Frantova & Nielsen, 2011). Arguably, the most salient and compelling felt presence occurs in the context of mystical and spiritual experiences. Otto (1958) introduced the idea of the *numinous* as a cornerstone of religious mystical experiences. Some of the recent work comes from anthropology: the ecstatic presence of God is manifested in the community of Evangelical Christians in the USA (Luhrmann, 2012). Other examples of felt presence have been documented in situations that are physically and emotionally straining or novel. Some examples of these experiences include high altitude climbing (Brugger, Regard, Landis, & Oelz, 1999); feeling of the presence of a baby in postpartum mothers (Nielsen & Paquette, 2007); presence of deceased relatives in the context of bereavement (Simon-Buller, Christopherson & Jones, 1989; Taylor, 2005; Keen, Murray & Payne, 2013); in extreme environments, such as solitary sailing (see also chapter by Suedfeld in this volume), surviving in remote and hostile environments (Suedfeld & Mocellin, 1987), and others. While in most cases felt presence is experienced spontaneously, in some cases it may be a product of sustained mental practices (as in prayer and some forms of meditation). One contemporary non-religious phenomenon is *tulpamancy* (Veissiere, 2016) – a long-term practice of conjuring up imaginary companions, that, over time, may be experienced as almost as real as other people.

Additionally, being able to have a felt sense of others may be seen as a prerequisite for the development of subjectivity. Recent work in phenomenology and enactivism suggests that development of sense of self depends crucially on sensing others, as early as in utero (Gallagher, 2005; Ammaniti & Gallese, 2014), that the sense of one's own body depends on the sense of others (Maclaren, 2008) and that the self-other dynamic is a necessary condition for the sense of self (Zahavi, 2014). Evidence from dream research too suggests that dream processes are relational and intersubjective. The fact that dreams are most often about other people has been conceptualized as simulations of social interaction (Revonsuo, 2016) and as representations of individual attachment styles (McNamara et al, 2001). Additionally, dreams, similarly to waking, can be seen as a dynamic interaction between the "self"-related and "non-self" elements of dream content (everything extraneous to the dreamer). These non-self elements (non-human characters, dream environment, even dream objects can be seen as a "dream other" due to their inherent relational property (Solomonova et al 2015) and to the fact that dream environment in its entirety affectively motivates dreamer to engage with it.

Toward a cultural neurophenomenology of SP

SP has often been characterized as dissociative (Terzaghi et al., 2012) state, since it effectively combines characteristics of 'waking' consciousness (self-awareness, access to autobiographical memory, ability to open eyes and perceive the environment) with REM-sleep phenomena, specifically muscle atonia/paralysis and mentation/dreams. This notion of SP as dissociative has been at the heart of the previous neurobiological work on the link between dreaming and REM sleep. The relative deactivation of the dorsolateral prefrontal cortex characteristic of REM sleep (Hobson, Stickgold & Pace-Schott, 1988; Maquet, 2000) has been long hypothesized to be at the root of the loss of autobiographic memory and of the inability to appreciate the contents of the dream as "bizarre" or implausible in relation to reality. This has led to the hypothesis that in REM sleep dreaming one is effectively delusional and in a state of a transient psychosis (Hobson, 2004). In SP, similarly, there is often incomplete autobiographical access. This association between SP and REM sleep has also displaced the experience of SP from the psycho-spiritual domain of meaningful encounters with menacing/unreal/supernatural others, into a more reductionist account of uncontrollable and inescapable REM-initiated hallucinations.

In contrast, an account of SP in the context of an oneiric phenomenology and in a 4EA perspective may allow for a more nuanced reading of these experiences. An emerging neurophenomenological framework of sleep challenges strict distinctions between wake, NREM, and REM sleep. Indeed, while SP is one of the examples of simultaneous presence of REM sleep and wake processes, it is not the only phenomenon that attests to the fluidity and interpermeability of states of consciousness. Lucid dreaming is another example of REM-wake co-occurrence (LaBerge, 1986); REM sleep behaviour disorder is characterized by preserved motor output during REM dreaming (Peever, Luppi & Montplaisir, 2014); somnambulism episodes combine NREM and wake physiology and phenomenology (Zadra et al, 2004); and a variety of dream-enacting behaviours, such as laughing, simple movement, crying and looking for a baby in bed, are prevalent in normal populations (Nielsen & Paquette, 2007; Nielsen, Svob & Kuiken, 2010).

A more continuous view of mentation in sleep includes viewing SP as a form of oneiric experience: as a process of intensified mind-wandering (Fox et al, 2013), as a process of creativity (Hartmann & Kunzendorf, 2013), or as enactive imagination (Thompson, 2014), a process of sense-making in a rich, embodied and intersubjective world (Solomonova & Sha, 2016). In his discussion of lucid dreaming, Thompson (2014) proposes that in addition to seeing this state as a dissociative superimposition of two distinct states of consciousness, it may be simultaneously approached as an integrative state, thus allowing for an integration of two different yet related ways of self-experience.

While SP sufferers feel awake and in their own bed, the realism of the experience and the quality of total immersion are completely overpowering to the dreamer, so that she is unable to appreciate the dreamlike quality or the unreality of the SP episode. The high prevalence of tactile and physical sensations probably contributes to this effect. There are, however, numerous accounts of long-time SP experiencers that are characterized by a certain 'feel' for the experience as somewhere between real and unreal. SP-related experiences may have a very compelling and realistic quality, but they are usually lived differently from waking experiences, as a kind of a liminal state.

Consider the following example: while the participant is experiencing intense emotion and is quite absorbed in the unfolding on the SP, he seems to have a kind of a dual awareness regarding the nature of his SP:

"*…Can't. Move. Not a muscle. Not an eyelash. It's often accompanied by hallucinations. So this bizarre or terrifying event is happening all around me, and I am completely unable to respond or defend myself. Sometimes I know it's not real, somewhere in my mind, but it looks real, and it sounds real, and I'm terrified or revolted (or maybe just bemused), but I cannot wake myself up to stop it*." (30-year-old man, USA)

Similarly, in another example the experiencer is also hesitant to ascribe any particular state to her experience:

"*… I might be answering wrong, because I see the beings in my dream-state immediately before waking. But their presence seems so real, I would compare the experience to having them accompanying me in the room*". (48-year-old woman, USA)

Grounding SP in its cultural context allows us to appreciate the variety of factors contributing to qualities of the lived experience, and it may not be possible to dissect the relative contribution of the multitude of neural, phenomenological and cultural narrative factors (Kirmayer, 2009). Importantly, in the current medical context, reducing SP to a dysfunction of REM psychophysiology may also have an important effect on reducing the potential for a deeper exploration of SP as a spiritual experience (Hufford, 2005).

The cultural neurophenomenology of SP is a powerful tool for investigating SP from the 4EA cognition perspective. As neurophysiological, experiential accounts of SP show, the dreamer is in fact embodied – the oneiric scenario is dependent on the dreamer's state of consciousness (REM intrusion) and on the dreamer's physiological state (atonia, shallow rapid breathing). She is embedded in a physical (interprets ambiguous stimuli around her) and in a cultural world (these ambiguous stimuli take on a familiar shape/are infused with a deeper cultural and interpersonal signification). The sleeper is also extended into the world – the whole environment, both dreamt and real, is part of her ongoing experience; and her experience is enactive – there is a relational quality: she is not a passive observer of the oneiric drama unfolding before her eyes, but rather she is deeply engaged (Solomonova & Sha, 2016).

In order to elucidate neurophenomenological qualities of SP in greater detail, future work may use microdynamic phenomenology/elicitation interviews, aimed at uncovering the fine-grained temporal and structural qualities of lived experience (Nielsen, this volume; Petitmengin, 2006; Petitmengin & Lachaux, 2013), in addition to neurophysiological data and deep awareness of the cultural, religious and spiritual context of the experiencer.

Sleep paralysis practices: prevention, disruption, treatment and exploration

While SP remains a relatively unknown phenomenon in much of Europe and America, a number of practical culture-specific practices have been developed to protect the sleeper from the negative influence of presumed supernatural forces. While some of these methods have deep roots in their respective metaphysical contexts, and therefore need to be grounded in existing religious and mystical practices, a number of practical and conceptually neutral recommendations have emerged, and seem beneficial for most SP sufferers, regardless of background.

No established treatment for SP currently exists; its clinical management is instead often focused on treating comorbid problems. According to a review by Sharpless & Doghramji (2015), psychoanalysis, cognitive-behavioural therapy (CBT), hypnosis, and education in sleep hygiene have been investigated in relation to SP, but no empirical consensus on efficacy of such interventions is currently available. Based on the available evidence on SP and cognitive-behavioural approaches to treatment of sleep disorders, especially insomnia, the authors propose a manual for CBT-ISP. This is a promising first step toward finding a systematic method of dealing with SP. Sparse evidence for pharmacological interventions for SP also exists: in one study it was suggested that REM sleep-suppressing antidepressants may provide temporary relief (Plante and Winkelman, 2008), and treatment of narcolepsy may reduce SP frequency (Mamelak et al., 2004). Antidepressants and anxiolytics were also used in severe cases (Hsieh et al., 2010). Terrillon and Marques-Bonham (2001) proposed that management of SP might benefit from administration of melatonin, which would help normalize the circadian rhythm. The cost of side effects associated with these treatments, however, may outweigh the benefit, and Shapless and Doghramji (2015) argue for a cautious approach, tailored to each individual situation.

While methods for dealing with sleep paralysis have not been systematically explored by empirical psychology or cognitive science, the contemporary context of Internet-facilitated support groups and information sharing practices are changing the solitary and culture-bound nature of SP attacks. Furthermore, a number of methods have been anecdotally reported and documented online and in print, that see SP experiences as an opportunity rather than a nuisance, and promote exploration of one’s own consciousness via SP-supported lucid dreaming or even contemplative approaches to SP (Hurd, 2010). One popular support group-mailing list is known as "Awareness during sleep paralysis" (ASP), and a reddit group on SP counts over 4000 users, sharing information on the phenomenology of their experiences and methods of overcoming them.

Cultural and clinical practices associated with SP can be roughly separated into three kinds: 1) preventative practices, focused on avoiding SP-enabling circumstances; 2) disruptive practices, designed to stop SP in the middle of the experience; and 3) observational/explorative practices, aiming at observing SP and possibly transforming it into a positive event, such as a lucid dream or an out-of-body experience.

Raising awareness of SP-associated phenomena itself may be one of the most important factors in reducing fear and distress before, during and after SP occurrence (Otto et al., 2006; Sharpless et al, 2010). Indeed, knowing that the experience is transient (will not last), benign (does not contain any real danger), and common (is shared with many individuals across the world) are powerful tools for psychological distancing and for facilitating an eventual observational, as opposed to fully immersive and fatalistic, attitude toward SP. Knowing about SP phenomenology and neurophysiology and having access to cultural grounding with available symbolic gestures helps prevent, disrupt and transform a negative experience into a tool for self-exploration. Figure 4 summarizes the intricate links between precipitating factors and effects of SP experiences in light of disruptive, and observational/transformational practices.

Methods for preventing sleep paralysis

While undoubtedly helpful, simply knowing the basis of SP may not be enough to alleviate terror and distress associated with the experiences, and disruption techniques are clearly warranted. A 25-year-old man from the United States reports: "This happens sometimes every night, sometimes only once every few weeks. Even though I 'know' what is happening, and that I am in no danger, it is always terrifying". The first study to systematically assess prevention strategies for SP by Sharpless and Grom (2014) has suggested that while no foolproof method for preventing SP is yet known, some strategies, such as avoiding sleeping on one's back (supine position), maintaining optimal sleep hygiene (avoiding stimulants, noise, irregular sleep patterns and anything that contributes to sleep fragmentation), and pre-sleep relaxation practices may help in preventing SP.

A number of culture-specific preventative ritualistic measures to prevent SP exist. These include placing a variety of defensive objects in the room or in the bed before going to sleep, such as a variety of knives (Hufford, 1982, Law & Kirmayer, 2005); sprinkling salt (a common anti-witch remedy) (Roberts, 1998); putting a broom bottom-up (Paradis & Friedman, 2005) or a pile of sand at the bedroom door (Jalal, Romanelli & Hinton, 2015); and many others. Putting a Bible in the room (Hufford, 1982) and saying a protective prayer before bedtime are also thought of as effective deterrents. Other ritualistic actions, designed to deter, divert and chase away unwelcome supernatural visitors were also documented in a variety of contexts (Sharpless & Doghramji, 2015).

Techniques for disrupting sleep paralysis

While preventative measures, whether culturally embedded or aimed at increased awareness and promotion of sleep hygiene, may be effective in reducing the frequency of SP episodes, many methods for dealing with an ongoing SP experience also exist. Considering that most SP experiences are characterized by fear and other unpleasant sensations, it is not surprising that in one study the majority of participants reported having attempted to disrupt the ongoing SP experience. Moving the extremities and self-monitoring (raising awareness, promoting calm) may be helpful during the SP episode (Sharpless & Grom, 2014). Not all attempts or all strategies are equally successful, but it seems that attempting micro movements, instead of trying to get up or to scream, are most effective. Culture-bound rituals include saying a prayer (Hufford, 1982), making a sign of a cross with one's tongue (Davies, 2010), and asking someone to physically shake the oppressed sleeper (Law and Kirmayer, 2005).

Observational/transformational practices

One may argue that ISP and lucid dreaming are polar opposites. However, they share the same underlying psychophysiology and seem to involve similar mechanisms: both are dependent upon REM sleep mechanisms; both are characterized by simultaneous presence of the dream state and by the feeling of being awake, including activation of higher order metacognitive functions indicative of some degree of waking thought processes (LaBerge, Levitan & Dement, 1986; Voss, Holzmann, Tuin, & Hobson, 2009; Dresler et al, 2012; Filevich et al, 2015); and in both cases muscle atonia is present. The crucial difference between the two states is the quality and the focus of awareness and metacognition: in lucid dreaming one is aware of the illusory nature of the dream scenario, whereas in SP the dreamer is often absorbed by the vision, not always fully realizing that it is dreamlike, and, in case of fearful SP, is too absorbed in the panicky state of perceived imminent danger.

The link between SP and lucid dreaming has not been systematically investigated in empirical research, but two studies report a positive correlation between frequency of lucid dreaming and SP (Denis & Poerio, 2016; Solomonova, Nielsen & Stenstrom, 2009), suggesting that the REM-wake intertwined state, characterizing SP, may be a trait-like phenomenon predisposing individuals to SP on the one hand, and facilitating lucidity in REM sleep dreams on the other.

Transforming SP into a positive experience, such as an OBE or a lucid dream, or utilizing SP experiences as a means of contemplative insight into one's own mind, may become a practice in itself, since not only techniques for disrupting and preventing SP exist in the contemporary digital culture, but also techniques for inducing SP, with the hope that the experience will function as a portal to a desirable altered state of consciousness (Hurd, 2010). The following two reports illustrate the transformative potential of SP:

"I have woken up from dreaming and found I can't move or open my eyes. I get the feeling of lemonade bubbling in my body, especially my head. It is very frightening. But since I have been having OBE[6]s I now relax and go with the flow of sleep paralysis and sometimes I actually achieve an OBE" (40-year-old man, Australia)

[6] OBE = out-of-body experience

*"At first I was very frightened until I found the ASP email group and found that I was not the only one being "visited" by this being during sleep paralysis. ... When it first started happening it was more of an assault and I had to fight terribly to escape. But after years, I learned to ignore and now I've been trying to communicate with the presence". (*40-year-old man, USA)

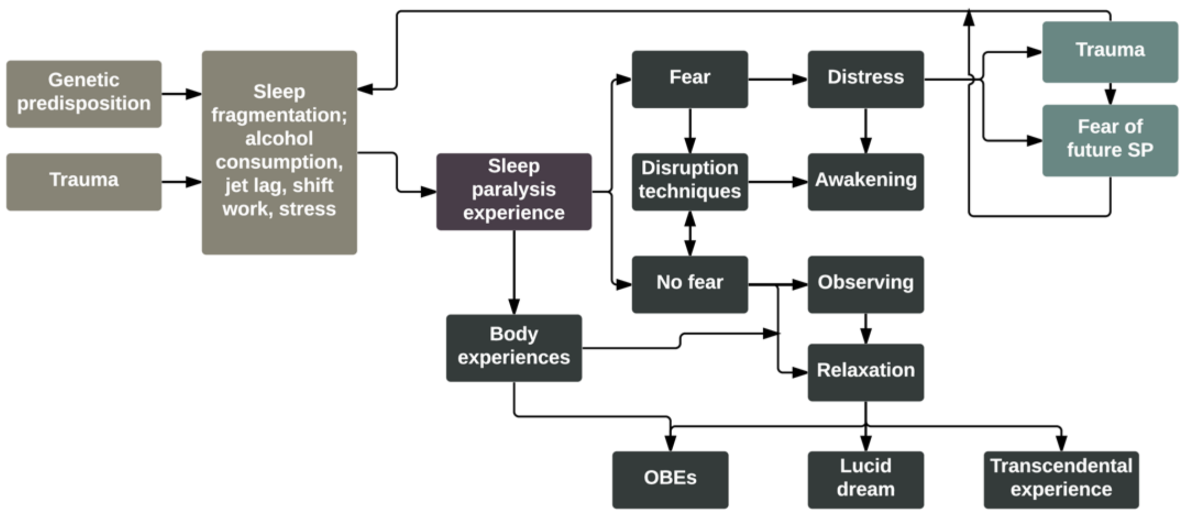

Figure 4. Predisposing, precipitating factors and experience and outcome of sleep paralysis episodes.

Further considerations and future directions

In terms of possible avenues for treatment, since SP can be conceptualized as a form of nightmare occurring in a mixed state of consciousness, nightmare treatment techniques could be useful in approaching SP. Currently, the most used and recommended technique for treating chronic nightmares is the Imagery Rehearsal Therapy (Krakow et al, 1995; Krakow & Zadra, 2006), which consists of "rehearsing" and transforming dysphoric oneiric imagery in a safe context. This method has been effective in treating PTSD-related nightmares (Krakow et al, 2001; Germain et al, 2004; Cook et al, 2010; Casement & Swanson, 2012), which seems particularly appropriate for intense and trauma-related SP experiences. Similarly, treatment of nightmares by lucid dreaming is a promising avenue (Zadra & Pihl, 1997; Spoormaker & Van Den Bout, 2006; LaBerge, 2009). Considering that neurophysiologically both states are characterized by an overlap between REM sleep and wakefulness, and that a number of folk approaches treating SP as a portal to lucid dreams already exist, mastering lucid dreaming could be an effective approach to transformation of an ongoing SP episode. Such a strategy may also be highly effective in de-stigmatizing and desensitising the experiencer, and especially in increasing her mastery and agency over her spontaneous oneiric experiences.

Contemplative practices, such as meditation or pranayama (yogic breathing) may also be useful in dealing with recurring SP episodes. There is currently no empirical evidence for contemplative techniques and SP management, with the exception of a case study by Jalal (2016), but anecdotal evidence from practitioners as well as growing empirical literature linking contemplative practices with stress management, emotion regulation, and increased self-awareness, provide grounds for future research.

Recent years have seen an important increase in empirical studies on the effects of meditation and meditation-based mindfulness interventions. There are documented benefits of contemplative practice in clinical populations including positive effects in mood disorders such as anxiety and depression (Hoffman et al, 2010; Goyal et al, 2014), social anxiety (Goldin & Gross, 2010), and PTSD (Kearney et al, 2013). At least four kinds of meditation are currently investigated in relation to mental health: focused attention, open monitoring (Lutz et al, 2008), self-transcendence (Travis & Shear, 2010) and loving kindness meditation (Hoffman, Grossman & Hinton, 2011). Different kinds of meditation practices may recruit different neural networks (Fox et al, 2016), and particular psychological and neuroplastic changes, associated with meditation practice, likely depend on the kind and duration of meditation experience (Lutz et al, 2015). These different kinds of contemplative practice may be helpful in targeting different kinds of recurrent SP experiences, promoting de-automatization (Kang, Gruber & Gray, 2013): deconstructing patterns of behaviour/reactivity. Meditation may be effective in SP management as a way of cultivating a non-judgemental or ‘non-sticky’ observational attitude to arising imagery, sensations and emotions, and in letting the experience unfold. In addition, one important feature of most mindfulness-related practices is the focus on the experience of the body (Kerr et al, 2013), and some evidence suggests that meditation practice may improve awareness of one's own body states (Solomonova et al, 2016) and increase introspective accuracy for somatic experience (Fox et al, 2012). Breathing practices, such as pranayama, may be particularly effective in transforming SP as it is happening due to the fact that many SP episodes are characterised by a feeling of disordered/insufficient breathing. A recent study (Seppälä et al, 2014) reported that breathing exercises were effective in decreasing PTSD symptoms in war veterans. This implies that practicing techniques that improve awareness of body sensations may lower the reactivity to SP episodes, thus lowering the distressing quality of the experience, and increasing the potential for disrupting or transforming SP.

Acknowledgements:

The author was supported by Social Sciences and Humanities Research Council (SSHRC) of Canada and by a J.-A. DeSèves Sacre-Coeur Hospital Foundation doctoral scholarship. Thanks are due to Tore Nielsen, Philippe Stenstrom and Michelle Carr for numerous conversations on sleep paralysis and its interpretation, and to the members of the Dream and Nightmare Laboratory at the Center for Advanced Research in Sleep Medicine. Additional thanks are due to Don Donderi and Elena Frantova, as well as to all participants who have consented to share their experiences with us. Special thanks to Benjamen Samaha (artist) and to the anonymous SP sufferer for generously offering the narrative and the drawing of a sleep paralysis episode.

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5. Article III

Contribution of REM sleep, sleep spindles and dream content to procedural memory consolidation in Vipassana meditators and non-meditating controls.

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Elizaveta Solomonova designed the study, obtained funding, collected and analyzed data, interpreted results, wrote the manuscript.
Tore Nielsen designed the study, interpreted results, wrote the manuscript
Simon Dubé, Cloé Blanchette-Carrière and Michelle Carr collected data,
Simon Dubé and Arnaud Samson-Richer analyzed data
Tyna Paquette designed and set up the task

Abstract

Rapid eye movement (REM) sleep, non-rapid eye movement (NREM) sleep, and sleep spindles are all implicated in the consolidation of procedural memories while a potential role for dreaming in memory consolidation remains unclear. The relative contributions of sleep stages and sleep spindles was previously shown to depend on individual differences in task processing. Experience with Vipassana meditation is one such individual difference that has not been investigated in relation to sleep. Vipassana meditation is a form of mental training that enhances proprioceptive and somatic awareness and alters attentional style. The goal was thus to examine a potential moderating role for Vipassana meditation experience on sleep-dependent procedural memory consolidation. Groups of Vipassana meditation practitioners (N=20) and matched meditation-naïve controls (N=20) slept for a single daytime nap in the laboratory. Before and after the nap they completed a procedural task on the Wii Fit balance platform. Meditators performed slightly better on the task before the nap, but the two groups improved similarly after sleep. The groups showed different patterns of sleep-dependent procedural memory consolidation: in meditators task learning was negatively correlated with density of fast and positively correlated with density of slow occipital spindles, while in controls task improvement was associated with increases in REM sleep. No group differences in task incorporation into dreams were found, however, control participants who incorporated either laboratory or task elements into dreams improved slightly more on the task than did meditators. Meditation practitioners had a lower density of sleep spindles, especially in occipital regions. Results suggest that neuroplastic changes associated with sustained meditation practice may alter overall sleep architecture and reorganize sleep-dependent patterns of memory consolidation. The lower density of spindles in meditators may mean that meditation practice compensates for some of the memory functions of sleep.

Keywords: Sleep, procedural memory, postural balance, Vipassana meditation, REM sleep, sleep spindles, body awareness, dreaming

Introduction

Recent cognitive science and philosophy of mind theories have seen an important shift of focus from inquiry focused predominantly on the role of the brain in subjective experience to the view that the brain is a part of a whole body and is intimately rooted in the physical and social world (Gallagher, 2005; Thompson, 2005; Thompson & Varela, 2001; Varela, Thompson, & Rosch, 1992). In this sense, the mind is considered to be *embodied* and *situated* in the world. An important component of this perspective is that the individual remains oriented toward and motivated in the world and uses his/her whole body in concert with surrounding world elements to pursue and accomplish tasks. From this perspective, a number of research questions have been raised concerning the level of awareness of one's own body. These include questions about the relationship between diminished awareness of the body during sleep and enhanced self-awareness and sensory discrimination learned from meditation practices.

Sleep challenges the idea of embodied cognition because, at least behaviourally, the sleeper appears disconnected from muscular activity and from sensory input due to thalamic sensory gating (McCormick & Bal, 1994). Yet, subjective experience continues in sleep in many forms, ranging from vivid dreams in REM sleep (McNamara et al., 2010; Nielsen, 2000) and at sleep onset (Nielsen, 2017), to less elaborate mental activity in NREM sleep (Windt, Nielsen, & Thompson, 2016), and to conscious and unconscious processes of memory consolidation throughout sleep (Nielsen & Stenstrom, 2005; Schredl, 2017; Wamsley, 2014). It is also possible that individuals, depending on traits such as learning capability, characteristically exhibit different neurobiological learning patterns. For example, in one study (Smith, Aubrey, & Peters, 2004) the level of mastery or ease with which participants initially performed a motor task determined whether REM or NREM sleep mechanisms were correlated with learning.

From the embodied cognition perspective, much current research focuses on relationships between awareness of one's body and physical and mental health. Mindfulness interventions, including sitting meditation practices and movement-based practices such as yoga or t'ai chi (Schmalzl, Crane-Godreau, & Payne, 2014), all include an element of cultivating access to and awareness of increasingly subtle bodily sensations

(Kerr, Sacchet, Lazar, Moore, & Jones, 2013; Zeng, Oei, & Liu, 2014). Meditation practitioners, therefore, may represent an 'expert' group of healthy individuals who intentionally cultivate attention to bodily states, and are better able to access and employ them (Fox et al., 2012). Meditators may embody cognitive processes differently than do non-meditators; in particular, they may rely more upon awareness of kinesthetic and other types of endogenous information to encode memories. The term *body awareness* captures this characteristic, referring to an ability to focus on, and become familiar with, one's bodily sensations; it is defined as a subjective, explicitly available aspect of proprioception and interoception (Mehling et al., 2011). Critically, while some individuals may be naturally more attuned to body awareness than others, it is a trainable skill that can be enhanced by contemplative practices (Bornemann, Herbert, Mehling, & Singer, 2014; Silverstein, Brown, Roth, & Britton, 2011), among other approaches. High body awareness, including the ability to recognize subtle body cues, has been associated with reduced anxiety (Garfinkel et al., 2016) and with a number of health benefits in different populations including patients suffering from chronic pain, (Di Lernia, Serino, & Riva, 2016), depression (Danielsson, Papoulias, Petersson, Carlsson, & Waern, 2014; Lackner & Fresco, 2016), sexual abuse (Price, 2005), and heart failure (Baas, Beery, Allen, Wizer, & Wagoner, 2004), among others. The opposite quality, the relative disconnection from one's body, has been referred to as *bodily dissociation* (Price & Thompson, 2007) and is typically associated with depersonalization, trauma and psychopathology.

The main research goal of the current study is to investigate whether meditation practice, by virtue of increasing body awareness, also changes the neurobiological and phenomenological qualities of sleep-dependent memory consolidation. Specifically, we chose a full body procedural memory task and a daytime nap protocol to test whether: 1) meditation practitioners and meditation-naïve controls differ in performance and improvement on a procedural balance task; 2) the two groups differ in their patterns of sleep stage, sleep microarchitecture, and dream content in reaction to the task; and 3) daytime nap sleep characteristics (sleep stages and sleep spindles) in meditation practitioners are similar in quality to nighttime sleep.

Memory and sleep

Memory systems

Traditionally, human long-term memory has been divided into the two broad categories of explicit/declarative and implicit/non-declarative memory (Graf & Schacter, 1985; Squire, 2004). Explicit memory deals with autobiographical events, is characterized by self-awareness and autonoetic consciousness or the ability to "mentally time travel" through past experience, and is responsible for accumulating semantic knowledge, or facts about the world (Tulving, 2002). Crucially, explicit memory is accessible to conscious retrieval (Baars, 2002). Implicit memory, on the other hand, concerns procedural knowledge, the learning of skills, behavioral conditioning and priming effects and is largely inaccessible to conscious report (Schacter, Chiu, & Ochsner, 1993).

Consolidation of procedural memory in sleep has been studied using a number of tasks, including sequential finger tapping (Antonenko, Diekelmann, Olsen, Born, & Molle, 2013; Benedict, Scheller, Rose-John, Born, & Marshall, 2009; Doyon et al., 2009; Dresler, Kluge, Genzel, Schussler, & Steiger, 2010; Genzel, Ali, Dresler, Steiger, & Tesfaye, 2011; Holz, Piosczyk, Landmann, et al., 2012; Van Der Werf, Van Der Helm, Schoonheim, Ridderikhoff, & Van Someren, 2009; Wamsley et al., 2012); serial-reaction time task (Ertelt et al., 2012; Galea, Albert, Ditye, & Miall, 2010; Prehn-Kristensen et al., 2011); motor sequence task (Manoach et al., 2010; Tucker & Fishbein, 2009); mirror-tracing task (Holz, Piosczyk, Feige, et al., 2012; Javadi, Walsh, & Lewis, 2011; Puetz et al., 2011; Smith, Nixon, & Nader, 2004); button-box sequence (Wilhelm, Metzkow-Meszaros, Knapp, & Born, 2012); visuomotor adaptation task (Doyon et al., 2009); texture discrimination task (Cipolli et al., 2009; Gais, Rasch, Wagner, & Born, 2008); visual discrimination task (Suzuki et al., 2012), and others. These tasks usually involve either fine motor skills using the fingers or hand-eye coordination, but do not typically involve balance or bodily displacements.

Tasks involving balance skills have only rarely been used in memory consolidation research (Tjernstrom, Fransson, & Magnusson, 2005): one example specific to sleep research is the Alpine Racer arcade game used in a study of memory incorporation into dream content (Wamsley, Perry, Djonlagic, Reaven, & Stickgold, 2010).

Sleep and memory consolidation

A wealth of research supports a role for sleep in memory consolidation (for reviews see Diekelmann & Born, 2010; Shönauer & Gais, 2017; Stickgold, 2013). Sleep is thought to strengthen information learned during the day, to select which experiences are best remembered and which best forgotten, and to assimilate new knowledge into existing autobiographical networks (Deliens & Peigneux, 2014; Rolls et al., 2013; Stickgold & Walker, 2013; Walker & Stickgold, 2010). While most research has focused on the effects of a full night of sleep, an increasing number of studies report that daytime naps have similar effects to nighttime sleep on memory processes (Backhaus & Junghanns, 2006; Fogel et al., 2014; Korman, Dagan, & Karni, 2015; Lahl, Wispel, Willigens, & Pietrowsky, 2008; Lo, Dijk, & Groeger, 2014; Mednick, Nakayama, & Stickgold, 2003; Nishida & Walker, 2007; Seeck-Hirschner et al., 2010).

A number of studies link procedural memory to rapid-eye-movement (REM) sleep processes; these include a variety of tasks: mirror-tracing (Plihal & Born, 1997), Corsi block tapping, Tower of Hanoi (Nielsen et al., 2015; C. T. Smith et al., 2004) and others. For example, among obstructive sleep apnea patients, reduced rate of REM eye movements (REM density) was associated with poor mirror-tracing performance (Kloepfer et al., 2009). Similarly, selective REM sleep deprivation disrupted visual discrimination learning (Karni, Tanne, Rubenstein, Askenasy, & Sagi, 1994).

Yet other studies suggest an important role for NREM sleep in procedural memory consolidation. NREM sleep duration (Walker, Brakefield, Morgan, Hobson, & Stickgold, 2002) as well as NREM electrophysiological events, such as sleep spindles (Barakat et al., 2011; Fogel et al., 2017), have been associated with post-sleep task improvement.

Sleep's role in memory consolidation is not only influenced by task type and sleep stage/sleep microarchitecture, but also by individual differences in learning abilities and cognitive styles. In one study, for example (Robertson, Pascual-Leone, & Press, 2004), the ability to bring a motor task into explicit awareness improved post-sleep performance on the task, suggesting that training a particular attentional engagement with the learning task may change the neurocognitive style of offline memory processing.

In sum, mounting evidence now links both REM and NREM sleep to procedural memory consolidation. In fact, the same procedural task has been shown to be related, in different contexts, to both REM and NREM sleep. While it is not yet clear why task performance may be associated with one or the other sleep stage—or both—some authors have proposed 2-stage or sleep organization models to account for the findings, i.e., that both stages are necessary for successful consolidation and integration of newly encoded information (Ficca & Salzarulo, 2004; Fogel, Smith, & Beninger, 2009), including procedural skills (Fogel, Ray, Binnie, & Owen, 2015). However, such models do not explain how the same task may be associated with different sleep stages. The present study assesses trained meditating participants who are known to differ on a key factor that may be critical for procedural learning—body awareness—and compares sleep-related changes of this group with a matched, meditation-naïve, control group.

Sleep spindles

One reliable index of memory consolidation in NREM sleep is the sleep spindle, a phasic event (.5- to 3.0-sec duration) characterized by bursts of 11-16 Hz EEG activity occurring predominantly during stage 2 NREM (N2) sleep. Converging evidence points to possible different neural mechanisms implicated in fast and slow sleep spindles (Molle, Bergmann, Marshall, & Born, 2011), but few studies to date have examined the combined contribution of slow and fast sleep spindles to memory consolidation. One example is a recent study wherein the differential contribution of fast and slow sleep spindles to memory for faces was reported; face memory can be considered as having both explicit and implicit components (Solomonova et al., 2017). In this case, fast spindles showed a positive correlation with post-sleep face recognition, and slow spindles showed a negative correlation.

The current study focuses on procedural memory, specifically on motor skill acquisition of a balance-oriented task. Procedural memory is thought to be acquired though repetition of a skilled activity that is stabilized over time (Gupta & Cohen, 2002). However, little is known about the effect of sleep on balance. Sleep deprivation was reported to negatively affect postural stability (Robillard, Prince, Boissonneault, Filipini, & Carrier, 2011;

Robillard, Prince, Filipini, & Carrier, 2011; Schlesinger, Redfern, Dahl, & Jennings, 1998), but no study to our knowledge has assessed relative contributions of sleep stages and sleep spindles on a postural task.

Dreaming

While the role of sleep in memory consolidation is rarely disputed (Vertes, 2004), dreaming's contribution to "offline" memory processes remains controversial. Dreaming is now known not to be restricted to REM sleep (McNamara et al., 2010; Nielsen, 2000); for example, rates of dream recall at sleep onset (NREM stages N1 and N2) are typically as high as during REM sleep (Nielsen, 2000). Researchers have tried to find evidence linking either the presence of dreaming (vs. its absence) or specific types of dream content (e.g., dream references to a learning task) with memory consolidation, but with very limited success. The usual approach is to look for incorporation of elements related to the task in dream reports (Blagrove et al., 2014; Nielsen & Powell, 1989; Solomonova, Stenstrom, Paquette, & Nielsen, 2015; Stenstrom, Fox, Solomonova, & Nielsen, 2012). This is not a trivial undertaking, since although dreams contain references to memories (Baylor & Cavallero, 2001; Eichenlaub, van Rijn, et al., 2014; Freud, Strachey, & Freud, 1958; Nielsen & Stenstrom, 2005), they virtually never replay full episodic memories (Fosse, Fosse, Hobson, & Stickgold, 2003; Hartmann, 2010; Horton & Malinowski, 2015), but rather draw on partial episodic memories and a wide variety of autobiographical and semantic memory sources to create new experiences. The present study allows for the assessment of dream content in relation to learning of a new procedural task using the Wii Fit balance platform. A similar task that also required the Wii Fit, was used in a study of balance incorporation into REM sleep dreams (Nefjodov, Winkler, & Erlacher, 2016) in a non-meditating population. No relationship between task incorporation and improvement on the task was reported. In our project, we collected dreams from hypnagogic awakenings and from REM/NREM nap awakenings.

Meditation and heightened body awareness

Recent years have seen a significant increase in research on the effects of various meditation practices, often grouped under the umbrella of "mindfulness" practices, on neuroplasticity, attention, and emotion regulation processes among others. While all contemplative practices share some elements such as attention training, body awareness (Kerr et al., 2013) and emphasis on insight and self-regulation (Lutz, Jha, Dunne, & Saron, 2015), different meditation practices are characterized by different kinds of subjective experiences, recruit different neural networks and may have different effects on cognitive and physical functions, including well-being (Fox et al., 2016; Fox et al., 2014).

Vipassana meditation is characterized by developing a sustained and systematic practice of being aware of one's bodily sensations in order to ultimately gain insight into the nature of reality (Chavan, 2008; Goenka, 1997; Hart, 1987). Practitioners typically start with a focused attention practice, specifically with mindfulness of breathing or *anapana.* The main part of the practice consists of the body scanning technique, where practitioners are instructed to mentally examine their bodily states to become aware of subtle sensations and, ultimately, to approach them with equanimity and nonjudgementally. We hypothesize that this contemplative tradition may change the practitioner's cognitive style in a global way, including changing processes of attention, memory encoding, consolidation and retrieval.

Recent research showed that Vipassana practice is similar to other contemplative practices in having the beneficial effects of decreasing stress and improving subjective feelings of well-being (Szekeres & Wertheim, 2015), helping generate greater perceptual clarity and decrease automated reactivity to stimuli (Cahn, Delorme, & Polich, 2013; Cahn & Polich, 2009; Delgado-Pastor, Perakakis, Subramanya, Telles, & Vila, 2013), and decreasing anger, hostility and depressive symptoms (Kasai et al., 2015). Other studies report improved psychological well-being (Montero-Marin et al., 2016) and cognitive flexibility (Kasai et al., 2015) and increased heart rate variability (Krygier et al., 2013).

The effects of Vipassana training include increased somatosensory awareness, e.g., increased awareness of pain, more spontaneous body movements, increased mindfulness, and development of equanimity, or the ability to adapt to extreme changes in lived experience (Kornfield, 1979). Effects also extend beyond the immediate effects of cultivating sensory acuity and involve broader positive consequences on personal and social life. For instance, Vipassana interventions in prison settings improved social relations, generated a more positive atmosphere in a difficult environment, created a context for overcoming ordeals (Ronel, Frid, & Timor, 2011) and diminished rates of substance abuse (Simpson et al., 2007).

Sleep architecture changes of Vipassana practitioners are few, but include longer REM sleep periods when compared to controls and yoga practitioners (Sulekha, Thennarasu, Vedamurthachar, Raju, & Kutty, 2006). Longer-term practitioners (over 7 years of daily practice) have more N3 sleep, less N2 sleep, fewer awakenings from sleep and an altered pattern of REM sleep microarchitecture (Maruthai et al., 2016).

While the idea that meditation practice, by virtue of enhancing specific cognitive and attentional skills (Jha, Krompinger, & Baime, 2007; Valentine & Sweet, 1999; Zeidan, Johnson, Diamond, David, & Goolkasian, 2010), should have an effect on learning and memory seems intuitive, very few studies to date have directly addressed the effect of meditation on memory consolidation. And existing results are mixed. One study reports very few differences between long-term meditation practitioners (including Vipassana meditators) and non-meditating controls; meditators showed better performance on short-term and free recall long-term memory (Lykins, Baer, & Gottlob, 2012). Some studies report improvements in working memory in meditation practitioners (Mrazek, Franklin, Phillips, Baird, & Schooler, 2013), including a military cohort (Jha, Stanley, Kiyonaga, Wong, & Gelfand, 2010), and adolescents (Quach, Jastrowski Mano, & Alexander, 2016).

With respect to procedural motor memory, only one study to our knowledge assessed contribution of post-training meditation practice to memory consolidation (Immink, 2016); experienced yoga *nidra* meditation practitioners showed post-training memory benefits on a sequence tapping task.

In sum, Vipassana meditation may produce changes in body awareness, which in turn may influence not only health and well-being but the effectiveness of memory. While studies of procedural memory are lacking, the preceding review suggests that increased body awareness may help meditators excel at procedural tasks. Critically, there are as yet no studies of sleep-dependent learning in meditators.

Objectives and hypotheses:

The primary objective of the present study was to investigate the relationship between Vipassana meditation practice and sleep-dependent processes of memory consolidation. Specifically, we tested the idea that training in a meditation technique which enhances introspective accuracy and increases body awareness will influence sleep characteristics and style of sleep-dependent learning of a procedural full-body task.

1) following a daytime nap Vipassana meditators (MED group) will show more improvement on a procedural task than will meditation-naïve controls (CTL group).
2) the MED and CTL groups will express two distinct neurobiological learning patterns:
    a. the MED group will show a NREM-dependent pattern, reflecting a more explicit learning process. fast sleep spindles in particular will correlate with task improvement
    b. the CTL group will show a REM-dependent pattern, consistent with previous research on non-declarative learning.
3) the MED group will incorporate more elements from the task into dream content than will the CTL group and their incorporation scores will correlate positively with task improvement.

Methods

Participants

Forty-two male (n = 21) and female (n = 21) participants between the ages of 18 and 35 y (M = 25.4 ± 4.4) were recruited for a daytime nap study via online advertisements and through contact with Vipassana Quebec and subsequently screened via phone or online questionnaire. In the Vipassana meditation practitioners group (MED) there were 22 participants (M age = 25.8 ± 4.1, 11 men, 11 women) and in the non-meditating control group (CTL) there were 20 participants (M age = 25.0 ± 4.8, 10 men, 10 women). Inclusion criteria for both groups were: 18-35 years of age, high dream recall (3+ per week), good self-reported physical/mental health, no sleep disturbances (e.g., shift work or jet lag). To be included in the MED group, Vipassana practitioners had to have taken part in at least one 10-day retreat, which consists of approximately 100 hours of practice, and to be currently practicing Vipassana meditation on at least a weekly basis. Participants completed an informed consent form approved by the Hôpital du Sacré-Coeur de Montréal ethics board. They were financially compensated for the time spent in the laboratory, parking or public transit, and lunch expenses.

Body Awareness

Body awareness was measured using the Scale of Body Connection (SBC) questionnaire (Price & Thompson, 2007), which consists of 20 items each scored on 0-4 scales and which produces two independent subscales: body awareness (12 items) with items that assess awareness of, e.g., tension, bodily stress, breath, and emotional state, and bodily dissociation (8 items) with items that assess e.g., feeling frozen/numb, separated from the body, and difficulty in expressing emotions. Subscale scores consist of the average ratings of constituent items (0-4). The questionnaire has been validated on studies of bodily awareness in women with substance abuse disorder (Price, Wells, Donovan, & Rue, 2012), of exercise and body awareness therapy in major depression (Danielsson et al., 2014), of body therapy for survivors of childhood sexual abuse (Price, 2007), and of interoceptive awareness of breathing in experienced meditation practitioners (Daubenmier, Sze, Kerr, Kemeny, & Mehling, 2013). This and the following questionnaires were completed at home and sent back to the laboratory by mail: short versions of the Beck Depression Inventory, Beck Anxiety Inventory, and Boundary Questionnaire; full versions of the Dream Experience Questionnaire; Mirror Behaviour Questionnaire; Dream Enactment Behaviour; Toronto Alexithymia Scale; Other Experiences Questionnaire. Results from these questionnaires are not discussed further in this paper.

Procedure

Participants arrived in the laboratory at 9:00 am and completed a consent form and a battery of questionnaires which included the Scale of Body Connection. They then completed the procedural task and had the PSG setup installed. Immediately before lights-out, the MED group meditated in bed for 10 minutes and the CTL group simply relaxed for the same amount of time. All participants were then given a window of opportunity to sleep of approximately 90 minutes. They were awakened twice with a non-stressful, 80 dB, 500 Hz, once at sleep onset and once at the end of the nap. At these times, spontaneous dream reports and dream questionnaires were completed. Following the second awakening, electrodes were removed and participants repeated the procedural task.

Procedural memory (balance) task

Participants performed a procedural memory task requiring whole body balance, i.e., a video game entitled "Balance bubble" for the Nintendo Wii Fit Balance Board. In this task, participants control a virtual character that moves along a river in a bubble (See Figure X) by shifting their weight on the Balance Board. The objective is to complete the river path as quickly as possible without touching the river's edges and thus bursting the bubble. Bursting the bubble required the participant to start again from the beginning of the path. The task was performed on a 42-in. television screen. All participants were assessed for any vision correction and instructed to wear their glasses or contact lenses if needed. Participants had a 2-minute period to acquaint themselves with the task, and to ask questions of the experimenter, who ensured that participants clearly understood the requirements of the game. The total maximum game time was 90 seconds, and participants were allowed to repeat the task until a total of 5 minutes of gameplay had elapsed. Participants were instructed to attempt to complete the task as many times as possible during the 5-minute period. The task was performed once before lights-out (T1) and once after awakening (T2).

The following variables were calculated to assess performance on the task: HiScore (highest score on all attempts averaged); #Wins (the number of times participants completed the task by arriving at the end of the "river"); GameScore (average score in game "meters" over all attempts at the game) and Time (average time spent correctly balanced in the bubble averaged over all attempts). Two measures of improvement on the task were used: T2-T1GameScore (Score after nap minus score before nap), and T2-T1Time (Time after nap minus TimeBalance before nap).

Polysomnography

Participants slept in a quiet bedroom under continuous audio-visual monitoring with a two-way intercom. A standard polysomnographic montage was used: 6 EEG channels (F3, F4, C3, C4, O1, O2) referenced to A1 and re-referenced to A1+A2 offline; four electrooculography (EOG) channels (horizontal and vertical), and three electromyography (EMG) channels (chin, wrist, leg). Acquisition of EEG signals was done using an M15 Grass Acquisition System (−6 dB filters with cut-offs at 0.30 and 100 Hz) and Harmonie v6.2b software (Natus Medical Incorporated, Pleasanton, CA, USA). Sleep stages were scored according to standard criteria (Iber, 2007) by an experienced technician and standard sleep variables were calculated using in-house software.

Sleep spindles were detected on artifact-free sleep epochs recorded from F3, F4, C3, C4, O1 and O2 derivations by an in-house detector. The full detection algorithm is described by Nielsen et al (2016) and by O'Reilly and Nielsen (2014). Spindles were separated into slow (10.00-12.99 Hz) and fast (13.00-16.00 Hz) types and densities calculated as the number of spindles of each type divided by time elapsed in N2 sleep.

Incorporation of task and laboratory experience into dream content

Dream reports were collected both at sleep onset: N1 (Hori, 1985) and after forced awakening from the nap-- from either REM or NREM sleep. For the collection of sleep onset dreams, participants were awakened with a 500-Hz sound by a trained technician after 5 consecutive seconds of theta activity had elapsed. For a similar protocol see (Nielsen et al., 2005; Stenstrom et al., 2012). Theta ripples (Hori, 1985) were determined visually on C3 and C4 channels by an experienced polysomnographer. Dream reports were audio and video recorded and later transcribed for analysis. REM and NREM awakenings were conducted in a similar manner either when 90 minutes of sleep had elapsed or when participants awakened spontaneously. Dream reports were scored by two judges blind to participant status for the presence/absence and number of elements related to the balance task and to the laboratory. Both direct and indirect incorporations were assessed (Solomonova et al., 2015), with direct incorporations being elements clearly traceable to the laboratory (e.g., electrodes, experimenters) or the task (e.g., Wii Fit, Bubble Balance), and indirect incorporations being elements that resembled those encountered in the laboratory (e.g., a hospital, wires) or the task (e.g., river, colorful forest scenery, navigating a difficult path).

Results

Body awareness and dissociation

32 participants (15 MED and 17 CTL; 80%) returned questionnaires by mail. Independent samples t-tests on the SBC score and Body Awareness and Bodily Dissociation subscales revealed, as predicted, that the MED group scored significantly higher on Body Awareness than did the CTL group (M(MED)=.243±.060; M(CTL)=.194±.061; t(30)=2.289; p=.029, 2-tailed) but did not differ on Bodily Dissociation (Figure 1).

Body Awareness and Bodily Dissociation scores were not correlated in the MED group (*r*=.182, p=.517) but tended to be inversely correlated (*r*=-.475, p=.054) in the CTL group. Body Awareness and Bodily Dissociation were not correlated with years of meditation experience in the MED group (Body Awareness: r=-.471, p=.077; Bodily Dissociation: r=.079, p=.779).

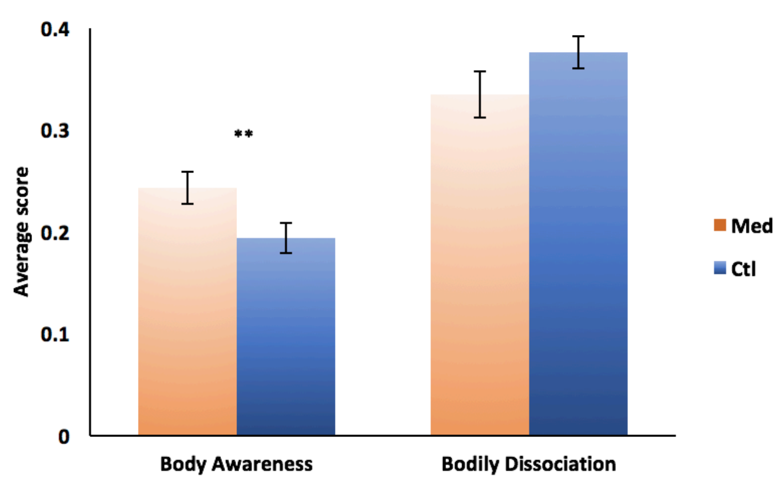

Figure 1. Scores (M±SD) on the Body Awareness and Bodily Dissociation subscales of the Scale of Body Connection

All correlations between Scale of Body Connection scores and task measures are shown in Table 1. The MED group showed positive correlations between Body Awareness and average time (*r*=.580; p<.05) and score (*r*=.518; p<.05) on the task at T1, and a strong negative correlation between Bodily Dissociation and task improvement (*r*=-.546; p<.05). In contrast, CTL participants showed a different pattern: no significant correlations were observed between Body Awareness scores and task performance measures but strong positive correlations were seen between Bodily Dissociation and several task measures: average time in balance at T2 (*r*=.681; p<.01); average score at T2 (*r*=.530; p<.05); average time improvement (*r*=.592; p<.05); and average score improvement (*r*=.619; p<.01).

Table 1. Pearson correlations between scores on Body Awareness and Bodily Dissociation Subscales of the Scale of Body Connection and task performance (T1, T2) and improvement (T2-T1) measures in meditators (MED) and non-meditating controls (CTL). MED N=15; CTL N=17. *p<.05; **p<.01. T1=task performance pre-nap; T2=task performance post-nap; T2-T1=post minus pre scores.

	MED		**CTL**	
	Body Awareness	**Bodily Dissociation**	**Body Awareness**	**Bodily Dissociation**
Body Awareness	1.00	0.18	1.00	-0.48
Bodily Dissociation	0.18	1.00	-0.48	1.00
T1 HiScore	0.24	0.04	-0.18	-0.05
T1 Time	0.58*	0.16	-0.33	0.31
T1 GameScore	0.52*	0.23	-0.30	0.13
T1 #Wins	0.26	0.42	0.01	0.13
T2 HiScore	0.39	-0.05	-0.41	0.18
T2 Time	0.37	-0.10	-0.47	0.68**
T2 GameScore	0.27	-0.22	-0.36	0.53*
T2 #Wins	0.35	-0.34	0.05	0.11
T2-T1Time	-0.39	-0.34	-0.26	0.59*
T2-T1GameScore	-0.43	-0.55*	-0.09	0.62**

Task performance

Separate paired samples t-tests were used to evaluate whether groups improved on the task following the nap. Scores on average time spent balanced on the board (T2-T1Time), average (GameScore) and highest score (HiScore) before nap (T1) and after nap (T2) served as improvement measures. Both MED and CTL groups significantly improved on all three measures (see Table 2/Figure 2).

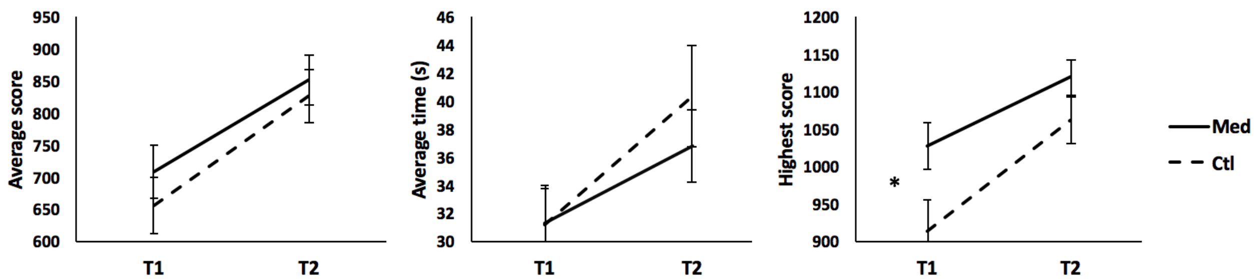

Figure 2. Performance on procedural balance task in meditators (MED) and non-meditating controls (CTL) before nap (T1) and after nap (T2). *p<.05

Table 2. Paired samples t-tests: comparison of task scores before and after the nap in meditators (MED) and non-meditating controls (CTL).

	MED				
	Mean ± SD	**Mean ± SD**	**Paired sample correlations**		**Paired t-test**
	Before nap	**After nap**	**R**	***p***	***p***
Time	31.31 ± 10.98	36.85 ± 11.35	0.71	0.000	0.009
GameScore	708.43 ± 184.71	852.35 ± 170.19	0.75	0.000	0.000
HiScore	1028.40 ± 142.21	1120.15 ± 106.44	0.48	0.034	0.006
	CTL				
	Mean ± SEM	**Mean ± SEM**	**Paired sample correlations**		**Paired t-test**
	Before nap	**After nap**	**R**	***p***	***p***
Time	31.20 ± 12.66	40.38 ± 16.11	0.68	0.001	0.003

GameScore	656.87 ± 199.14	827.98 ± 186.02	0.78	0.000	0.000
HiScore	913.25 ± 187.54	1061.95 ± 141.42	0.63	0.003	0.000

No group differences were observed on post-nap measures of task improvement. However, meditators finished the game more often (more #Wins), especially after the nap: 2 (10%) of CTL participants finished the task at least once before the nap (T1), compared with 5 (25%) of MED participants (χ2=0.693, p=.405, 2-tailed, Yates corrected) whereas 6 (30%) of CTL participants finished the task after the nap (T2) compared with 12 (60%) of MED participants (χ2=3.636, p=.057) (Figure 3).

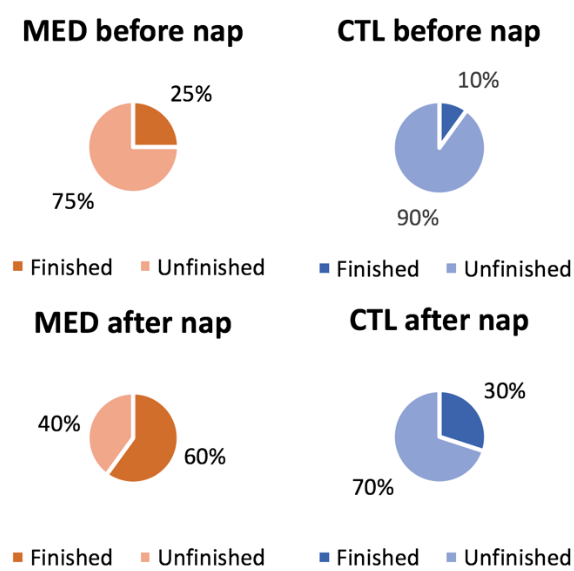

Figure 3. Proportion of meditators (MED) and controls (CTL) who did (Finished) and did not (Unfinished) complete the procedural task at least once before and after the daytime nap

Similarly, the HiScore at T1 was significantly higher in MED than in CTL (M(MED)=1028.4±142.21; M(CTL)=913.3±187.54; t(38)=2.188; p=.035). For a comparison of complete results on task performance between the two groups see Table 3.

Table 3. Scores on procedural task for Vipassana meditators (MED) and non-meditating controls (CTL). *p<.05; †p <.10

Task variable	Mean MED ± SD	Mean CTL ± SD	t	df	p	
T1 HiScore**	1028.40 ± 142.21	913.25 ± 187.54	2.19	38.00	0.04	*
T1 Time	31.31 ± 10.97	31.20 ± 12.66	0.03	38.00	0.98	
T1 GameScore	708.43 ± 184.71	656.87 ± 199.16	0.85	38.00	0.40	
T1 #Wins	0.30 ± 0.57	0.10 ± 0.31	1.38	29.18	0.18	
T2 HiScore	1120.15 ± 106.44	1061.95 ± 141.42	1.47	35.30	0.15	
T2 Time	36.85 ± 11.35	40.38 ± 16.11	-0.80	38.00	0.43	
T2 GameScore	852.35 ± 170.19	827.98 ± 186.02	0.43	38.00	0.67	
T2 TotScore	7322.75 ± 1631.78	6458.45 ± 1806.54	1.59	38.00	0.12	
T2 #Wins*	0.95 ± 0.10	0.45 ± 0.83	1.73	38.00	0.09	†
T2-T1Time	5.54 ± 8.46	9.18 ± 11.97	-1.11	38.00	0.28	
T2-T1Score	143.93 ± 126.76	171.12 ± 129.26	-0.67	38.00	0.51	

T1 refers to procedural task completed before the daytime nap; T2 refers to the same task completed after the nap. Score was calculated in "meters" according to the gameplay distance measure. Time was measured in seconds. Game completion was measured as a number of times participants arrived at the end of the virtual river. Improvement on task was measured as the difference between post-nap and pre-nap performance (T2-T1).

Sleep structure

Two MED participants were dropped from spindle analyses due to insufficient sleep duration. No statistically significant differences between MED and CTL groups were observed for any sleep characteristic, except for a non-significant trend (p=.09) for the MED group to have lower total sleep duration (See Table 4 for complete results).

Table 4 Sleep measures for Vipassana meditators (MED: N=20) and non-meditating controls (CTL: N=20). †p <.10

Sleep characteristic	Mean MED ± SD[a]	Mean CTL ± SD	t	df	p
Total sleep duration (min)	65.98 ± 25.27	78.30 ± 19.32	-1.73	38.00	0.09†

Sleep latency (min)	8.78 ± 6.75	14.35 ± 20.08	0.20	38.00	0.84
REM latency (min)	16.35 ± 22.35	20.74 ± 31.23	-0.47	32.00	0.64
Sleep efficiency	73.66 ± 23.10	81.70 ± 13.31	-1.31	29.68	0.20
N1 duration (min)	7.13 ± 7.67	7.03 ± 3.81	0.05	38.00	0.96
N2 duration (min)	32.83 ± 16.47	36.05 ± 15.05	-0.65	38.00	0.52
N3 duration (min)	15.05 ± 13.38	22.53 ± 18.99	-1.44	38.00	0.16
Total NREM duration (min)	55.00 ± 23.28	65.60 ± 22.37	-1.47	38.00	0.15
REM duration (min)	10.98 ± 6.12	12.70 ± 9.99	-0.66	38.00	0.51
Wake duration (min)	24.75 ± 24.71	17.45 ± 12.33	1.18	27.91	0.24
N1%	13.31 ± 16.30	10.45 ± 8.94	0.69	38.00	0.50
N2%	50.55 ± 17.18	45.10 ± 15.68	-0.90	38.00	0.50
N3%	19.46 ± 15.95	26.45 ± 20.43	-1.21	38.00	0.24
NREM%	83.32 ± 10.68	82.90 ± 15.17	0.10	38.00	0.92
REM%	16.69 ± 10.68	17.11 ± 15.17	-0.10	38.00	0.92
Wake%	26.29 ± 24.02	18.30 ± 13.31	1.30	29.66	0.20
N awakenings	5.65 ± 3.84	6.70 ± 4.18	-0.83	38.00	0.41

Relationship between sleep and meditation experience

For the MED group, Spearman correlations revealed a strong negative correlation between lifetime meditation experience (in hours) and time in NREM2 sleep (r_s=-.546, p=.015) but no other relationships with sleep measures.

Sleep spindles

A total of 20 CTL and 20 MED subjects were compared (See Table 5 and Figure 4 for group comparisons of spindle density). There were no group differences in total spindle density or fast spindle density. However, the MED group showed lower slow spindle densities in occipital derivations, specifically: a lower spindle density in O1 (M(MED)=1.074±.797; M(CTL)=1.754±.100; t(38)=2.385; p=.022) and a marginally lower slow spindle density in O2 (M(MED)=1.264±.838; M(CTL)=1.848±1.035; t(38)=1.963; p=.057).

Table 5. Sleep spindle density in Vipassana meditators (MED; N=20) and non-meditating controls (CTL; N=20).

Channel and kind	Mean MED ± SD	Mean CTL ± SD	t(38)	p	
Total C3	4.37 ± 1.70	4.89 ± 1.95	0.90	0.37	
Total C4	4.28 ± 1.60	4.92 ± 1.91	1.16	0.25	
Total F3	4.61 ± 1.73	5.16 ± 2.43	0.82	0.42	
Total F4	4.55 ± 1.71	5.17 ± 2.40	0.95	0.35	
Total O1	3.92 ± 1.76	4.29 ± 1.87	0.65	0.52	
Total O2	3.90 ± 1.59	4.32 ± 1.77	0.79	0.44	
Fast C3	2.93 ± 1.60	3.19 ± 1.64	0.51	0.61	
Fast C4	2.87 ± 1.42	3.27 ± 1.68	0.82	0.42	
Fast F3	1.51 ± 1.07	1.84 ± 1.64	0.76	0.45	
Fast F4	1.47 ± 1.00	1.88 ± 1.81	0.88	0.38	
Fast O1	2.84 ± 1.71	2.54 ± 1.36	-0.62	0.54	
Fast O2	2.64 ± 1.40	2.47 ± 1.24	-0.40	0.69	
Slow C3	1.44 ± 1.12	1.70 ± 0.99	0.78	0.44	
Slow C4	1.41 ± 1.12	1.65 ± 0.97	0.73	0.47	
Slow F3	3.10 ± 1.40	3.32 ± 1.97	0.41	0.69	
Slow F4	3.08 ± 1.47	3.30 ± 2.17	0.37	0.71	
Slow O1*	1.07 ± 0.80	1.75 ± 0.10	2.39	0.02	*

Slow O2	1.26 ± 0.84	1.85 ± 1.04	1.96	0.06

*Spindle density was calculated as number of sleep spindles/time in NREM2 sleep. *p<.05*

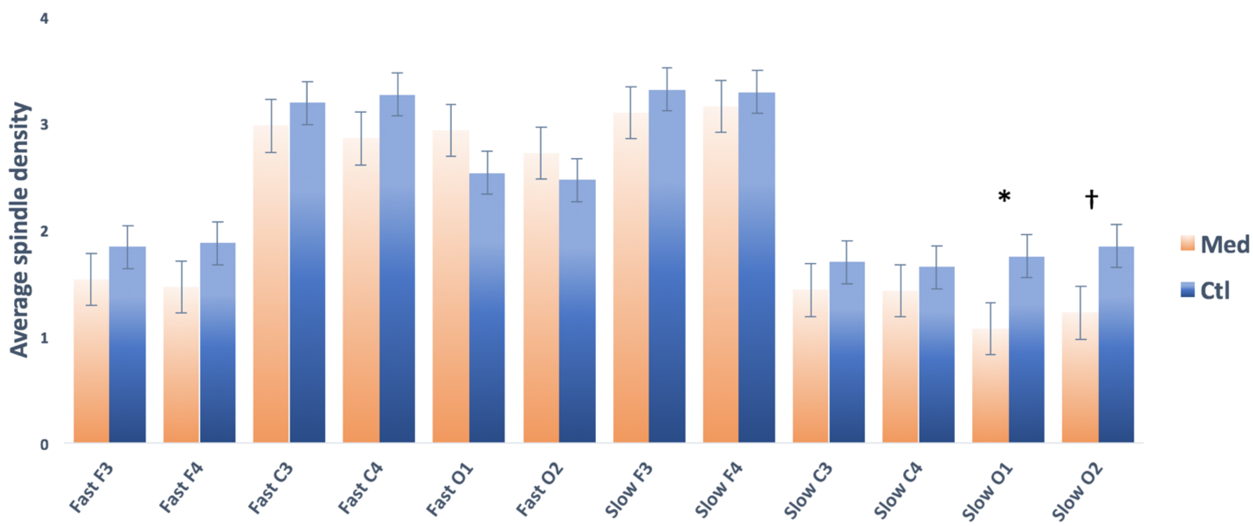

Figure 4. Sleep spindle densities (M±SEM) for Vipassana meditators (MED; N=20) and non-meditating controls (CTL; N=20). Spindle density calculated as the number of sleep spindles/time in NREM2 sleep. *p<.05; †p<.06

Sleep and procedural memory consolidation

To assess sleep relationships with improvement on the balance task, the two most sensitive task measures were used: change in average time spent in balance (T2–T1) and change in average score (T2-T1). Spearman correlations were calculated to evaluate dose-response relationships between change in sleep stages, task performance, and slow and fast spindle density.

Sleep stages

For the MED group there were no statistically significant relationships between task improvement scores (average time and average score) and sleep stages. For CTL group, improvement on average time spent balanced correlated negatively with Stage 1 NREM duration (*r*=. -465, p=.007) and positively with REM sleep duration (*r*=.592, p=.006). Further, improvement on average score correlated negatively with Stage1 NREM duration (*r*=-.470, p=.037); and positively with REM sleep duration (*r*=.536, p=.015). Improvement on average score also correlated with several other sleep measures which were not predicted, i.e., negatively with sleep latency (r=-.475, p=.034); positively with sleep efficacy (r=.451, p=.046); and negatively with wake duration (r=-.498, p=.025). See Table 6 for complete results.

Table 6. Pearson correlation coefficients between sleep characteristics and post-nap improvement in performance on a procedural task in meditators (MED) and controls (CTL). Average improvement in time and in score is reported. *=p<.05; **=p<.01; ***=p<.001 (Conservative error rate adjustment for 32 correlations per group=32/.05=.002).

	MED		**CTL**			
Sleep variable	**Time**	**Score**	**Time**		**Score**	
total sleep duration	0.31	0.06	-0.10		0.01	
sleep latency	0.16	0.20	-0.20		-0.48	**
REM latency	-0.02	0.18	0.28		0.26	
Sleep efficiency	0.20	0.04	0.29		0.45	**
N1 duration	0.01	-0.09	-0.47	**	-0.47	**
N2 duration	0.22	0.14	-0.39	*	-0.23	
N3 duration*	0.20	-0.01	-0.01		0.01	
Total NREM duration*	0.30	0.06	-0.35		-0.23	
REM duration	0.11	0.00	0.59	***	0.54	**
Wake duration	-0.15	-0.02	-0.32		-0.50	**
N1%	-0.11	-0.14	-0.41	*	-0.42	*
N2%	0.02	0.20	-0.42	*	-0.33	
N3%	0.12	-0.07	-0.01		0.00	
NREM%	0.05	-0.01	-0.66	***	-0.57	***
REM%	-0.05	0.01	0.66	***	0.57	***
Wake%	-0.20	-0.04	-0.29		-0.45	**

Sleep spindles

Pearson correlations between measures of task improvement (T2-T1Time and T2-T1GameScore) and sleep spindle densities revealed significant relationships for the MED group, but not the CTL group (Figure 5 and Table 7). T2-T1Time correlated positively with density of slow sleep spindles in O1 (*r*=.515, p=.024) and marginally in O2 (*r*=.421; p=.072). T2-T1GameScore correlated positively with density of slow sleep spindles in O1 (*r*=.539, p-.017); negatively with density of fast sleep spindles in O1 (*r*=-.551, p=.014); and negatively with density of fast sleep spindles in O2 (*r*=-.520, p=.022).

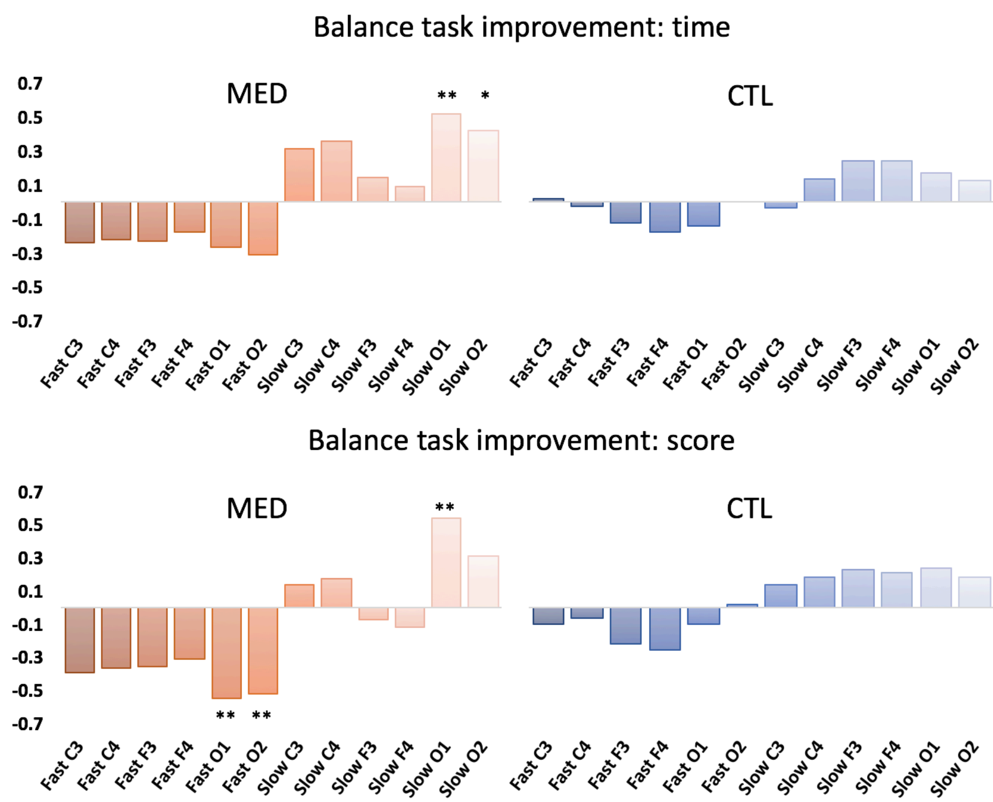

Figure 5. Pearson correlations between fast and slow sleep spindle densities and post-nap improvement on the balance task (average time and score) in meditators (MED) and controls (CTL). *p<.05; **p<.01

Table 7. Pearson correlation coefficients between fast and slow sleep spindle densities and post-nap improvement on the balance task (average time and score) in meditators (MED) and controls (CTL). *p<.05; **p<.01

	MED		CTL	
Derivation	**Time**	**Score**	**Time**	**Score**
		Fast spindles		
C3	-0.24	-0.39	0.01	-0.10
C4	-0.22	-0.37	-0.03	-0.07
F3	-0.23	-0.36	-0.13	-0.22
F4	-0.18	-0.31	-0.18	-0.26
O1	-0.27	-0.55**	-0.15	-0.10
O2	-0.31	-0.52**	0.00	0.02
		Slow spindles		
C3	0.31	0.14	-0.04	0.14
C4	0.36	0.17	0.13	0.18
F3	0.14	-0.07	0.24	0.23
F4	0.09	-0.12	0.24	0.21
O1	0.52**	0.54**	0.17	0.24
O2	0.42**	0.31	0.12	0.18

Dream content in relation to task consolidation

Participants had relatively infrequent task and laboratory incorporations into dream content. Chi-square analyses did not reveal any differences between MED and CTL groups (See Table 8). Spearman correlations did not reveal any relationships between task performance and incidence of task or laboratory incorporations into dream content.

Table 8. Incorporation rates of Laboratory and Task elements into dream content in Vipassana meditation practitioners (MED) and controls (CTL) during awakenings at sleep onset (hypnagogic) and at the end of the nap (REM/NREM)

Incorporation	MED	CTL	$\chi2$	*p*
Laboratory and Task incorporations				
REM/NREM awakenings	11 (55%)	9 (45%)	.1	0.752
Hypnagogic awakenings	8 (40%)	8 (40%)	0	1.000
Task incorporations				
REM/NREM awakenings	5 (25%)	2 (10%)	.693	0.405
Hypnagogic awakenings	3 (15%)	4 (20%)	.173	0.677
Laboratory incorporations				
REM/NREM awakenings	8 (40%)	9 (45%)	.102	0.749
Hypnagogic awakenings	5 (25%)	6 (30%)	.125	0.723

REM and NREM dreams

As shown in Table 9, 9 MED participants and 9 CTL (45%)were awakened in REM sleep, 8 (40%) of MED and 10 (50%) of CTL participants were awakened from NREM sleep, and 3 (15%) MED and 1 (5%) CTL had already been awake for a significant amount of time when they were prompted by experimenters. 17 (85%) of MED and 15 (75%) of CTL participants recalled a dream upon awakening, of which 6 MED and 6 CTL (66%) were reported from REM sleep and 8 MED (100%) and 8 CTL (80%) were reported from NREM sleep. Laboratory elements were incorporated in 44.4% (MED)-50% (CTL) of REM dreams, and in 30% (CTL)-37.5% (MED) of NREM dreams. Procedural task elements were incorporated once in REM in MED group (11.1%), and in two instances in REM in CTL group (22.2%); and 3 MED participants incorporated task in dream content from NREM sleep (37.5%).

Table 9. Stage of sleep upon awakening, dream recall and rates of Laboratory (Lab) and procedural task incorporation into dream content for Vipassana meditators (MED) and controls (CTL).

	MED				CTL			
	REM	**NREM**	**Wake**	**Total**	**REM**	**NREM**	**Wake**	**Total**
Awakened from stage	9 (45%)	8 (40%)	3 (15%)	20 (100%)	9 (45%)	10 (50%)	1 (5%)	20 (100%)
Dream recalled	6 (66.7%)	8 (100%)	3 (100%)	17 (85%)	6 (66.7%)	8 (80%)	1 (100%)	15 (75%)
Lab incorporation	4 (44.4%)	3 (37.5%)		7 (41%)	5 (55.6%)	3 (30%)		8 (53%)
Task incorporation	1 (11.1%)	3 (37.5%)		4 (24%)	2 (12%)	0 (0%)		2 (13%)

Given the relatively low rate of task incorporation into dream content, for the following analyses we combined task and laboratory incorporations. Participants were divided into two groups: incorporators (Inc; at least one instance of a lab or task incorporation) and non-incorporators (Non-Inc; no instances of lab or task incorporation). Independent samples t-tests were performed to test whether the Inc group showed more improvement on the task (using T2-T1GameScore T2-T1Time as dependent measures) than did the Non-Inc group (See Figure 6). For meditators, no differences between Inc and Non-Inc groups were found for T2-T1GameScore (M(Inc)=109.01±104.68; M(Non-Inc)= 186.60±144.01; t(18)=1.395; p=.180) and for T2-T1Time (M(Inc)= 3.25±8.87; M(Non-Inc)= 8.34±7.45; t(18)=1.369; p=.188). For control participants, however, no difference was found for improvement on T2-T1GameScore (M(Inc)= 206.62±113.02; M(Non-Inc)= 113.02±37.67; t(18)=-1.118; p=.139, 1-tailed) but the Inc group improved significantly more on T2-T1Time than did the Non-Inc group (M(Inc)= 12.35±4.12; M(Non-Inc)= 9.92±2.99; t(18)=-2.056; p=.028).

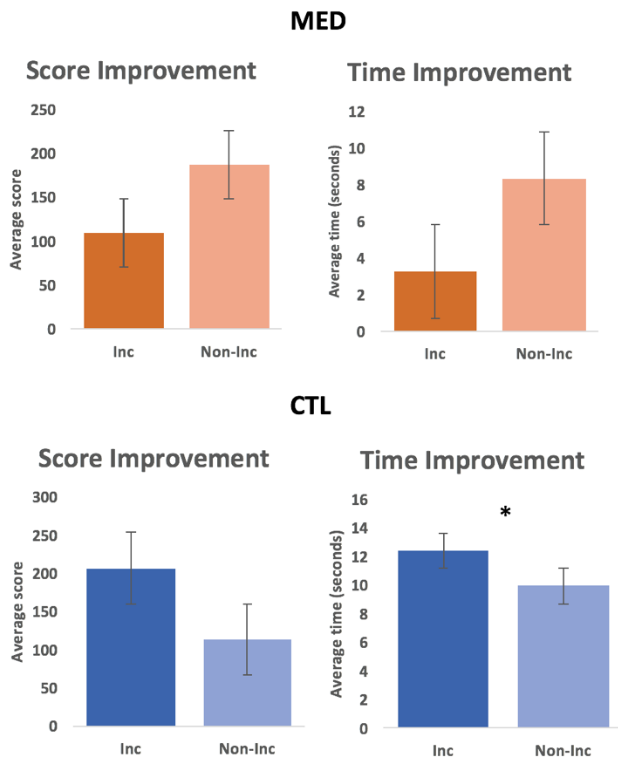

Figure 6. Differences (M±SEM) in total score and time improvement on the procedural task for Vipassana meditators (MED) and controls (CTL) with regards to whether there were (Inc: MED=11; CTL=9) or were not (Non-Inc: Med=9; CTL=11) incorporations of elements from the laboratory or the procedural task into dream content obtained from combined awakenings from REM and NREM sleep at the end of the nap. *p<.05

Hypnagogic dreams

All participants reported hypnagogic mentation when awakened at sleep onset (after approximately 5 seconds of theta activity and diminished alpha activity). 6 (30%) MED and 5 (25%) CTL participants reported incorporation of laboratory elements into dream content; and 4 (20%) MED and 3 (15%) CTL participants incorporated task-related elements. In a manner similar to that described above, participants were divided into incorporators (Inc; at least one instance of lab or task incorporation into hypnagogic mentation), and non-Incorporators (Non-Inc; no instances of lab or task incorporation into hypnagogic mentation).

Independent samples t-tests revealed no significant differences between task performance and incorporation status in the MED group for either improvement on T2-T1GameScore (M(Inc)=99.26±155.29; M(Non-Inc)=173.30±99.95; t(18)=1.311; p=.206) or T2-T1GameScore (M(Inc)= 5.26±12.68; M(Non-Inc)= 5.73±4.59; t(18)=.116; p=.909). For

CTL participants, however, there were no significant differences between Inc and Non-Inc in improvement on T2-T1GameScore (M(Inc)= 145.33±51.38; M(Non-Inc)= 200.11±114.56; t(18)=1.247; p=.229), but there was a non-significant trend wherein the Inc group performed worse than the Non-Inc group on the measure of improvement in T2-T1Time (M(Inc)= 3.61±11.48; M(Non-Inc)= 12.89±11.23; t(18)=1.794; p=.090). The results are plotted in Figure 7.

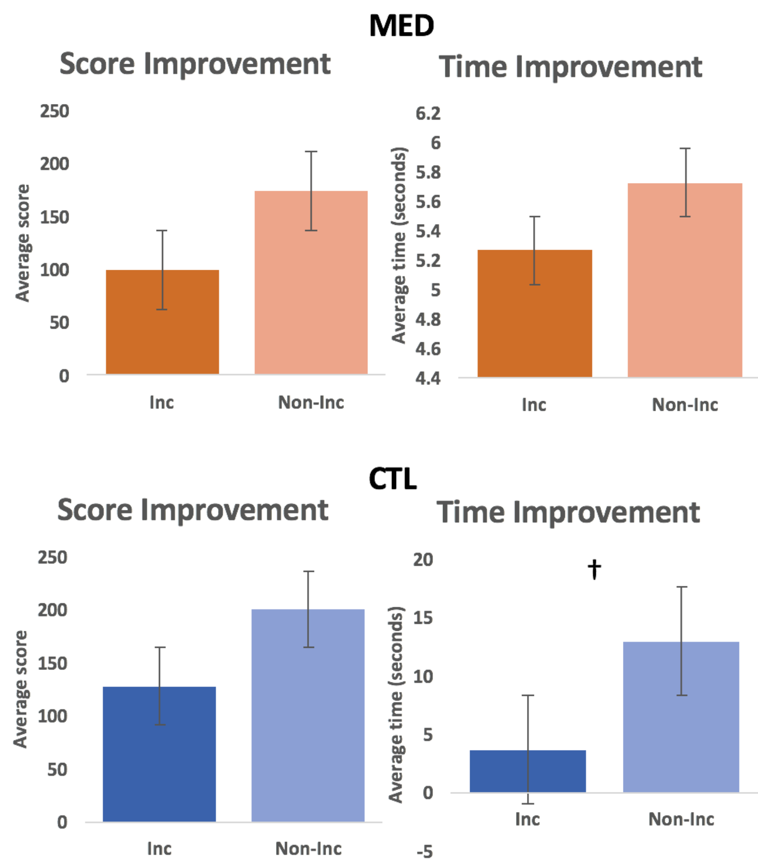

Figure 7. Differences (M±SEM) in average score and average time improvement on the procedural task for Vipassana meditators (MED) and controls (CTL) with regards to whether there were (Inc, MED=8; CTL=8) or were not (Non-Inc; Med=12; CTL=12) incorporations of elements of the laboratory and the procedural task into dream content obtained from awakenings in N1 sleep at sleep onset at the beginning of the nap. †p<.10

Discussion

This study is the first to examine sleep-dependent memory consolidation in meditation practitioners. Although meditators were found to perform slightly better on the balance task at first testing than were controls, both groups improved to a similar extent after a morning nap. However, markedly different patterns of relationships between task improvement and sleep structure were observed for the two groups: meditators showed a relationship between task improvement and occipital NREM sleep spindles while controls showed a relationship between task improvement and REM sleep time. No relationships between task improvement and dream content were found however. Additionally, there were marked differences in spindle density between meditators and controls, with meditators having significantly lower spindle density, especially in occipital regions. These results together suggest that meditation experience contributes to large-scale changes in the electrophysiological indicators of neuroplasticity during sleep.

Different sleep-dependent memory consolidation styles in meditators and controls

Results support the study's main hypothesis that Vipassana meditation practitioners, by virtue of training in attending to bodily states and stimuli, may rely upon a different neurobiological learning style, one that manifests in distinct changes in sleep microarchitecture.

Specifically, meditation practitioners showed relationships between the density of slow and fast occipital spindles in N2 sleep and task improvement. While slow occipital spindle density correlated positively with task improvement, fast occipital spindle density showed the opposite. Meditators did not, however, show any links between duration of REM or NREM sleep stages and task improvement. On the other hand, non-meditating controls did show a strong positive correlation between time in REM sleep and task improvement. They did not, however, show any links between sleep spindles, especially fast sleep spindles, and task improvement. Both of these findings have been reported in previous studies. To illustrate, for the N2 spindle finding among meditators, we previously reported similarly perpendicular relationships between fast and slow spindles in relation to learning: fast N2 spindles correlated positively and slow spindles correlated negatively with face recognition (Solomonova et al., 2017). For the REM sleep finding in controls, earlier research similarly linked duration of REM sleep with implicit memory consolidation (Karni et al., 1994).

In sum, post-task sleep architecture of meditators was distinctly different from that of non-meditating controls; it was correlated with occipital spindle density in N2 sleep but not with the duration of any sleep stages whereas in controls task improvement was associated with increased time in REM sleep, but not with N2 sleep spindles. Both patterns of sleep changes have been observed in prior research although never linked differentially to meditation experience as in the present study.

Different styles of post-task sleep-dependent processing?

One interpretation of these findings is that meditation practitioners, by virtue of attending to their somatic sensations and bodily states, approach a procedural full-body balance task in a more "explicit" manner, in the sense that they are able to bring to awareness elements of their somatic and bodily experience that usually remain unconscious among untrained individuals. Their greater familiarity with bodily sensations may thus have allowed them to perform somewhat better on some, but not all, aspects of the task. They performed slightly better than the control group on the task overall, achieving higher maximum scores both before and after the nap. This advantage may reflect a shift in the neuroplasticity mechanisms that were brought to bear on the task during sleep. In other words, because of their body-oriented training, meditators may have been better equipped to learn this task and found it easier to improve. This idea is consistent with the suggestion (Smith, Aubrey and Peters (2004) that REM sleep is associated with processing of complex tasks while Stage 2 sleep benefits the consolidation of simpler tasks. Smith et al (2004) propose that the involvement of REM or Stage 2 sleep in consolidation of a motor task depends on perceived complexity of the task; participants who are less skillful at the outset will show a dependence on REM sleep and those who find the task easier will show a Stage 2 dependence. Because our meditators were higher in body awareness and possibly found the task slightly easier, they may have needed only Stage 2 spindle mechanisms to refine their learning. In contrast, if control participants found the task more complex or novel they may have had a greater need for REM sleep control mechanisms.

Despite the feasibility of this explanation, the significance of several additional findings from the current study remain unclear. One is the question of why meditators had a lower overall rate of spindles when sleep spindle density was associated with task improvement.

A second outstanding question is why slow rather than fast sleep spindle densities were associated with task improvement. Many previous studies (Barakat et al., 2011; Lustenberger et al., 2016; Tamaki, Matsuoka, Nittono, & Hori, 2009) report that fast spindle density is preferentially correlated with improvement on procedural tasks. However, a growing body of evidence supports the notion that slow spindles are also a reliable correlate of procedural learning in some contexts. Nishida and colleagues (Nishida, Nakashima, & Nishikawa, 2016) showed a negative association between slow spindle power and a finger-tapping motor tracing task in depressed but not in healthy participants. A second group (Holz, Piosczyk, Feige, et al., 2012) showed a positive correlation between slow spindle activity (sigma: 12-14 Hz) in NREM sleep and improvement on a mirror tracing task. Third, some studies have shown that slow spindles are associated with explicit memory consolidation on tasks such as word-lists (Holz, Piosczyk, Feige, et al., 2012) and auditory verbal learning and declarative learning in epileptic patients (Del Felice, Magalini, & Masiero, 2015). Fourth, in children slow sleep spindle activity was found to be associated with declarative learning efficiency (Hoedlmoser et al., 2014). Finally, in a study using daytime naps (Schmidt et al., 2006), participants learning difficult and easy word-pairs showed evidence of slow spindle associations with improvement only on the difficult pairs. Such converging evidence links slow spindles to procedural learning and is consistent with our finding that meditators reacted to the balance task as a procedural task requiring N2 sleep mediation.

Possible napping profile

A second possible explanation of our group differences in sleep-dependent effects is that meditators are conforming to a profile known to characterize habitual nappers, either because they are used to taking frequent naps or because periods of daytime meditation may confer advantages similar to those provided by sleep, especially theta-rich Stage 1 NREM sleep (Aftanas & Golosheykin, 2005). Unfortunately, our findings do not further clarify the first point because we did not collect information about habitual napping practices. Yet, there is evidence (Milner, Fogel, & Cote, 2006) that individuals habitually taking daytime naps show a relationship between motor task improvement and sleep spindles whereas non-habitual nappers do not. Such findings, together with evidence that meditation practitioners commonly fall asleep during meditation sessions (Pagano, Rose, Stivers, & Warrenburg, 1976), provides some support for the notion that meditation confers either sleep-dependent or sleep-like advantages in memory consolidation. However, more research taking into account the habitual napping practices of participants is clearly needed for this explanation to be considered probable.

To summarize, our finding of different patterns of sleep-dependent memory consolidation for meditating and non-meditating controls can be accounted for by at least two explanations. On the one hand, the body-focused practices of meditation may contribute to large-scale changes in learning, including changes in sleep microarchitecture and sleep-dependent memory consolidation. On the other hand, similarities between meditation practice and habitual napping may confer additional sleep-related or sleep-like advantages to meditators. At present, more research supports the former possibility as an explanation for the present findings.

The notion that meditation practice leads to a different style of learning is consistent with both the philosophy of meditation approaches and a growing body of research. Indeed, the underlying goal of most traditional meditation practices, including Vipassana meditation, is not simple training of attentional acuity, but rather development of insight into one's own patterns of reactivity in order to decrease unwholesome traits and increase wholesome traits and behaviours (Goenka, 1997; Hart, 1987). Ultimately, the goal is not to improve at meditation, but to improve at life skills more generally. Thus, neuroplastic changes and acquired mental skills associated with meditation practices may have an important effect on changing one's cognitive, emotional and memory patterns more broadly (Hasenkamp & Barsalou, 2012). This idea is consistent with previous findings, including those from a study wherein mindfulness training led to increased somatosensory awareness of the experience of sadness, which in turn was related to decreased depression (Farb et al., 2010). Neurophysiologically, meditation training may change the functional connectivity associated with bodily representation and thereby recruit the interoceptive skills that underlie several perceptual and cognitive tasks (Farb, Segal, & Anderson, 2013). Our findings are thus consistent with the notion that Vipassana practice, through increased interoception and body awareness, facilitates the development of cognitive

Dream content and incorporations of task and laboratory elements

Contrary to our expectations, rates of task and laboratory incorporations into dream content were not different between the two groups. No relationship was found between incorporations of lab or task dreams upon awakening from REM or NREM, and at sleep onset and improvement on the task for meditators. However, we found a modest positive relationship between lab/task incorporations into dream content and improvement on average time spent in balance, but only for control participants. In addition, surprisingly, we found a trend indicating that control participants with lab/task incorporations at sleep onset improved less on average time spent in balance.

Our results partially replicate a study by Wamsley and colleagues (Wamsley, Tucker, Payne, Benavides, & Stickgold, 2010) in which participants in a daytime nap protocol who reported dreaming about a virtual navigation task (NREM sleep awakenings), improved more that those who did not. Due to the low rate of task element incorporations into dream content we combined incorporations of both laboratory and task as referring to the same overall experience participating in a sleep and dream study. The fact that only controls showed a relationship between task improvement and dream incorporations, and only on one measure of improvement suggests that dream content may be related to some aspects of sleep-dependent memory consolidation (in this case, balance) but not to others (in this case, eye-body coordination). In addition, it is possible that these effects were detected by expanding the scope of what counts as incorporation, in our case, by including elements from the laboratory in addition to those from the task. Dream content may facilitate sleep-dependent memory consolidation processes not only by reactivating imagery that is directly related to the task, but by reactivating elements that are contextually associated with the learning situation. This possibility is consistent with findings that dream content represents waking experiences both directly, in the form of incorporated episodic memory fragments, and more globally, for example, by incorporating only the emotional tone of an experience

(Hartmann, 2008; Hartmann & Brezler, 2008; Schredl & Erlacher, 2010) or by shifting the general dream locus of control from internal to external (Solomonova et al., 2015).

These results also partially replicate findings from a recent study that incorporation of a number of Wii Fit balance tasks in REM dream reports did not predict improvement in the task after a whole night's sleep (Nefjodov et al., 2016). We also found higher rates of task incorporation into dream content: 10-25% in our cohort compared to 5.6% in the Nefjodov and colleagues sample, and this despite a much shorter average game time in our study (7 minutes) than in theirs (2 hours). In both cases task incorporations were rated by independent judges. The different incorporation rates could possibly be attributed to the fact that our study involved a daytime nap (theirs was nighttime sleep), or to methodological differences in scoring direct and indirect dream incorporations.

Apart from a few exceptions (e.g., De Koninck, Christ, Hebert, & Rinfret, 1990; De Koninck, Christ, Rinfret, & Proulx, 1988; De Koninck, Prevost, & Lortie-Lussier, 1996; Wamsley, Tucker, et al., 2010), most prior research has found no relationships between dreaming of a task and improvement on post-sleep performance (Nguyen, Tucker, Stickgold, & Wamsley, 2013; Schredl & Erlacher, 2010; Smith, 2010; Wamsley, Perry, et al., 2010). One explanation of the lack of further evidence for a direct relationship between dreaming of a task and improving performance on that task may lie in the idea that the representation of a task is not necessary for memory consolidation of it, i.e., its consolidation over time is not dependent upon phenomenologically accurate episodic 'replays' during dreaming as it might be during waking. Memory replay has emerged as a major explanatory principle in theories of how patterns of neurophysiological activity in sleep that resemble those of wake may account for consolidation in NREM sleep (Lehmann, Schreiner, Seifritz, & Rasch, 2016; Peyrache, Khamassi, Benchenane, Wiener, & Battaglia, 2009) and to a lesser extent REM sleep (Louie & Wilson, 2001; Poe, Nitz, McNaughton, & Barnes, 2000; Poe, Walsh, & Bjorness, 2010) but the replay notion has proven difficult to reconcile with the finding that true-to-life reflections of episodic memories are only rarely seen in REM dream content (Fosse et al., 2003; Malinowski & Horton, 2014).

Rather, it may be that dreaming is concerned principally with the integration of newly learned experiences into broader autobiographic and semantic memory networks (Carr, Blanchette-Carriere, Marquis, Ting, & Nielsen, 2016; Horton & Malinowski, 2015; Stickgold, Hobson, Fosse, & Fosse, 2001). In other words, dreaming may serve an associative function, connecting different memory and affective elements in order to help in contextualizing or making sense of new experiences (Carr & Nielsen, 2015; Hartmann, 1996; Horton & Malinowski, 2015; Stickgold, 2005; Stickgold & Walker, 2004; Walker & Stickgold, 2010). From such a view, dream content may contribute to the flexibility of the memory system—its ability to adapt and adjust to novel experiences—without needing to concretely represent the new experience itself. Such a mechanism may be more fundamental than any intentional practice such as meditation may afford.

The negative trend, suggesting that control participants who dreamt at sleep onset of laboratory or task improved less on the task, raises the possibility that perhaps dreaming of some aspects of some tasks may be beneficial for certain types of sleep-dependent memory consolidation, while also *not dreaming* of a task may facilitate its consolidation. One possible explanation of this effect may be related to the phenomenon known as verbal overshadowing (Lane & Schooler, 2004; Schooler & Engstler-Schooler, 1990). With verbal overshadowing, rehearsing the task by verbally describing the stimuli that are of non-verbal nature, such as faces, following initial learning impairs its consolidation. One proposed explanation of this effect is that some memory processes require unconscious, implicit mechanisms and thus bring these newly encoded memories to explicit representational awareness may interfere with their successful consolidation. It is possible, therefore, that explicitly dreaming of certain aspects of a task may interfere with its consolidation via a similar mechanism of mentation overshadowing. Some evidence for this idea comes from research by de Koninck and colleagues, who show that awakenings during the night for dream recall following pre-sleep exposure to a stressful event increase subsequent anxiety and decrease adaptation upon awakening (De Koninck & Koulack, 1975; Koulack, Prevost, & De Koninck, 1985). Future work on the relationship between explicit and implicit forms of memory and their representation in imagery, dream content or neural replay could untangle the delicate relationships between processes that require awareness and those that necessitate a lack of it.

Task performance, body awareness and bodily dissociation

Both meditators and non-meditating controls improved their performance on the balance task following a daytime nap. Contrary to our predictions, meditators performed only marginally better on the task than did controls: they did not improve more than controls overall, but they had higher scores before the nap and they completed the task more often after the nap.

As predicted, however, meditators scored higher than controls on the Body Awareness subscale of the Scale of Body Connection and that these scores were related in a graded fashion to task performance (time and score) before the nap. These finding are consistent with studies suggesting that sustained meditation practice contributes to higher levels of somatic awareness (Fox et al., 2012) and confirms our rationale for choosing a full-body balance task to examine patterns of sleep-dependent memory consolidation. In this case, one required skill for learning the task quickly is a heightened level of attunement to one's own bodily/somatic states.

Further, we found a negative correlation between bodily dissociation subscale scores and task improvement among meditators but a positive correlation among controls—even though the two groups did not differ on mean bodily dissociation scores. These findings are not easily explained and clearly require replication with a larger battery of body awareness and dissociation measures. One possible explanation is that the two groups differed in other ways than simply practicing meditation regularly; in fact, such differences may have led participants to seek out meditation (or not) in the first place. To provide but one illustration, the bodily dissociation subscale was originally found to discriminate between participants who had and had not been exposed to physical trauma; specifically, childhood sexual and physical abuse among females and adult physical assault among males (Price & Thompson). While we did not assess our participants for histories of adversity or trauma, substantial research shows that childhood adversity can lead to changes in sleep and dreaming (see review in Nielsen, 2017). It is thus possible that the groups differed in their degrees of past exposure to adversity and that this both led them to seek (or avoid) meditation practice and differentially altered relationships between the body connection factor (dissociation vs. awareness) and learning.

Sleep and spindle differences between meditators and controls

In contrast to existing literature, we did not find longer REM sleep or SWS periods in meditation practitioners or differences in sleep efficiency or #awakenings, but meditators did show a tendency for a lower overall sleep time. For instance, in one study on Mindfulness-Based Cognitive Therapy, meditation practitioners showed more cortical arousal and more awakenings during nighttime sleep than did controls (Britton, Haynes, Fridel, & Bootzin, 2010). On the other hand, experienced long-term Buddhist practitioners (Ferrarelli et al., 2013) had a lower total sleep time like the trend in our study but also more awakenings—unlike our sample.

The fact that we found no associations between meditation experience and sleep latencies, sleep efficiency or duration/proportion of individual sleep stages may be due to the fact that our sample contained no expert meditation practitioners, typically quantified as having more than 10 000 hours of meditation practice (Brefczynski-Lewis, Lutz, Schaefer, Levinson, & Davidson, 2007). Because all our participants can be considered meditation novices or at best intermediate practitioners, it is possible that the short daytime naps taken were insufficiently sensitive to reveal subtle group differences. Future studies might require all-night recordings or protocols that unmask subtle group differences by augmenting homeostatic pressure or REM sleep propensity.

We found sleep spindle density differences between meditators and controls, with meditators unexpectedly showing reduced sleep spindle density, especially in occipital derivations. Reduced spindle density has been suggested as a marker of neurodegeneration (Ktonas et al., 2007; Latreille et al., 2015) and psychopathological conditions such as schizophrenia (Schilling et al., 2016; Wamsley et al., 2012). Our finding is unexpected because practice of meditation has been associated with increased neuroplasticity (Kang et al., 2012; Lazar et al., 2005; Slagter, Davidson, & Lutz, 2011), and is thought to have neuroprotective effects against cognitive decline (Gard, Holzel, & Lazar, 2014) and psychopathology (Shonin, Van Gordon, Compare, Zangeneh, & Griffiths, 2015). For instance, in one study (Pattanashetty et al., 2009) Vipassana practitioners showed no age-related decline in slow-wave sleep and REM sleep compared to controls, suggesting that Vipassana practice may protect against age-related neurodegeneration.

Sleep spindles have also been suggested to play a role in maintaining sleep in face of environmental stressors, especially noise (Cote, Epps, & Campbell, 2000; Dang-Vu et al., 2011; Dang-Vu, McKinney, Buxton, Solet, & Ellenbogen, 2010; Lecci et al., 2017). Reduced sleep spindles, in addition to other markers of physiological arousal during sleep in meditation practitioners may represent a general developed trait of increased alertness/awareness of the environment during sleep. While in normal populations sleep fragmentation may represent a pathological hyper-vigilance that may lead to insomnia and increased stress levels (Dang-Vu et al., 2015; Mezick et al., 2009) in meditation practitioners, it may not have the same negative effect due to practices that emphasize non-reactive awareness, an active monitoring of the contents of awareness, and a general increase in alertness (MacLean et al., 2010). These effects, however, tend to depend on proficiency in meditation practice: meditators in early stages of practice report more fatigue and sleepiness, while more experienced practitioners report greater alertness (Britton, Lindahl, Cahn, Davis, & Goldman, 2014).

Another possible explanation of our group difference in slow spindles is that some effects of meditation practice overlap with the function of sleep spindles, thus reducing the processing load on sleep-dependent processes. For instance, sleep spindles are associated with intelligence (Bodizs, Gombos, Ujma, & Kovacs, 2014; Fogel & Smith, 2011; Ujma et al., 2014; Ujma, Sandor, Szakadat, Gombos, & Bodizs, 2016), and pharmacologically induced sleep spindles correlate with memory for emotionally negative memory, suggesting an emotion regulation function (Kaestner, Wixted, & Mednick, 2013). Analogously, meditation practice may contribute to the slowing of age-related decline in fluid intelligence (Gard, Taquet, et al., 2014), to improvement in cognitive function (Zeidan et al., 2010) and to enhanced emotion regulation (Chambers, Gullone, & Allen, 2009).

Finally, it is possible that meditation subsumes some of the beneficial functions of sleep. While meditation practice is generally associated with increased self-reported well-being, health and life quality, during intensive meditation practice e.g., a meditation retreat, meditators require less sleep (Kornfield, 1979), and exhibit physiological arousal signs, such as increased gamma coherence during slow wave sleep (Ferrarelli et al., 2013). And while sleep plays an important role in memory consolidation, restful wakefulness (as opposed to active wakefulness) also promotes learning (Brokaw et al., 2016). It is possible, therefore, that daytime meditation practice is sleep-like in nature and thus reduces sleep pressure and alter subsequent sleep architecture.

Acknowledgements

This research and ES were funded by the Francisco J. Varela Research Award from the Mind and Life Institute, by the Joseph-Armand Bombardier doctoral scholarship from the Social Science and Humanities Research Council of Canada, by the J.-A. DeSeve doctoral scholarship from the Foundation of the Sacre-Coeur Hospital of Montreal and by an Operating Grant from the Natural Sciences and Engineering Research Council of Canada to TN. CB-C was funded by a master's scholarship from the Canadian Institutes for Health Research. The authors are grateful to Alexandra Duquette, Olivier Dussault, Sarah Hertz, Cecile Renucci, and Jonathan Faucher for help in development of the experimental protocol, pilot work, and analyses of dream reports.

Author contributions
ES and TN designed the study, interpreted the results and wrote the manuscript and ES, TN, SD, AS-R, CB-C, MC, TP collected data and analyzed results.

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6. Discussion

The theoretical and empirical work presented in the present dissertation was conducted under the overarching idea of situating sleep and dreaming processes within the framework of the embodied mind, specifically, the enactive research program. Article I makes the case that dreaming is an embodied phenomenon, as opposed to the common view that dreaming is disembodied hallucination), and proposes an empirical program of research that includes insights from phenomenology and enactive cognitive science to elucidate fundamental qualities of dream formation that may otherwise be undetected by currently used tools. I argue that dreaming is embodied, enactive and a skillful affective process of sensorimotor sense-making, and that dreaming and waking share many processes with imagination. I suggest that a neurophenomenological research program may uncover the perceptual, sensory and metaphorical elements of dreaming and that it would complement existing "breadth"-based approaches with a transversal "depth" approach. The depth approach to dream content would focus not only on the *what* (i.e. the formal qualities of dream production), but also and especially on the *how* of dreaming. Article I was selected as a target article for a special issue of *Constructivist Foundations* titled "Exploring the Diversity in Enactivism and Neurophenomenology", and has generated seven open peer commentaries (see Appendix 2).

A detailed study of relationships between bodily and dream alterations is provided in a review of sleep paralysis experiences; this work illustrates the alterations in spatial imagery, social imagery and sense-making in a common form of dream intensification. This work (Article II) is a chapter in press for the upcoming *Oxford Handbook of Spontaneous Thought.* It is a review of the current state of neurobiological and cross-cultural research on sleep paralysis and its treatment and proposes that studying sleep paralysis experiences through the lens of enactive cognition can provide cues to some of the subtle triggers of dream formation and to the role of the spontaneous imagination in the perception of ambiguous stimuli. More specifically, the review shows how sleep paralysis is a rare opportunity to observe how space perception and social imagery (felt presence) may be transformed in situations of intense bodily paralysis.

The empirical study investigated embodied cognition in the context of sleep, dream content and learning in meditation practitioners and non-meditating controls. In this work, the embodied dreaming hypothesis is tested in relation to five factors: 1) as an expression of a particular cognitive skill, in this case, heightened interoceptive/bodily awareness cultivated by Vipassana meditation practice; 2) as a function of procedural learning; 3) as an expression of large-scale changes in brain plasticity, reflected in sleep-dependent patterns of procedural memory consolidation; 4) in differences in dream content; and 5) in patterns of incorporation of kinesthetic stimulation during sleep into dream content. Research questions 1-3 are presented in Article III; and preliminary results for questions 4-5 are examined in sections 6.3.7 and 6.3.8 of the present Discussion.

This is the first study, to my knowledge, to assess the contribution of sleep and dreaming to procedural memory consolidation in meditation practitioners. We found distinctly different neurobiological styles of sleep-dependent memory consolidation in our two groups. Specifically, while in control participants, procedural learning of a balance task was associated with general sleep architecture, in particular with REM sleep duration, in meditation practitioners these same processes were associated exclusively with sleep spindle density. This suggests that intentional body-oriented training, in this case Vipassana meditation, may have an effect on a large-scale reorganization of fundamental cognitive processes, such as sleep-dependent memory consolidation.

Considering dreaming within an enactivist framework helps expand and revise the embodied mind proposition. How is it possible that we are able to generate, endogenously, worlds that appear and feel realistic, compelling and multisensory? What is the relationship between dreams, perception, imagination and memory? What can be learned about dreams by studying the perceptual systems, and, perhaps more interestingly, what can be learned about waking perception by studying dream formation? These are some of the fundamental research questions that may be clarified by developing an enactive and embodied framework for the study of dreaming.

6.1. Theoretical framework: embodied cognition and dreaming

6.1.1. Article I and reply to Open Peer Commentaries

In Article I we introduce the notions of depth and breadth of dream content in dream research, and propose that an enactive theoretical framework, together with practical neurophenomenological methods of study, can illuminate features and qualities of dream life that have largely been neglected or overlooked in traditional cognitive neuroscience and psychology research. We argue that dreaming experiences share a lot of qualities with processes of perception and of imagination, and that there is no sharp separation between the states of consciousness. Thus, we offer an alternative approach to dream content, one that includes phenomenology of dreams and neurobiology of sleep, in order to study the dreaming mind. Finally, we situate dreaming on a continuum of conscious experiences, and challenge the prevalent notion that dreams are a distinct state of consciousness.

The article inspired seven open peer commentaries, also published in *Constructivist Foundations,* that can be found in Appendix 2. The present section is an edited and slightly expanded version of our responses to these commentaries (Solomonova & Sha, 2016).

The main points of discussion raised in the commentaries are the following:

1. To what extent can dreaming be framed through an enactive perspective, specifically:
    a. What is the relationship between imagination and perception, and are the two distinctly different modes of experience, or dependent on the same fundamental processes that make mental life possible; and
    b. To what extent can dreaming be considered an embodied and skillful activity
2. Practical and epistemological concerns with the neurophenomenological paradigm:
    a. How to conduct dream research that would reveal deep and broad qualities of dream content and ways of being a dream self;
    b. What are the advantages of the second-person perspective in studying dream content, including the epistemic status of the researcher; and

c. How can neurophenomenological work on dreams benefit from a more radical phenomenological turn, including use of *epoché*, and of existing phenomenological strategies for studying lived experience, such as Gendlin's work on felt sense (Gendlin, 1982; Gendlin, 1986; Gendlin, 1997).

6.1.1.1. Perception, imagination, hallucinations, and dreaming

The issue raised by a majority of the commentaries concerns relationships among imagination, perception, and dreaming. Our position, as articulated in the target article, presupposes a fundamental inseparability and important overlaps in imagining and perceiving. However, we prefer to avoid collapsing imagination and perception into one single underlying process, and we acknowledge that there are important experiential and physiological differences between interacting with the world and imagining interacting with it. Still, there is evidence to suggest that these two modes of experiencing are not completely distinct modes of awareness.

A strong version of the equivalency between dreaming and waking perception was proposed by a number of researchers, such as Llinás and Ribary (1994) and LaBerge and Rheingold (LaBerge & Rheingold, 1991). We do not, however, endorse the view that just because dreaming can sometimes feel real and be experienced to be as (and sometimes even more) vivid and intense as waking perception, that the two are essentially the same. There are, certainly, important differences between actively perceiving and exploring the outside world and being engaged in the dream world. Thompson (2014), for instance, notes that these differences lay in qualities of the two types of experience, for example, in how processes of attention and volition are engaged:

> "Perception, therefore, is not online hallucination; it is sensorimotor engagement with the world. Dreaming is not offline hallucination; it is spontaneous imagination during sleep. We are not dreaming machines, but imaginative beings. We do not hallucinate at the world; we imaginatively perceive it" (Thompson, 2014: 188).

The phenomenological approach to imagination and perception can clarify some of the continuities and discontinuities between the two processes. Experientially, perception likely has developmental primacy: we learn about the world by being active, engaged, and motivated agents. Memories of our prior experiences create a vocabulary of possible ways of perceiving, understanding, and of interacting with the world. However, as Casey suggests, imagination as a process is irreducible to perception: "even if imagining relies on perceiving regarded as a premise of all human experience, it remains master in its own house, displaying an autonomous action that is without parallel in perception" (Casey, 1976: 173). Processes of imagination play an important role in perception, and cases of illusions and misperceptions can illustrate the seamless overlap between the two. The Gestalt figure/ground images are immediately perceived as wholes, despite missing pieces and empty spaces. Ambiguous stimuli are (mis)interpreted as meaningful wholes before they are perceived as ambiguous.

In phenomenology, the core mechanism of being-in-the world or *être au monde* (being *of* the world) is the creative and active relational dynamic of the agent-world dance. In Merleau-Ponty's famous example of perception of a boat that has run aground, the subject first experiences that the forest is fused with elements of the ship (the mast), in accordance with her expectations and with the fundamental principle of unity of perception (Merleau-Ponty, 2012: 16-17) [7]. In other words, we do not encounter the world as it is, we encounter it as we are attuned to it, and we always already experience it as a meaningful habitat. In a similar vein, Varela and Depraz discuss the co-dependence and dynamic co-constitution of processes of imagination and perception, suggesting that studying such phenomena as illusions would allow for a detailed phenomenological investigation of "how perception can be enlarged to become a kind of imagination" and, conversely, that investigating dreams allows one to probe into how "an imaginary consciousness … produces images that look very much like perception" (Varela & Depraz, 2003).

[7] "If I am walking on a beach toward a boat that has ran aground and if the funnel of the mast merges with the forest that borders the dune, then there will be a moment in which these details suddenly reunite with the boat and become welded to it" (Merleau-Ponty, 2012: 16-17)

On the neurobiological level, as Kirchhoff notes in his commentary to our target article (Kirchhoff, 2016), visual perception and visual imagination do not rely on activation of the same neural networks. It would be expected that, indeed, perception and imagination would not recruit exactly identical networks since the two are physiologically and phenomenally related yet also different. Growing evidence, however, points to the possibility that some overlap exists on the neural level. To illustrate, one study (Halpern, Zatorre, Bouffard, & Johnson, 2004), reports overlapping activations in perceived and imagined musical timbre, including activation of the supplementary motor area, which suggests there may be a strong kinesthetic element of musical performative imagination. Similarly, a position sometimes referred to as the functional equivalency hypothesis of mental imagery is based on the idea that imagined and acted movement share underlying neural substrates (Gallese & Goldman, 1998; Grezes & Decety, 2001; Johnson, 1982; Williams, Cumming, & Edwards, 2011). Shared neural substrates were reported for imagined and executed motor actions (Decety, 1996), including partially overlapping networks for actual and imagined hand movements (Gerardin et al., 2000). One study reports that practicing vivid mental imagery can even lead to the formation of false memories, as if the imagined event was in the end experienced to be as real as if it had actually happened (Gonsalves et al., 2004).

In his commentary, Kirchhoff proposes two ways to approach what he calls the "inseparability condition" of imagination and perception: a "strict" and a "relaxed" option. The latter opens a possibility that "dreaming and imagining make use of the same enabling resources as perceiving" (Kirchhoff, 2016). We agree with this position and suggest that these enabling resources for dreaming, imagination and perception may be in activity of the default mode network (DMN). The DMN is known to underlie many forms of spontaneous mental activity, such as mind-wandering, spontaneous thought, day dreaming and, likely, oneiric mentation (Domhoff, 2011b; Domhoff & Fox, 2015; Fox et al., 2013; Windt, 2015a).

6.1.1.2. Embodied and skillful dreaming

The idea that dreaming is embodied may seem counterintuitive and was challenged by many commentaries to our article. Gonzalez (González, 2016), for instance, questions this notion by pointing out that during dreaming the body is usually inert. He challenges if and how imagination can be the bridge that connects the embodiment program with dream research, since during dreaming anchorage with the actual perceptual domain is absent. Indeed, the dreamer appears to be minimally if at all responsive to the outside world, both in behavioural and perceptual terms. However, (and as reviewed in section 1.2.4 of the Introduction and presented in the form of new results in section 6.3.7 of the present Discussion), the dreaming body is not completely inert. Dream content is known to react to outside stimuli including visual (Rechtschaffen & Foulkes, 1965), auditory (Hoelscher, Klinger, & Barta, 1981), olfactory (Schredl et al., 2009), and somatosensory (Nielsen, 1993, 2017a) stimuli; however, these are rarely in the form of direct representational incorporations. Despite all the thalamocortical safeguards preventing the sleeper from awakening and protecting sleep (Dang-Vu, McKinney, Buxton, Solet, & Ellenbogen, 2010), stimuli during sleep are able to change dream content in a number of ways. Thus, one possible neurophenomenological research question is: How exactly do dreams process endogenous stimuli, such as pain (Raymond et al., 2002), thirst (Dement & Wolpert, 1958), and digestion (Nielsen & Powell, 2015) and external stimuli, such as touch, sound or smell? Dream content seems to be, at least in some cases, directly correlated with autonomic arousal, for example as in the case of intense and emotional nightmares (Nielsen & Lara-Carrasco, 2007). Studies of lucid dreams also show direct and even isomorphic relations between the sleeping and dreaming bodies: for example, exercising in a lucid dream increases heart and respiration rates in the sleeping body (Erlacher & Schreld, 2008). Permeability between the sleeping and dreaming bodies is also illustrated by the rather high prevalence of dream-enacting behaviours in non-clinical; populations; these behaviors include waking up crying from a sad dream, talking during a dream, performing movements corresponding to dream content and others (Nielsen et al., 2009). All these examples indicate that while most motor output is, indeed, blocked during REM sleep, subtle changes in autonomic arousal, even muscle activity, corresponding to dream content, can be detected and that the body is not entirely inert during dreaming. Rather, bodily sensations and bodily expressions are simply attenuated; some level of arousal appears to be tolerable and does not interrupt sleep; higher levels of arousal, such as in case of intense nightmares or in reaction to a loud noise, would wake the dreamer.

Research questions regarding the status of embodiment while dreaming must transcend simply evaluating the overt representation of the body and its parts in dream content. If, in accordance with phenomenological tradition, embodiment is understood as one of the primary and irreducible conditions of subjectivity, then simply seeking direct correlations between sensations of the sleeping body and dreamed body representations is a limited form of inquiry that misses the full potential of phenomenological methods. One alternative approach would be to assess how the dream as a whole (not just the dreamt body) reacts to external stimuli—and corporeal stimuli in particular. One could, for example, assess discontinuities in dream content or global changes in the dream, such as in theme or dreamt locus of control (Solomonova, Stenstrom, Paquette, & Nielsen, 2015), among other candidate qualities. Another way to assess dreaming as embodied is to concentrate on somatic foundational qualities of affect (Colombetti, 2013). The strong relationship between affect, emotion and body has a long history (also see section 1.2.3 of the Introduction). Indeed, scholars of dreams including Freud (1900/2010) and including Hartmann (Hartmann, 1996, 2010b) and Gendlin (1986), among others, argue that dreams are symbolically structured by affect and deeply rooted in somatic experience.

Kirchhoff (2016) raises concerns with our account of dreaming as a skillful activity, rather than as a passively lived experience, and points out, rightly, that practices of dream reporting or lucid dreaming can be skillful, but perhaps not typical dreaming. In our reply, we start from the idea that dreaming, like perception, is a developmental achievement (Foulkes, 2017). While some dreams may be described as experienced somewhat passively by the dreamer, this perception may be due to cultural differences in the interest and importance accorded to dreaming. Dreaming practices, such as dream reporting, dream interpretation and dream-sharing, play an important role in many traditional societies – shamanic and yogic traditions being the most well-described (Holecek, 2016; Wallace, 2012). Contemporary practices also exist; these include dream incubation for problem-solving (Barrett, 1993a), or Ullman's group dream analysis (Ullman & Limmer, 1987), among others. Since these and other dreamwork techniques can be learned and applied, it entails that dreaming is at least indirectly responsive to intentional practices. Here, we draw an analogy with perceptual and attentional skills: mental activity is active, arising in response to an organism exploring his/her environment. Similarly, experienced dreamers may train their attentional skills to notice or change particular elements in some kinds of dreams. We do agree, however, that spontaneous mental activity during sleep is not necessarily (and probably rarely is, barring lucid dreams) intentional in the sense that the dreamer is explicitly involved with a metacognitive awareness of the dream content and/or exercising control over the dream narrative.

6.1.1.3. Breadth and depth of dreaming

In her commentary, Windt (2016) presents very insightful comments regarding a more nuanced view of the breadth vs. depth description as they relate to concrete methodologies for research on dream reports. While in our target article we expand upon an earlier view (Solomonova, Fox, & Nielsen, 2014) and we promote a depth approach to quantifiable/qualifiable analyses of dreams, we agree with Windt that breadth and depth approaches are complementary, and are encouraged that the depth/breadth distinction appears, in her opinion, to be a helpful tool for advancing dream content research. Our current position is in alignment with Windt's formulation that "speaking of the depth of dream experience is shorthand for a *multi-level, inclusive, and integrative research strategy*" (Windt, 2016: §10, author's emphasis). While breadth approaches (the *what* of dreaming), focused on quantifying easily recognizable elements and characteristics, allow an objective characterization of the formal qualities of dream reports, depth approaches focus on the *how* of dreaming, transcending the dream's formal qualities and expose the temporal, embodied, affective, intersubjective, and metacognitive qualities of dreaming.

As we note in the target article, and as Windt points out, depth strategies focus on questions such as the temporal patterning of dreaming (Blagrove, Henley-Einion, Barnett, Edwards, & Heidi Seage, 2011; Nielsen & Powell, 1989, 1992, 2015; Solomonova et al., 2015), the affective qualities of dreaming, e.g., the dream's "central image" (Hartmann, 2008), or the apparent locus of control of the dream events (Solomonova et al. 2015), to name a few. And although the *how* and the *what* of dreaming may be complementary, they nonetheless tap largely independent features. For example, in studying memory sources of dreaming one may be interested in the kinds of experiences that appear in dream content (breadth), but to make sense of this information, one would study the elements' personal relevance to the dreamer (depth) (Horton & Malinowski, 2015; Malinowski & Horton, 2014; van Rijn et al., 2015), their relationship to the locus of control (depth), their affective charge (depth), etcetera.

As a further example, the themes, frequency, or even intensity of nightmares is well-known to be less predictive of the dreamer's well-being than is the nightmare's particular affective quality, referred to as nightmare distress (Belicki, 1992; Levin & Fireman, 2002). Neurophenomenological studies of nightmares that focus on their depth characteristics – for instance assessing the temporal patterns of nightmare occurrence, linking a nightmare with changes in bodily affect *before* it happens, describing in greater detail the manner in which the threatening scenario unfolds – all can serve to further a fundamental understanding of both nightmare formation and its first-person phenomenology. To enhance this process, we agree with Windt, in that the *detail-specificity-expressive granularity* balance is beneficial to the depth approach.

To sum up, in our conceptualization, the breadth (*what*) of dreaming refers to the study of the *formal qualities of dream reports*, e.g., frequencies of themes, motives, or specific elements (characters, family members, places, animals, objects, etcetera). In this sense, breadth approaches are typically focused on what is *common* in dream reports of a particular socio-cultural population: typical dreams, dream themes by age, between sexes, etcetera. In contrast, the depth (*how*) of dreaming concerns the *phenomenal qualities of dream reports*, such as the temporal manner of appearance of dream characters, the affective and bodily quality of interaction with a dream element, links between dream objects and memories of a lived experience, among others. Although these are complementary approaches the depth approach seems much better suited for exposing the many features of embodiment that are embedded in dream experience.

6.1.1.4. Second-person approach, *epoché*, and the felt sense

Kordeš (2016) argued for a "more detailed rethinking of the epistemic position of the researcher", and Windt (2016) echoed this sentiment by stating that "what exactly can be gained from dissolving the distinction between researchers and expert participants is an open question” (§13). We agree with their sentiments and share their concerns. Dream research has a long tradition of scholars including Freud (Strachey 1953) and Léon Hervey de Saint Denis (Hervey de Saint Denis, 1867) as well as contemporary dream researchers including Nielsen, Hartmann, and Hobson, who analyse and publish their own dreams. This can be seen as the first phenomenological step, an initial undertaking of phenomenological reduction, and may provide the researcher with unique insights into the potential mechanisms and dynamic elements of dream formation that may be assessed in subsequent 2nd- and 3rd-person experiments. On a cautious note, Windt rightly points out the particular difficulties inherent in adopting a full-fledged second-person, researcher-practitioner perspective with regards to dream research: “[T]he challenge will be how to balance the potential benefits of expertise and firsthand familiarity with the risk of bias, and in some cases, bracketing one’s own experience may be the most cautious approach” (Windt, 2016: §13). As Schaffer and Shapin (Shapin & Schaffer, 2011) note, scientific objectivity and “facts” are constructed out of socially shared accounts of experimental experience. Thus, second-person accounts inherit objective status to the extent that they are constructed jointly by more and more people across broad social distributions.

A neurophenomenology of dreaming (and of any other subjective experience) would greatly benefit from taking the “phenomenological turn” in a more radical way, and using the *epoché* to bracket out both participants’ and researchers’ “beliefs and attitudes about the world and the origins of experience” (Kordeš, 2016: §13). We agree with Kordeš in that if we bracket the presupposition about “bizarreness” or implausibility of dream experience (relative to the waking world), we may be able to approach dreaming on the terms of the dream world, and move away from a delusional/symptomatic view of dreaming. While still in nascent form, the methods of phenomenological reduction and *epoché* have a central place in the neurophenomenological approach. Suspending the “natural attitude” and letting the experience guide the experimenter’s understanding of the phenomenon, may be interpreted as a variant of the practice of the *epoché*, and using the second-person guided interview approach facilitates this task for untrained subjects. As Lutz and Thompson propose, the gesture of the *epoché* requires three steps: suspension, redirection, and receptivity. They also encourage their participants to practice the “letting go” attitude, which facilitates the appearance or noticing of usually overlooked experiences. Through communication of these first-person reports, an intersubjective verification is made possible (Lutz & Thompson, 2003).

In addition, performative and theatrical aspects of dreaming as a creative imaginary activity fall very neatly into this picture. To extend this line of thinking , we agree with Roesch, who posits that the performative dimension is constitutive of not only dreaming but of a more general way of being in the world (Roesch, 2016). As Ellis (2016) suggests in his commentary, the sense-making processes depend upon affordances that we recognize in the world. A creative and imagination-based view of dreaming, then, expands the notion of affordances beyond the physical environment and into the symbolic and imaginary (Ramstead et al., 2016). This, in turn, may entail including the social and symbolic dimensions among the variety of affordances that motivate the social organism and modulate its coupling with the environment through skilled intentionality (Bruineberg, 2017).

As Ellis suggested in his commentary (Ellis, 2016), Gendlin's "felt sense" and "focusing" approach (Gendlin, 1982; Gendlin, 1986; Gendlin, 1997) can be instructive in three additional ways in the study of corporeal aspects of dream content, i.e., by highlighting: 1) proprioceptive imagery (the way the body feels), 2) sensorimotor imagery (the way doing and moving feels), and 3) felt sense, or the global feeling about the nature of one's state in relation to the dream. The focusing approach is often used in therapy, but less often in research (but see Kuiken, Carey & Nielsen (1986). The method can be particularly useful for uncovering the metaphorical, subjective, and individual elements of insight, sense-making, and affective reactivity within the dream environment. It also provides tools for grounding the phenomenological and formal descriptions of dream content in somatic and bodily experience. Further, it is possible to train individuals to notice sensations *in* the dream, as well as to notice sensations while *remembering* the dream. Indeed, Gendlin's approach, centering on *how* the living body provides grounds for dream experience, is particularly well-suited to shifting the focus from the breadth of dreaming to its depth.

We also welcome Kordeš' (2016) suggestion of epoché as a trainable and, especially, transferrable skill, which would facilitate paying attention to the dream as it unfolds (and not just upon awakening). Such a self-observational skill could fruitfully compliment techniques used to recall dreams, such as dream interviews, Gendlin's (1986) "felt sense" approach to dream interpretation, and elicitation interviews (Petitmengin 2006), as adapted to dream research. Dreaming, by virtue of being less constrained by sensory inputs and dependent on subtler somatic and motor processes, can be seen as a window into the creative constitution of subjectivity. Moreover, dreaming can be seen as a process of "bracketing" of the world, i.e., during dreaming the intentional object is fluid, unstable spontaneous mentation grounded in somatic and affective states.

6.1.1.5. Influence of dreams on waking life

The continuity hypothesis of dreaming states that dream content is influenced by daily experiences and preoccupations (Domhoff, 2011a; Schredl, 2000a; Schredl & Hofmann, 2003). A more provocative suggestion is that just as the waking experiences influence much of the dream experience (including memory sources, current concerns, skills and habits), so does the recalling of dreaming change and texture our perceptual experiences in wake. To illustrate, frequent lucid dreamers are able to practice motor skills during dreaming, and subsequently improve their performance at wake (Erlacher & Schredl, 2010) or to solve a problem during dreaming and even received useful advice from dream characters (Stumbrys & Daniels, 2010).

Non-lucid dreaming is also known to influence waking life (Schredl, 2010) although few studies have systematically investigated this effect. However, some regularities are worth noting. Dream content was found to influence waking life by: 1) influencing daytime mood (Kuiken & Sikora, 1993; Pagel & Vann, 1992; Schredl, 2000b; Wasserman & Ballif, 1984); 2) triggering spontaneous reminiscences (Kuiken & Sikora, 1993; Schredl, 2000b) and thus influencing the content of thoughts and concerns the following day; 3) engaging social behaviours, specifically, seeking out a person in the dream (Schredl, 2000b). Further, in frequent nightmare sufferers, a lingering daytime distress that follows negative dreams has been well-documented. Evidence also suggests that awakening from REM or NREM sleep changes some cognitive functions, for instance, in two studies, individuals awakened from REM sleep were able to perform on word-association task in a more creative way (i.e., their answers showed more atypical associations to word prompts) than those awakened from NREM sleep (who produced more common associations to the prompts) (Cai et al., 2009; Carr & Nielsen, 2015). Finally, evidence points to the notion that dreams facilitate creativity, insight and problem solving (Barrett, 1993b; Cartwright, 1974; Schredl, 2010) thus possibly affecting future behaviour and decision-making. Similarly, dreaming has been linked to mind-wandering (Domhoff & Fox, 2015; Fox et al., 2013), a form of spontaneous cognition linked to creativity, problem-solving and ability to plan future events (Baird et al., 2012; Mooneyham & Schooler, 2013; Smallwood & Andrews-Hanna, 2013).

It is possible, therefore, that in addition to the affective carry-overs and behavioral changes brought about by dream content, dream experiences change and shape subtler and more fundamental perceptual and cognitive processes in wakefulness. Waking affects dreaming on many levels: as a continuity with waking concerns, in form of memory traces, as affective background, and in form of habitual sensorimotor patterns of interaction with the world. Similarly, dreaming allows for novel experiences to be lived and remembered, thus likely shaping, in turn, some of our perceptual and cognitive patterns of interaction with the real world in waking life.

6.1.2. Conclusions

In Article I and our replies to peer commentaries, we have attempted to show that dreaming is an embodied process of spontaneous imagination conditioned by the habitual sensorimotor patterns of relationship with the world. In this sense, there is a continuity between our embodied engagement with the physical and social worlds on the one hand, and dream experiences on the other. However, there are many dream experiences that occur without having a clear parallel in the waking life. Intense and compelling experiences of flying or falling, shapeshifting, out-of-body experiences, or being someone else have no obvious parallels in wakefulness. Furthermore, it is possible to practice such anomalous experiences in some dream states and thus to develop new skills over time. Flying or dying in lucid dreams are two such skills (LaBerge, 2009). While it is well-established that waking experiences have an effect on dreaming, systematic study of dream content that would use both breadth (the *what* of dreams) and depth (the *how* of dreams) approaches could not only illuminate the temporal and qualitative aspects of dream formation, but also uncover the ways in which dream perception may influence waking life.

We have argued that dreaming is strongly embodied, and that dream embodiment goes beyond representations of body-as-object in the dream. Further, we highlighted the notion that dreaming is a cognitive skill that is sensitive to training. This quality of dreaming allows developing more directed probes into the *depth* of dreaming qualities, and a development of a rich second-person perspective on dream research, with researcher-practitioners co-constructing experimental paradigms with research participants. Practices of *epoché*, "felt sense", or elicitation interviews are some of the phenomenologically-minded approaches that are particularly well-suited for this kind of detailed study of phenomenal qualities of dreaming.

6.2. Sleep paralysis as an example of embodied social and spatial dream imagery

6.2.1. Summary of Article II

Article II is an overview of experiential and neurophysiological aspects of sleep paralysis. In this work, I attempt to step away from a common equation between sleep paralysis and delusion, and to discuss sleep paralysis as a culturally grounded, integrative (as opposed to dissociative) state of overlap between REM sleep and waking experience. I conceptualize sleep paralysis as a variant of an intensified nightmare that appears to the subject to take place in the waking environment. Seen as a fundamental dream (and not hallucination) experience, sleep paralysis can be approached as an opportunity to elucidate some fundamental features of dream formation by virtue of its unique combination of dream mentation and reflective self-awareness. Existing and potential treatment strategies are outlined in the last part of the chapter.

Sleep paralysis is a relatively common sleep phenomenon, but due to general lack of awareness and possible cultural differences, its prevalence is hard to estimate. Reported prevalence rates in the literature fluctuate between 1.5% and nearly 100% (Sharpless & Barber, 2011). In many cases sleep paralysis experiences are reported as a kind of a dream/nightmare, but in others as a paranormal experience that might not be disclosed because of cultural interpretations that carry biases or even stigma, e.g., the *Old Hag phenomenon* thought by many in Newfoundland to signify that one is a cuckold. Sleep paralysis may be accompanied by dream imagery that is experienced as a realistic, often occurring in the context of one's actual bedroom and with accompanying wake-like cognitions. Dream mentation can be in any sensory modality, including visual, auditory and tactile (Cheyne, 2005; Cheyne, Newby-Clark, & Rueffer, 1999; Cheyne, Rueffer, et al., 1999) Most research focuses on sleep paralysis episodes that are accompanied by fear and vivid experiences of felt presence, the distinct sensation that someone sentient (human or non-human) is present in the close extracorporeal space of the dreamer (Cheyne, Newby-Clark, et al., 1999). These experiences are known in some cultures as instances of supernatural assault, or *Incubus*, and are often described as demons (Fukuda et al., 2000), ghosts (Hinton, Pich, Chhean, & Pollack, 2005), witches (Hufford, 1989) or aliens

(McNally & Clancy, 2005). Not all sleep paralysis experiences, however, are negative in affective tone, but the prevalence of positive experiences is unknown, likely because they are underreported. Some neutral or positive sleep paralysis experiences involve unusual somatic sensations, such as feelings of tingling, erotic arousal or passing out-of-body, and felt presence is sometimes experienced as a mystical or transcendental epiphany of deceased relatives or benevolent supernatural beings.

In this chapter, I describe the neurophenomenological associations between the physical basis of sleep paralysis (REM sleep paralysis/atonia, vivid dream mentation, shallow and irregular breathing pattern) and its experiential qualities, including especially felt presence and bodily sensations and cultural grounding. The latter may decrease or increase sleep paralysis -related distress, depending on the nature of the predominant cultural interpretation of the experience as well as on the perceived efficacy of folk remedies. While there is a relatively strong association between sleep paralysis and trauma, it is possible that these links are due to an underlying reactivity factor, such as an affect distress trait (Cheyne & Pennycook, 2013; Levin & Fireman, 2002; Nielsen, 2007; Solomonova et al., 2007), an environmental sensitivity trait (Carr, 2016), or a history of early adversity (Nielsen, 2017b) – all of which may predispose an individual to intensified negative oneiric experiences.

The following two aspects of sleep paralysis merit further discussion in light of the objectives of the present dissertation: 1) the relationship between felt presence and embodied mind, especially through the lens of enactivism and phenomenology; and 2) possible avenues for treatment and making sense of sleep paralysis using body-based interventions. I argue that felt presence is best understood as an expression of a basic, albeit anomalous, social and spatial imagery mechanism, and that body-based contemplative practices may be beneficial in treating and managing sleep paralysis experiences. These aspects of sleep paralysis are considered in more detail in the following sections.

6.2.2. Embodiment and felt presence experiences: the sense of space

Sleep paralysis experiences accompanied by felt presence are of particular interest to enactive and embodied cognitive science due to their particular entanglement in body, space and intersubjective alterations. The felt presence has been conceptualized as a paranoid hallucination, brought about by feeling of paralysis, which, in turn, creates a sense of panic and then conjures up the object of the threat in form of a hallucinated menacing entity (Cheyne & Girard, 2007). This idea has been challenged, and an alternative view proposed that sleep paralysis -related felt presence experiences are manifestations of spatial social imagery (Nielsen, 2007; Solomonova et al., 2008).

According to Cheyne and Girard (2007), felt presence experiences are activated by the general vigilance system. When an individual awakens in a physical state of paralysis, feelings of being unable to move or speak and a general sense of helplessness and oppression generate a hypervigilant state and create an over-interpretation of ambiguous stimuli as a menacing other. Nielsen (2007) challenges this fear- and delusion-based genesis of felt presence and proposes that threat-activation and fear may represent a specific pattern of reactivity proper to susceptible individuals, especially those with a previous history of trauma or suffering from recurrent nightmare. Whereas Cheyne and Girard consider threat and fear to be primary sleep paralysis experiences that give rise to presence, Nielsen considers felt presence to be the primary experience, which may trigger fear and affective distress, depending on the nature of the experience and the individual's predispositions.

In fact, felt presence experiences are not exclusive to sleep paralysis or psychosis. Otto referred to presence experience as the "numinous", which is a cornerstone of all religious experience (Otto, 1958). In fact, presence experiences are likely not an all-or-nothing phenomenon, but a continuum on which the world is perceived as animate to varying degrees. Some examples are the anthropomorphic animistic experiences of children's play (Piaget, 2013), feeling the presence of God (Luhrmann, 2012), or even subtler everyday attributions, such as attaching an anthropomorphic meaning to particular objects or feeling the artist's presence in a work of art. Perhaps surprisingly, this aliveness of the environment and objects is only rarely at the center of systematic inquiry. This lack reflects what Weber referred to as the "disenchantment of the world" in modernity (Weber, 1993), a way in which the modern rational person rejects all relationship with animism or magic. Thus, spiritual, supernatural or any other experiences that do not fit into a clear materialist story, are often simply classified away as disorders or delegated to the domain of art or literature.

Distinct, impactful, felt presence experiences may also arise under ambiguous or extraordinary conditions in non-clinical populations. These include a variety of situations of extreme isolation or stress, such as solitary sailing, sensory deprivation (Suedfeld & Vernon, 1964), effects of certain drugs, epileptic auras (Landtblom, 2006), post-partum dream-enacting behaviours (Nielsen & Paquette, 2007), mystical epiphanies, bereavement visions of deceased relatives (Steffen & Coyle, 2010) and even art installations designed to evoke presence (Solomonova et al., 2011). In fact, with our installation at Concordia University's Topological Media Lab, we were able to induce felt presence experiences in a group of healthy undergraduate art students using multimedia stimuli that were designed to reproduce sensory elements often associated with sleep paralysis: e.g., electric or human sounds, dim lights, shadows in the peripheral vision, or sensations of being observed (Frantova, Solomonova, & Sutton, 2011). One of the most striking effects of this experience was that participants were able to localize where exactly they felt a presence, so the experience was simultaneously of a spatial and social nature.

Why would alterations in the sense of one's own body bring forth alterations in the sense of space and, especially, facilitate presence experiences? Within the embodied mind framework (including phenomenology and more recent cognitive science approaches), the mind is not only bodily or incarnate, but it is also fundamentally intersubjective. Maclaren, for instance, has argued that embodied perception of (animate) others is a precondition for a fully embodied self-perception and for the development of selfhood in more general terms (Maclaren, 2008). One line of research within the enactive paradigm concerns social and interpersonal spheres (Cuffari, Di Paolo, & De Jaegher, 2015); De Jaegher and Di Paolo (2007) extend the concepts of enactive cognition into the domain of the interpersonal, face-to-face interaction and introduce the notion of 'participatory sense-making', which involves shared creation of meaning in language, culture, and embodied interactive social norms. In other words, meaning of experience is always a shared one. Subjectivity, then, is not only negotiated within a system of an individual body and world, but also within a social context, in concordance with others. Felt presence, then, is an imaginal manifestation of this fundamental structuring principle of human embodiment.

In cognitive science, surprisingly little attention is paid to the sense of space. Much research concerns specific elements of environmental perception, such as depth, form, color, movement of objects, etc., but very little concerns how spatiality is experienced as a whole and how it is influenced by changes in an agent's state, such as changes in mood, disease or disability. Phenomenology, however, provides some important insights into the sense of space and how its experience is articulated in an embodied subject.

Space has been proposed to be a fundamental precondition of an embodied meaningful experience (Merleau-Ponty, 2012; Morris, 2004). Felt presence experiences illustrate a tripartite way of participating in the world though the body as a "subject of space" (Merleau-Ponty, 2012: 261), i.e., as a locus for sense-making and a possibility for transcending an enclosed subjectivity through others as a "certain 'view' of the world". In other words, subjective experience always has a minimal perspectival self, it is a view that exists for someone and from somewhere (Gallagher & Zahavi, 2012), this position is consistent with Windt's immersive spatiotemporal model of dreams (Windt, 2010). Additionally, the body allows for meaningful interaction with the world, in part due to its spatiality and somatosensory entanglement with the environment and, finally, intercorporeal subjectivity, an ability to resonate with experiences of others via sensorimotor empathy (Chemero, 2016; Thompson, 2001).

Space and its objects and bodies form a "habitat" (Merleau-Ponty, 2012: 260) for the perceiving subject and is made animate simply by his/her own relational and moving presence within it. One of the more radical claims in Merleau-Ponty's account is that even the sense of space is not fully imposed, as a pre-given objective world, on a passive perceiver, but rather is labile and can change under certain circumstances that affect one's manner of perceiving. Sense of space, then, is a fundamental unsurpassable condition, an ontology to human existence and ways of thinking: it is always "already there" and it is pre-reflective. However, its unsurpassable nature is not an a priori of our species in a ready-made world, but unfolds within a temporality of a thick and opaque lived experience, and is deeply entangled with our attitudes and ways of gearing towards the world; sense of space expresses a "certain *hold* my body has on the world" (Merleau-Ponty, 2012: 261).

Space can be experienced differently depending on both physical conditions of the subject, such as wearing glasses or headphones, and also on mental states and moods, such as when one is ill or depressed. By virtue of our experience of the world being relational, even the most familiar space, such as home, can be felt in different ways, contingent on our state and affective reactions. In his discussion of depth perception, Morris writes: “The ordinary depths of the world are transformed (...) by the mood of my relation to the world. When the buoyant dimensions of life are collapsed in a mood of despair, despair worms outward into the ordinary depths of the world, collapsing them too” (Morris, 2004: 18). It is in sudden alterations of the habitual ways of perceiving space that it becomes subjectively evident that the sense of space is dynamic and lived instead of fixed and geometrical. Consider the following example: one may perceive one’s home or city in a certain habitual way, but should one suddenly be afflicted by physical limitations, such as being bound to a wheelchair, one’s experience the very same space may change. Stairs become inaccessible, losing their grip as affordances, streets with steep elevation appear higher and more difficult to navigate. Physical limitations affecting the subject have been transposed so as to change one’s perception of one’s home space. Similarly, in post-traumatic stress disorder sufferers, hypervigilance and attentional bias change the very way they attend to their environments, and these changes are evident in perception, behaviours and even lower-level mechanisms such as gaze fixation or pupil size (Kimble et al., 2014).

Felt presence experiences in general, and those associated with SP in particular, provide an invaluable opportunity to investigate how the perception of the environment changes when the body is effectively paralyzed. Under normal circumstances, one is able to act upon, explore and use orienting movements to situate oneself in one’s environment. SP provides a unique situation in which the environment is experienced differently, likely due to the unexpected experience of immobility.

In his discussion of the space of the night, Merleau-Ponty argues that even in darkness, in apparent absence of “anchorage points”, the body “sketches out a spatiality without things” (Merleau-Ponty, 2012: 296). One can argue that there can be no spaceless way of being by virtue of the dimensionality and orientations stretching out in all directions from our own physical situated body. If, according to the phenomenological approach and to the notion of intentionality, all consciousness is always a consciousness of something, then perhaps all consciousness is also a consciousness of *somewhere*, and in some relational stance. While the sense of space makes use of all available senses, it has its own internal dynamic, within which the experiences of felt presence could be understood as fundamentally spatial social experiences.

6.2.3. Embodiment and sleep paralysis treatment

Conceptualizing sleep paralysis as a variant of a dream or a nightmare, and framing felt presences not as delusional and paranoid hallucinations, but as manifestations of basic qualities of spatial and social perception, altered by dreamlike mentation, allows for a variety of prevention and disruption methods. Many traditional ritualized treatments of sleep paralysis exist, and these are specifically designed to appease malevolent spirits and supernatural threatening presences. In a contemporary secular context, the first systematic treatment strategy for sleep paralysis was proposed by Sharpless and Doghramji (Sharpless, 2016; Sharpless & Doghramji, 2015). It consists of a structured short-term cognitive-behavioral therapy and is based on combining existing treatment strategies for insomnia with specific recommendations for relaxation and episode disruption. In addition, a recently published study of two cases (Jalal, 2016), successfully used relaxation and a simple meditation technique to alleviate sleep paralysis.

An additional strategy that may be helpful in alleviating sleep paralysis -related distress, is one that would make use of sleep paralysis' unique combination of physiological and experiential qualities. sleep paralysis provides a window into how experiences supported by REM sleep (muscle paralysis, vivid spontaneous imagery) are integrated into a relatively awake consciousness. Since not all sleep paralysis experiences are characterized by fear and distress, not all SP may be considered as an undesirable experience, and some sleep paralysis episodes, especially ones that involve unusual physical sensations, out-of-body experiences or mystical/transcendental experiences, may be rather attractive as a unique source of insight. Dreams and visions are often cultivated for reasons of personal growth or creativity (Garfield, 1995; Wallace, 2012) and if sleep paralysis is regarded as a variant of intensified dreaming, it needs not be seen as a clinically negative symptom. Sleep paralysis, when it is accompanied by distress, however, may be seen as a form of an intensified nightmare and existing nightmare interventions, such as Imagery Rehearsal Therapy (Krakow, Kellner, Pathak, & Lambert, 1995; Krakow & Zadra, 2006; Thunker & Pietrowsky, 2012) or lucid dreaming (Mota-Rolim & Araujo, 2013; Spoormaker & van den Bout, 2006; Zadra & Pihl, 1997) might be effective.

While clinical intervention strategies for sleep paralysis are rare and largely unknown, in popular culture, and especially in Internet-mediated communities, sleep paralysis has been used for many years as an entry point into lucid dreaming (Hurd, 2010). In fact, these lucid dreaming techniques, often make use of the relationship between physical and bodily experiences, visions, and sense of presence in order to transform the experience from negative and frightening into either neutral/positive or into a lucid dream. This apparent disconnect between popular practices of dealing with sleep paralysis and sleep science is likely due to the general naturalistic bias against engaging with any phenomena that appear religious or mystical/spiritual/New Age (Slife & Reber, 2009). A systematic study of these approaches from the phenomenological standpoint can be beneficial in formulating appropriate and nuanced treatment strategies for fearful and distressing sleep paralysis.

In addition to working with sleep paralysis imagery, contemplative practices may be beneficial not only in treatment of sleep paralysis but also in gaining insight into the phenomenal qualities of sleep paralysis -related bodily and felt presence experiences. Some of the beneficial effects of meditation include emotion regulation and the amelioration of anxiety; the latter are known to exacerbate the negative components of SP. The fact that many meditation methods teach practitioner to face negative experiences (e.g., negative emotions, unpleasant sensations) and approach them without judgement (Goenka, 1997; Santorelli, 2000) corresponds well with the proposal that meditation acts on the brain networks that underlie fear extinction (Holzel, Lazar, et al., 2011). Finally, by working on the level of bodily and interoceptive awareness (Kerr et al., 2013; Schmalzl et al., 2014), meditation may be particularly instrumental in alleviating distress and promoting non-judgmental awareness of the somatic and kinesthetic components of sleep paralysis experiences.

6.3. An empirical study of embodied sleep, memory and dreaming in meditation practitioners and non-meditating controls

The empirical study investigated the overarching embodied cognition hypothesis in the context of sleep, dream content and learning among meditation practitioners and non-meditating controls. In this work, we tested the following 3 hypotheses: 1) that Vipassana meditators will have higher levels of bodily awareness than controls; 2) that meditators will perform better on a procedural learning task, and 3) that meditators and controls will show different sleep-dependent patterns of memory consolidation. In addition, I report here on findings from 2 additional hypotheses that were examined but have not yet been submitted for publication: 4) that meditators will have longer, more positive, more pro-social and more lucid dreams than controls, and 5) that somatosensory stimulation in sleep will produce direct and indirect changes in dream content in both groups. The embodied mind hypothesis is thus tested on the following five levels: 1) as an expression of a particular cognitive skill, in this case, heightened interoceptive/bodily awareness cultivated by Vipassana meditation practice; 2) as a function of procedural learning; 3) as an expression of large-scale changes in brain plasticity, reflected in sleep-dependent patterns of procedural memory consolidation; 4) in differences in dream content between meditation practitioners and non-meditating controls; and 5) in patterns of incorporation of somatosensory stimulation during sleep into dream content. Research questions 1-3 are presented in Article III; and preliminary results for questions 4-5 are examined in sections 6.3.7 and 6.3.8 of the present Discussion.

6.3.1. Summary of findings

Our empirical project (Article III and this Discussion section) is the first study to comparatively assess sleep-dependent procedural memory processes and dream content in Vipassana meditation practitioners and non-meditating controls. The guiding idea was that the practice of learning to pay attention to one's body sensations would change how somatosensory stimuli are perceived and processed and thus influence waking performance, sleep-dependent memory and dream content. In this dissertation, I report the following 6 sets of findings:

1) Meditators performed initially slightly better at a procedural balance task than did non-meditating controls. However, these differences only occurred at the onset of the task and there were no differences in the way the two groups improved following the daytime nap.

2) Meditators and controls showed distinct patterns of relationship between sleep characteristics and improvement on the procedural balance task. Specifically, meditators showed a strong relationship between improvement and occipital sleep spindles in NREM sleep, while controls exhibited a relationship between improvement on the task and REM sleep duration. Thus, we found support for our main hypothesis that Vipassana meditation may change processes of procedural learning consolidation in sleep.

3) An unexpected finding regarding sleep characteristics in Vipassana meditation practitioners: meditators had fewer sleep spindles (especially in occipital derivations) than did non-meditating controls. This finding was counterintuitive because spindles are considered to be markers of neuroplasticity and to protect against cognitive decline. We discuss these findings in light of a speculative idea that daytime meditation practice takes over some of the neurocognitive functions of sleep.

4) With regards to dream incorporations and memory, meditators did not incorporate the procedural balance task more than did controls and the relationship between task performance and dream incorporation was very weak in both groups. For control participants, a marginally significant positive correlation was found between task performance and incorporation of the task into REM/N2 dreams, and a negative trend was found between dreaming about the task at sleep onset and improvement on the task performance. Vipassana meditators showed no relationship between incorporation of the task elements into dream content and task performance.

5) There were very few differences between Vipassana meditators and controls with respect to general characteristics of dream content. Meditators had marginally longer dream reports and friendlier and marginally more compassionate interactions with other dream

characters. No group differences were found on measures of dream emotion, dream locus of control or dream lucidity.

6) The somatosensory incorporation experiment was partly successful. Inflating the pressure cuff at sleep onset and during REM sleep produced a variety of changes in dream content; most of these were indirect incorporations which were nonetheless traceable in a metaphorical/associative way.

6.3.2. Meditators score higher on bodily awareness

In the study, we used the Scale of Body Connection questionnaire (Price & Thompson, 2007) to assess whether Vipassana meditation practitioners had heightened bodily awareness compared with controls. Our prediction was supported and justified treating our meditation group as an 'expert' sample with an increased capacity for recognizing somatic sensations and physical states. Recent research, however, underscores that interoceptive awareness is a multidimensional concept with many facets, only one of which is awareness of bodily sensations (Bornemann et al., 2014; Daubenmier et al., 2013; Mehling et al., 2011). A recent study (Bornemann et al., 2014) showed that interoceptive awareness has at least eight different components: noticing; not-distracting (staying with discomfort); not-worrying (not experiencing distress with discomfort); attention regulation (maintaining attention on bodily sensations); emotional awareness (making links between bodily and emotional states); self-regulation (minimizing distress by attending to body); body listening (noticing bodily states for insight); trusting (experiencing body as safe). Thus, interoceptive awareness and explicit connection to one's own body experience may not be completely synonymous with measures of bodily awareness and body dissociation as measured by the Scale of Body Connection. For the purposes of the present study, however, this measure was taken as an indication of a generally higher capacity for a more explicit knowledge of bodily states.

6.3.3. Modest advantage for procedural balance learning in meditators

One of our hypotheses for the study was that Vipassana meditators would perform better than controls on a procedural balance task. This hypothesis was partially supported:

meditators performed slightly better than controls initially: they had higher initial scores and finished the task more often. However, both groups improved to similar degrees after the nap and there were no differences on the magnitude of this improvement. This initial learning boost may be explained by Vipassana practice and by the fact that the meditators appeared to complete the game more often than controls, i.e. meditators were possibly more patient and thus "burst" the bubble less often. Since meditation requires a high degree of self-discipline, some studies have reported increased self-control and frustration tolerance in meditation practitioners (Leach, Francis, & Ziaian, 2014; Rosaen & Benn, 2006). These qualities may have facilitated initial task learning in practitioners. Additionally, scores on bodily awareness in the meditation group correlated positively with performance on the procedural task, further strengthening the claim that improved somatosensory awareness, achieved by meditation practice, may translate into a more generalized cognitive skill, such as an overall ease of relationship to learning that requires full-body awareness, such as, in our case, a Wii Fit balance game. A recent study, for example, shows that motor imagery is enhanced in yoga practitioners (Hartnoll & Punt, 2017), suggesting that somatosensory and movement-based expertise may extend into the larger domains of motor learning, perception and, possibly, imagination.

While an engaging postural balance task requiring using the whole body to obtain a goal is intuitively suitable to study procedural learning, it is unclear whether a relatively short interval of practice on the task succeeds in tapping into the procedural ("*how to*") process of habit formation. Further research into procedural and motor learning involving full body and balance tasks is required to clarify to what extent balance can be considered a procedural trainable skill, and what its relationship is to other kinds of motor learning, such as hand-eye coordination tasks or novel skill acquisition.

6.3.4. Different learning styles in meditators and controls

The most novel aspect of the study is the finding that meditators and controls show very distinct patterns of relationship between sleep characteristics and measures of post-nap improvement in performance on the procedural balance task. Thus, the primary hypothesis of the study was supported and gives credence to the notion that meditation fosters a different neurobiological learning style that extends into initial procedural learning (meditators performed slightly better than controls on the pre-sleep, initial learning task) and, more importantly, into sleep-dependent processes of memory consolidation. These differences were evident in the relationship between sleep architecture (sleep stages, sleep spindles) and task scores. More specifically, improvement on the procedural balance task was associated with density of occipital sleep spindles in N2 sleep for meditators, but not for controls. On the other hand, REM sleep duration was associated with improvement on the task for control participants, but not for meditators.

In addition, this study was the first to use a whole-body task to study procedural memory consolidation in sleep. Most tasks that study procedural and motor memory involve hand-eye coordination (for example a mirror tracing task or rotor pursuit) or hand/finger motion (for example finger tapping task). Only rarely has procedural memory been studied using paradigms that involve the whole-body movement. Some examples include a series of studies in which a novel motor skill, in this case jumping on a trampoline, was associated with increased REM sleep (Buchegger, Fritsch, Meier-Koll, & Riehle, 1991; Buchegger & Meier-Koll, 1988). Our results partially replicate these findings to the extent that improvement on our procedural balance task was associated with length of REM sleep during the daytime nap for control participants only.

We suggest that these differences in sleep-dependent procedural memory for a balance task between the two groups can be explained by at least two possible accounts. First, is the idea that initial skill level (Carlyle T Smith et al., 2004) of participants, as reflected by higher learning scores before sleep, is important in determining whether a task will be treated as REM-dependent (for low proficiency individuals) or as N2-dependent (for those who are initially better at the task).N2 sleep spindles have been associated with declarative memory consolidation (Schabus et al., 2004; Tamminen, Lambon Ralph, & Lewis, 2013; Tamminen et al., 2010; Weber, Wang, Born, & Inostroza, 2014).

The second, more speculative interpretation of these findings relies on the idea that there may be a strong link between meditation and sleep. One study reported that in individuals who have a habit of taking daytime naps, motor learning is associated with N2 sleep spindles (Milner, Fogel, & Cote, 2006), while in those who do not typically take naps that relationship was not observed. In our sample, we did not collect information about napping habits, but there is anecdotal evidence that meditation practitioners commonly fall asleep for very short periods during practice (Pagano, Rose, Stivers, & Warrenburg, 1976). Thus, meditation practitioners may be seen as a subgroup of "habitual nappers", which would be consistent with the Milner et al (2006) findings.

It is also possible that meditators treated the procedural task, which is an implicit memory task, in a more "explicit" manner, thus shifting from REM sleep to N2 sleep sleep-dependent consolidation mechanisms, specifically to N2 sleep spindles. In general terms, meditation practices are thought to de-automatize normally unconscious (or implicit) processes (Kang et al., 2012) by bringing them, to a certain extent, to conscious awareness. This may not only increase insight into individual patterns of reactivity and change one's relationship with outside stimuli, but also is likely to bring about large-scale changes in brain connectivity (Brewer et al., 2011; Fox et al., 2016). Further, networks associated with interoceptive awareness are also known to be involved in other perceptual and cognitive skills (Farb, Segal, & Anderson, 2013).

Overall, the idea that meditation would change one's perceptual, learning and memory consolidation style is consistent with research on meditation and neuroplasticity (Hasenkamp & Barsalou, 2012) and with traditional Buddhist teachings, including Vipassana theory and practice (Goenka, 1997; Hart, 1987). Our study is the first to show that Vipassana practitioners show a markedly different association between learning of a procedural balance task and sleep architecture during a daytime nap. It is unclear why sleep spindles, especially slow occipital sleep spindles, correlated positively with the improvement on the task in meditators but not in controls, although the association between slow spindles and learning has previously been reported (Schmidt et al., 2006).

6.3.5. Overlapping roles of sleep and meditation in memory and other cognitive functions

Our study did not replicate earlier research showing differences in REM or SWS duration between meditation practitioners and controls (Maruthai et al, 2016; Pattanashetty et al, 2009; Sulekha et al, 2006). We did, however, partially replicate some work showing less sleep among meditators (Kaul et al, 2010) in that our meditators tended to have lower overall sleep time. Additionally, in our cohort 2 meditators (out of 22 recruited) did not sleep at all during their 2-hour opportunity (those participants were excluded from the analyses) whereas all 20 control participants had some amount of sleep. This finding is consistent with findings showing that meditators sometimes require less sleep and may have a lower sleep propensity, especially at more advanced levels of practice (Kornfield, 1979; Lutz et al., 2008).

The only significant group difference in sleep architecture that we found was in the density of N2 sleep spindles. Meditators showed reduced sleep spindles density, particularly in occipital derivations. This finding was unexpected because reductions in sleep spindles have been associated with neurodegeneration (Christensen et al., 2015; Latreille et al., 2015) and psychopathology (Schilling et al., 2016), while meditation has been hypothesized to protect against both cognitive decline (Gard et al., 2014) and psychopathology (Shonin, Van Gordon, Compare, Zangeneh, & Griffiths, 2015).

These findings, together with the previously described relation to a possible “napping” profile in meditators, point to an intriguing speculative idea that daytime meditation may take over some of the functions of sleep or even be a sleep-like state in some respects and thus reduce overall need for sleep and alter sleep architecture. A number of parallels between meditation and sleep point to this idea. First, it is often reported that meditators require less sleep, especially in advanced stages of practice or during intensive meditation retreats (Britton et al., 2014; Kornfield, 1979). In the very few laboratory studies of sleep in meditators, less sleep time, lighter sleep, more awakenings and less SWS were reported pointing to the possibility of reduced homeostatic pressure in meditators. Additionally, one study reported that meditation improves psychomotor vigilance after sleep deprivation (Prashant, Passafiume, Sargent, & O'Hara, 2010), suggesting that meditation may be beneficial in counteracting at least some effects of sleep deprivation Second, meditation is well-documented to induce alpha and theta states (Aftanas & Golosheykin, 2005; Cahn et al., 2010; Cahn & Polich, 2006; Hebert & Lehmann, 1977; Slagter, Lutz, Greischar, Nieuwenhuis, & Davidson, 2009). Theta activity is the predominant frequency that characterizes sleep onset/N1 sleep (Hori, 1985). There is some disagreement in the literature regarding whether N1 sleep is a true sleep state or is a transitional period between wakefulness and sleep. Nonetheless, even very short naps (approximately 6 minutes) are beneficial for memory processing (Lahl, Wispel, Willigens, & Pietrowsky, 2008). Such naps likely contain a high proportion of N1 sleep.

Finally, the mechanisms by which daytime meditation may take over some sleep functions are likely to depend on the kind of meditation and the level of expertise of the practitioner. As discussed in the Introduction, at early stages the meditation may be effortful and taxing, while as the practitioner advances in their practice, ease and clarity of experience increase, making the outcome more likely to be a restful state (Lutz et al., 2015). Results of the present study, especially differences between meditators and controls in the density of sleep spindles and the relationship between these spindles and learning suggest that Vipassana practice in particular may be related to spindle mechanisms and function. It is possible that the reduced spindle density in our meditator group reflects larger neuroplastic changes associated with this form of meditation.

Some of the mechanisms by which meditation may take over some sleep functions may be explained by examining brain plasticity. It is possible that meditation produces spindle-like brain activity during wake transitions into sleep, thus enabling activation of large-scale neural mechanisms underlying interoceptive awareness, skill and habit formation (Farb et al., 2013; Holzel et al., 2008). These networks are known to be activated in meditators and may contribute to a general reorganization of brain reactivity to stimuli, of learning styles and of sleep need. Brain synchronization mechanisms have been proposed to be a marker of neuroplasticity, reflecting processes of strengthening of neuronal connections and creation of new, experience-dependent, networks (Engel, Fries, & Singer, 2001). These processes were shown to have a strong top-down attentional component (Steinmetz et al., 2000). Long-term meditation practitioners generate long-distance phase-synchrony during a compassion meditation practice, and express EEG signatures different from those of controls during both active meditation and the resting state (Lutz, Greischar, Rawlings, Ricard, & Davidson, 2004). This long-distance synchrony has been proposed to be a marker of cognitive integration (Lachaux, Rodriguez, Martinerie, & Varela, 1999; Varela, Lachaux, Rodriguez, & Martinerie, 2001), and alterations in neural synchrony patterns can be seen as markers of psychopathology (Uhlhaas & Singer, 2006). Sleep spindles involve synchronization on the level of thalamo-cortical communication in NREM sleep (Steriade & Amzica, 2003). Recently, slow spindles were reported to be associated with brain synchrony over longer circuits, and faster spindles with more local connectivity (Zerouali et al., 2014). Thus, involvement of slow sleep spindles in procedural memory consolidation in meditators may reflect large-scale reorganization of brain connectivity—perhaps an increased efficiency of these networks—which may positively affect many cognitive skills, including memory.

Meditation practitioners, therefore, may develop a trait-like neurophysiological profile that involves both daytime and sleep changes. This trait may be similar to that of individuals with high dream recall: in a recent study, we showed that increased fast but decreased slow sleep spindles correlate with dream recall frequency (Nielsen et al., 2016). Dream recall frequency is a measure linked with higher reactivity to auditory stimuli both in wake and during sleep (Eichenlaub, Bertrand, Morlet, & Ruby, 2014), and with increased activity in the temporoparietal junction and medial prefrontal cortex – areas typically associated with attention and memory (Eichenlaub, Nicolas, et al., 2014). The latter finding is consistent with observations in our current study: all our participants had high dream recall, and meditators had fewer slow sleep spindles than did non-meditating controls, possibly reflecting their increased alertness in sleep.

Further research is needed to clarify how sleep reacts to different kinds of meditation practice (both in school of meditation and in proficiency in the skill) and how different practices are related to cognitive functions typically associated with sleep: memory, emotion regulation, vigilance, etcetera. According to the results of the current study, one candidate sleep phenomenon that deserves further attention is the sleep spindle and its relationship to learning and memory.

6.3.6. Dream content and memory consolidation: mixed results

Our study provides limited support for a hypothesis that dreaming of a procedural task is related to learning. Both meditators and controls incorporated elements from the balance task and the laboratory into dream content to the same extent and no statistically significant relationship was found between performance on the task and dream content for Vipassana meditators. In the control group, however, a modest relationship was found between post-sleep improvement on the task and dream content: participants who incorporated elements from either the task or the laboratory visit into their REM/N2 sleep dreams improved slightly more in the time spent in balance score than those who did not incorporate any study elements into dreams. Further, control participants who incorporated task or laboratory elements into their dreams at sleep onset showed less improvement on the time spent in balance score.

As discussed in the Introduction (sections 1.3.3 and 1.4.3.2), current research on the role of dreams in cognitive processes has identified three interrelated key areas: memory consolidation, emotion regulation, and associativity. While a role for sleep in memory consolidation is now rarely challenged, the place of dreaming in this process remains unclear. Research focusing on the neural correlates of consciousness (Koch, Massimini, Boly, & Tononi, 2016; Siclari et al., 2017) often regards mental activity, including dreams, as epiphenomenal to underlying brain processes (Hobson et al., 2000). Within such views, dreaming might be tightly linked to functions of the underlying brain state, primarily REM sleep, and would represent, in the form of imagery neural replay (Hobson & Pace-Schott, 2002; Louie & Wilson, 2001; Wamsley, Perry, et al., 2010), newly learned information that would then correlate with learning. Contrary to this hypothesis, however, dreams do not normally replay waking events in their entirety (Fosse et al., 2003; Malinowski & Horton, 2014); rather, they tend to remix various elements from lived experience with semantic, affective and other elements in novel ways.

I suggest two possible interpretations of our limited results for dream incorporation. First, since complete replays of experiences are rare in dreams and considering that dreams often bind together memory sources that come from temporally recent and distant experiences, it is likely that dream content, per se, is not causally related to memory consolidation, i.e., to the strengthening of connections between elements of experience, thus ensuring that memory is stored as a separate experience. Rather, dreams likely play a role in integrating new experiences with existing autobiographical networks, i.e., ensuring the flexibility of the memory system. Dreams thus may help make sense of new memories by creating new associatively-linked experiences (Carr & Nielsen, 2015; Hartmann, 1996; Horton & Malinowski, 2015; Stickgold, 2005; Stickgold & Walker, 2004; Walker & Stickgold, 2010).

Second, the lack of association between task and laboratory dream incorporations and learning, and a marginally negative relationship between hypnagogic dream incorporations and learning in control participants is consistent with the notion that dreaming may impede memory consolidation. Or, at the very least, it is possible that not dreaming of a task facilitates learning more than does dreaming of the task. This may be especially true for learning a procedural balance skill. I speculate that, in case of learning a procedural balance task, dream incorporations may have an effect similar to the phenomenon of verbal overshadowing (Finger & Pezdek, 1999; Schooler, 2014; Schooler & Engstler-Schooler, 1990). This refers to the possibility that to learn new information, especially if the task is of implicit nature and not easily described in words, it is necessary to not think about or verbalize about it. In other words, explicitly activating newly learned memory traces may harm unconscious processes of memory consolidation. For example, in a study of skilled golfers (Flegal & Anderson, 2008), describing how to play impaired the golfers' ability to perform. The authors suggest that overthinking procedural knowledge creates a competition between procedural and declarative memory and impairs both performance and memory. Similarly, in novice golfers, explicitly rehearsing newly learned skills did not improve and, to an extent, even impaired subsequent performance (Chauvel, Maquestiaux, Ruthruff, Didierjean, & Hartley, 2013).

In sum, a weak and mixed relationship was found between dream content and improvement on a procedural balance task, and this only for control participants. I suggest that dream content likely does not represent underlying REM- or N2-dependent processes of memory consolidation, but rather may act in an associative manner, incorporating new experiences into existing memory networks. Further, we hypothesize that dreaming of a procedural task may not be beneficial for its consolidation and might even interfere with consolidation in some situations. It is plausible that some procedural processes need to take place without conscious representations such as dreaming in order to be properly integrated.

6.3.7. Effects of somatosensory stimulation on dream content

Article III does not include results from the somatosensory stimulation protocol used in this study. While in previous work (Nielsen, 1993), somatosensory stimulation administered by slowly inflating a blood pressure cuff on the leg produced a number of body imagery effects, it proved more difficult to apply in our nap study. Some participants (N=12) did not enter REM within the 1.5-hour window of sleep, thus stimulation protocol was not implemented, and many (N=6) were awakened by the stimulation, possibly because daytime napping, due to reduced homeostatic pressure, is more fragile. Nonetheless, in this section I present examples of dreams containing likely incorporations of the somatosensory stimulus (see Table 3 for examples). I include participants from the study of procedural balance learning (meditators and controls) as well as some pilot participants who did not receive the procedural balance task, but who were administered the same somatosensory stimulation protocol at sleep onset and during REM sleep. These and other dream reports are being prepared for a future article; although systematic group comparisons have not been done, the select experiential reports are presented here to illustrate different ways in which sensory stimulation in sleep may alter the ongoing dream narrative.

Preliminary results are consistent in many respects with those from previous research (Nielsen, 1993, 2017a) in that most cases of stimulation did not produce overt dreams about pressure on the leg. As discussed in the Introduction, somatosensory stimulation during dreaming is almost never incorporated directly into dream content, rather it tends to produce a rich variety of abrupt changes in the ongoing dream narrative—many of these reflect changes in how the body acts and is represented in imagery. In our cohort, the following general themes related to somatosensory stimulation emerged: a strong sense of discontinuity in the dream narrative; intensified bodily experiences (flying, swimming with animals, being clumsy, running), sensations in the leg (electric shock, pressure cuff, pain, being grabbed by the ankle), projections of the pressure sensation in a metaphorical manner into the dream environment (taxidermy, being stuck in a gorilla costume).

Additionally, many dreams after somatosensory stimulation produced false awakenings and incorporations of other elements from the study, such as the experimenters, being in a hospital or being in the lab. False awakenings are dreams during which dreamers feel themselves to be awake, going about their usual morning routine until they notice that something is not quite right (Nielsen & Zadra, 2005). This realization may trigger a lucid dream (Holzinger, LaBerge, & Levitan, 2006) or the scenario may transition into a new dream. In our case, stimulation provoked false awakenings in at least five instances and triggered what might be considered partial false awakenings in that the dreams incorporated clear elements of the laboratory, the experimenter or the hospital.

The possibility that somatosensory stimulation may have evoked changes in the dream narrative either in body representations/sensations or in visual, auditory emotionally charged imagery or, is consistent with 1) previous work on stimulus incorporation, and 2) current theories of dream function.

1) The examples presented here illustrate that under certain conditions the dreamer is not entirely disconnected from the environment but is reactive to it in a manner which incorporates and contextualizes this new stimulus in the ongoing dream experience (Nielsen, 2017a). This process could be seen as reflecting multisensory integration (MSI) processes: the notion that experience is lived as unified and coherent despite consisting of stimuli from many different modalities. One MSI phenomenon that might explain somatosensory incorporations is that when two experiences from different sensory modalities (such as sound and image) coincide temporally, they are interpreted as coming from the same source and make up a meaningful event (Chen & Spence, 2017; Welch & Warren, 1980). In the current literature, evidence for both bottom-up (sensation creates meaning) and top-down (attention and goals contextualize sensations) approaches to MSI exist (Hartcher-O'Brien, Soto-Faraco, & Adam, 2017), suggesting that the mind has a tendency for an economical approach to perception, favoring a coherent whole over a multiplicity of simultaneous processes. Nielsen (2017a) proposes that known MSI factors

(percept timing, percept localization, percept intensity, and event change) can explain some of the effects of stimulus incorporation into dream content and provide a rich experimental framework for testing the limits of coherent sense-making processes under the conditions of stimuli intrusions in sleep and dreaming.

2) With regards to dream function, the present examples illustrate some of the key notions of the three main hypotheses of why we dream: memory consolidation, emotion processing, and associativity/creativity. In some cases, stimulation produced direct links to previous somatic memories (e.g. the sensation of a cat jumping off the ankle; #14) or prompted a direct incorporation of laboratory elements (e.g., pre-sleep lab experiences #7-12). In some examples (e.g., #1, 5, 6), stimulation produced an abrupt change in emotional tone, which is consistent with the idea that emotions are strongly linked to somatosensory experiences (Colombetti, 2009, 2013) and that dream content is structured around a central emotional image (Hartmann, 1996). Thus, a sudden change in bodily feeling, especially sudden sensations of discomfort, may produce a shift in the overall emotional tone of the dream or completely switch to another central image. Finally, the wide variety of changes associated with somatosensory stimulation attest to the associative nature of dreaming (Carr & Nielsen, 2015; Horton & Malinowski, 2015), wherein a change in one dimension of the bodily experience may progressively or abruptly lead to changes is dream content.

The following example (dream #2) illustrates how dreaming may integrate somatosensory stimulation in a variety of ways, from engaging pre-sleep memory sources, to metaphorically connecting pressure on the ankle with imagery of immobilized animals, to representing pressure sensations in one's own legs to projecting such sensations onto the body parts of other dream characters. "*I was in a room and I was being tested, kind of like the room I was in, except the door was open*": here, the initiation of stimulation appears to prompt incorporation of the lab. "*I was in a kind of museum*": gradually, since the participant did not wake up, his dream narrative adapts to the stimulation and continues. "*There was something with placing taxidermy animals in different positions and making them have a different face":* here the stimulation appears to color his dream experience, now in an associative manner with feelings of pressure on the ankle likely being experienced as a projection of immobility onto the dream environment. "*There was a place* *where we had to do exercise, and there was something about a broken leg…*": eventually, as stimulation reaches its peak intensity, dream imagery appears to be transformed into a representation of leg imagery—but still not of a first-person experience of the stimulation. "*Then I remember someone else having a broken rib";* finally, the image appears to be transformed yet again into a kind of a generalized idea of trauma, related to a completely different body part.

Table 3. REM sleep and sleep onset N1 dreams with incorporation of the somatosensory stimulation.

Dream #, Participant	Illustrative dream excerpt	Relation to stimulation
	REM dreams	
1. Male. Pilot study. CTL	*… I was in my parents' car … and a large marine animal approached me as if he knew me. It wanted to play with my purse and it bit me! I didn't want (it to continue) and I was saying Oh No!**	Discontinuity, sense of powerlessness, being suddenly attacked
2. Male. Pilot study. CTL	*At first I was flying… there were mountain tops everywhere, there was snow (…) then I found myself on a boat, it was stormy I was holding on to a prow, when the boat was tilting, I could touch the water (…). Suddenly, a dolphin took me and I was swimming on its back. Then I was in my childhood bedroom**	Discontinuities; sense of almost losing control, being taken away
3. Male. Pilot study. CTL	*I was in a room and I was being tested kind of like the room I was in except the door was open (…) I was in a kind of museum (…) There was something with placing taxidermy animals in different positions and making them have a different face... There was a part where we had to do exercise and there was something about a broken leg that would stop you from being able to do the task. Then I remember someone else having a broken rib but that the broken rib would not affect the task, you can still function with a broken rib.*	Discontinuities, incorporation of the lab, immobility, body alterations (taxidermy, broken leg and rib)
4. Female. Pilot study. CTL	*I was thinking about my father, then I felt an electric shock in my leg…**	Unusual leg sensation
5. Female. CTL	*I am at my parents' place… I am talking to my father (…) I am at my place in Montreal, I'm stepping outside with 13 ounces of strong liquor, I think I have to bring it to someone … I swallow a large quantity of alcohol. I am clumsy with my grocery bag… and I drop the alcohol on the ground, to my disappointment **	Discontinuities, unusual physical sensations, altered pattern of movement (clumsiness)
6. Female. CTL	*… I am at a secondary school. I'm playing a role of a teacher, and a fire alarm starts suddenly, I don't know why. It then suddenly stops, as if it were a drill. A second alarm sounds and so everyone runs out of school very fast, and we still don't know why…**	Discontinuities, sudden sound, running outside
7. Female. MED	*Liza was there to wake me up. She turned on the lights and asked me about my dreams. I was answering her. I could feel the pressure pump on my leg. She asked me what does it feel like, I said it feels like a hug. She said: "Doesn't it feel like someone pulling on your leg"?*	False awakening, experimenter asking about her experience

8. Male. MED	*I was in the bed for the testing, but I needed to use the washroom and get some water, but I kept getting lost. I found a washroom, and noticed the cuff was inflating too much, to a painful degree. I found my way back to Liza, she was with other technicians. You (Liza) assured me the cuff was fine and that I should get back to bed. I remember seeing the clock, it was 6:15 pm. (…) I went back to bed, somehow this transitioned into being in a linguistics class, where the lecturer was trying and failing to make a Halloween joke.*	False awakening, laboratory, bed, experimenter, pressure cuff, pain. Continued with another dream.
9. Female. CTL	*Dreamt that I had just awakened from sleeping, was asked to describe my dream about me in a first-person shooter video game. Then, a man wheeling a movable dumpster passed by. I was then walking with my colleagues at McGill talking about my experience in this study. Then my hands felt numb…*	False awakening, laboratory protocol, video game, unusual somatic sensation in hands
10. Male. MED	*I woke up due to pain in my arm, which I thought was coming from the electrodes. I left the room to find Liza or someone else, but no one I recognized was around. I walked into a hallway and found many children with disabilities playing there, supervised by adults. (…). A 17 year old with some sort of disability laid down on the floor in front of me and grabbed me by the ankles…*	False awakening, pain in arm, experimenter, disabilities, grabbed by ankle.
11. Male. CTL	*I was doing a check list of what I was supposed to take with me and I realized that I forgot the blood pressure cuff, and I was not really sure if it was mine ore belonged to the laboratory…*	Pressure cuff.
12. Female. CTL	*I wake up in my dream inside this lab because I want to go to the bathroom. Then Liza shows me a paper with the recording data of the session. (…) I see the video of my room, and I see myself sleeping, but there is a window behind me and my hand is up hanging out of the window in a very uncomfortable position.*	False awakening, laboratory, experimenter, experiment, unusual and uncomfortable arm sensations
	Sleep onset dreams	
13. Male. Pilot study. CTL	*I was in a mining town with people who were jumping, like on a drill. Then there was something like a Mario cart, a car race…**	Excessive movement, jumping
14. Female. Pilot study. CTL	*I felt the pressure from the cuff, and all of a sudden I thought about my cat jumping, because my cat sleeps all the time on my legs.**	Sensation of the pressure release on the leg, jumping
15. Male. CTL	*… I was not really thinking of anything but pieces of memory from my childhood came in my mind, and then I was thinking about the game I just played (…) I was going with the bubble through the river…*	Discontinuity, balance game
16. Female. CTL	*I was thinking of someone pulling off? a gorilla costume… and then at some point they try to take off its head, but it was blocked and wouldn't come off (…) they were not moving because they were stuck*	Unusual bodily movement projected onto another character, being stuck.

*translated from French; MED=Vipassana meditation practitioner, CTL=meditation-naïve control

In sum, examination of a set of stimulated dreams indicates that dream content is in fact sensitive to somatosensory stimulation and that it reacts to such stimulation in a number of ways. These reactions include abrupt changes in the dream narrative, in emotional tone and in bodily experience. In most cases, sensory incorporation is indirect and changes the ongoing dream in such a way as to accommodate the new sensations by making sense of them in the larger context of the dream. This process can be understood, in part, as due to processes of multisensory integration leading to a sense of a unified coherent experience. It is also consistent with the proposed functions of dreams, especially with the associative nature of dream mentation. The material presented suggests that classifying the ways in which dream content reacts to perturbations in the field of bodily sensations will help clarify the role of the sensing sleeping body in the processes of oneiric formation. Studying how alterations in body imagery change dream experiences may illuminate some of the ways in which waking state multisensory integration also participate in the maintenance of unity and coherence of the dream experience.

6.3.8. Dream content in meditators and non-meditators

Preliminary content analyses were conducted on sleep onset and REM/N2 dreams collected in the laboratory. I hypothesized that meditators would have longer and more detailed dream reports, due to their introspective capacities, that they would have more emotionally positive dreams, that they would show friendlier and more compassionate interactions with other dream characters by virtue of the practice of *metta* (loving-kindness/compassion) meditation, and that they would have more indications of lucid dreaming.

However, few differences were found between meditators and controls (see Table 4 for results). Meditators showed marginally longer REM/N2 dream reports than did controls and more friendly and marginally more compassionate interactions with other dream characters (see Figure 1). No group differences on these same measures were found for dreams collected at sleep onset.

Table 4. Dream attributes in REM/N2 in Vipassana meditators and controls

	MED Mean±SD	CTL Mean±SD	t	df	p
Total word count †	282.12±235.25	163.40±105.26	-1.799	30	0.082
Emotional content	5.00±1.00	5.07±.73	0.223	29	0.825
Locus of control	4.59±1.37	4.71±1.68	0.230	29	0.820
Friendly interactions *	5.71±1.38	4.43±1.01	-2.733	26	0.011
Compassionate interactions †	5.43±1.09	4.79±.70	-1.858	26	0.075
Lucid insight	.24±.66	.27±.59	0.140	30	0.890
Control	1.06±.66	1.20±.78	0.557	30	0.581
Logical Thought	1.18±1.67	.53±1.30	-1.204	30	0.238
Bizarreness	1.53±.72	1.87±1.36	0.895	30	0.378

*p<.05; †p<.10

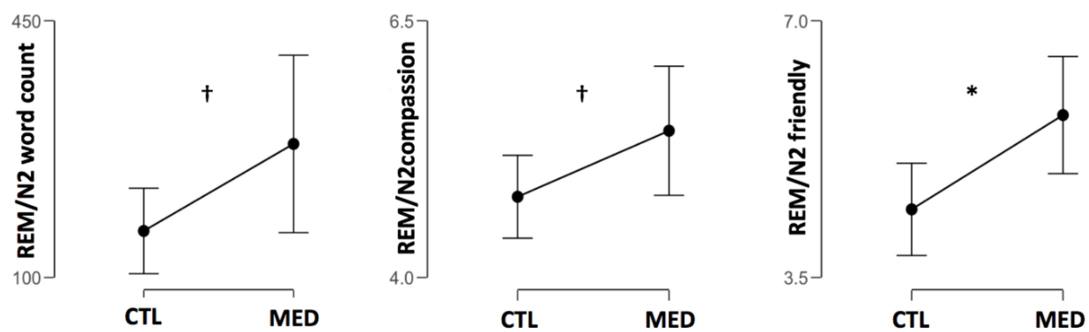

Figure 3. Mean±SD on measures of word count (in #words), compassionate and friendly interactions in REM/N2 dream reports for meditators (MED) and controls (CTL). †p<.1; *p<.05

The interpersonal quality of meditators' dreams suggests that training in the loving-kindness/compassion meditation that is integral to Vipassana practice may translate into a more generalized cognitive pattern/style of interaction. Previous research has shown that compassion training promotes empathetic concern (Rosenberg et al., 2015) and altruism (Weng et al., 2013) and our findings suggest that this training generalizes even further to social interactions during dreaming.

Contrary to our predictions and to past research, however, the meditators did not differ from controls on measures of dream lucidity. It is possible that a daytime nap in the laboratory, together with the procedural learning task and somatosensory stimulation and repeated awakenings for dream collection, interfered with some dream qualities. Self-reflection and control of dream events may thus have been sidelined by the need to dream about these other pressing concerns. Or, it may be that Vipassana meditation does not increase the frequency of lucidity qualities during dreaming because of its particular emphasis on bodily experience. Thus, lucid dreaming might be more prevalent among practitioners of dream yoga or Shamatha meditation because it is more directly focused on the observing of thoughts, images and other explicit mental contents. In other words, Vipassana meditation may be less likely than other forms of meditation to induce lucid dreaming because the latter is less dependent on bodily self-reflection and more dependent on cognitive self-reflection. Further analyses of home diary dreams may be a more effective method of sampling lucid dreaming prevalence and qualities in this population.

7. Conclusions

The present dissertation proposed an embodied and enactive view of the mind in sleep, focusing on three aspects: a general framework for viewing dreaming as enactive, sleep paralysis as an illustrative example, and sleep- and dream-mediated memory consolidation. The overarching goal of this work was to suggest that dreaming is embodied. This objective was addressed in the three following ways: 1) in developing a theoretical framework for the study of the mind in sleep from an embodied perspective; 2) in conducting a case study of embodied dreaming as it appears in a particular form of intensified dreaming and dreamed body experience (sleep paralysis); and 3) in conducting an empirical study targeting relationships between sleep physiology, dream content and sleep-mediated learning of a procedural balance task by Vipassana meditators (an “expert group” in bodily awareness) and non-meditating controls.

I have argued that dream embodiment manifests in a number of ways. First, following the phenomenological tradition of Husserl and Merleau-Ponty, as well as on contemporary theories and science of embodied mind and enactive cognition, embodiment is a precondition for any subjective experience. Dream experience, although in appearance an isolated, private and disconnected phenomenon, is in fact structured by somatosensory and perceptual skills and habits that unfold in an active, affective and motivated interaction with the environment. I also argue that perceptual and imaginary processes are not so easily separated, just as waking and dreaming are not completely different. By questioning sharp separations between these states, I suggest that there are underlying processes of imagination and of motivated and affective orientation towards the world that are shared across states.

This work is the first to argue for a strong dream embodiment position and I propose that there are many levels on which dreams are embodied experiences. First, they are most often experienced from an explicitly and representationally embodied actor’s perspective. Body parts and body movements are often mentioned in dream reports—but need not be for the embodiment argument. Second, dreams, like waking experiences, are almost always experienced from a first-person point of view, thus presupposing a spatial location and a minimal perspectival self. Further, dreams are structured by emotion and affect and thus have strong foundational bodily and somatic roots. Lastly, the sleeping and dreaming bodies are not independently functioning entities: studies of sensory incorporation and of intensified dream experiences, such as sleep paralysis, lucid dreaming and parasomnias, show relative permeability between the physical, sleeping body and the dreaming body.

To further study the numerous ways in which dreaming is embodied and skillful activity (as opposed to the common view of dreaming as a disembodied passive hallucination), I propose in Article I a neurophenomenological approach that includes developing novel qualitative techniques for dream interviews and dream content analysis that will reveal the temporal, bodily and affective fine-grained qualities of dream formation. These new techniques would complement existing qualitative approaches and, in conjunction with high-resolution neuroimaging or EEG methodologies, would help answer fundamental questions about the role of the body and affect in dream formation, of temporal and structural relationships between memory elements, and of the differences between perception and imagination. Moreover, studying how subjects live their novel embodied experiences during sleep could help elucidate the roles of imagination and memory in perception more generally.

In the illustrative case of sleep paralysis, I discuss the neurobiological, experiential and socio-cultural aspects of embodied dreaming. The particularity of this parasomnia lies in its strong and distinct bodily experience of muscle atonia coupled with altered perceptions of the environment and accompanying experiences of felt presence. In Article II, I review the current state of knowledge of sleep paralysis's prevalence, association with trauma and anxiety, cultural underpinnings and treatment avenues. I also argue that sleep paralysis is best understood as a variant of intensified dreaming (as opposed to a paranoid hallucination or an undesirable symptom), that may or may not be accompanied by negative and fearful experiences. Just as sensory stimulation may penetrate and thus change dream content, so too may the dream experiences of sleep paralysis alter relationships between dreamers and their environments. I propose that felt presence experiences, from a phenomenological and enactive perspective, represent a fundamental form of social and spatial imagery. Further, sleep paralysis may be treated and transformed into opportunities for self-knowledge and familiarization with one's own mental life. A number of existing strategies for sleep paralysis management are discussed in Article II and a proposal for a contemplative practice-based approach is presented.

Lastly, to test some of the assumptions of the embodied dreaming proposition, we conducted the first ever empirical investigation of relationships between a developed expertise in bodily and somatic awareness (Vipassana meditation), sleep- and dream-dependent processes of procedural memory consolidation and somatosensory stimulus incorporations. We found distinctly different neurobiological patterns of sleep-dependent procedural memory consolidation in meditators and non-meditating controls, suggesting that expertise in somatosensory awareness may produce large-scale changes in cognitive and neurophysiological functioning, including memory consolidation and sleep architecture. Additionally, we found a very modest relationship between dream content and learning, suggesting that dreaming about a procedural task may sometimes help and sometimes hinder subsequent performance. Furthermore, we found very few differences in dream content between the two groups: our meditation practitioners had more pro-social interactions with other dream characters, but did not show more lucidity or metacognitive awareness in dreams as expected. Finally, somatosensory stimulation during sleep produced a variety of changes in dream content, further strengthening the notion that the sleeping and dreaming bodies are in a constant interplay of affective, associative sense-making.

Overall, the results of this inquiry into dreams point to the conclusion that dreams are indeed embodied experiences. To make sense of memories and new experiences, dreams essentially create novel experiences that embed one's rich personal vocabulary of imagery, metaphors and semantic knowledge in a flow of lived bodily experience that are rooted in a sociocultural context. Studying dreams and other oneiric experiences, such as sleep paralysis, can illuminate some aspects of the role of the imagination and cognitive skills and habits formed in sleep, in perception and in making sense of interactions with the outside world. In other words, while it is clear that dreams are crafted from daytime memories, emotions and thoughts, it is also possible that daytime experiences are more dreamlike than we realize. Thus, dream science is the study of the mind that is maximally unencumbered by the usual demands of the outside world, but that is still busy creating spatio-temporal worlds and populating them with meaningful places, objects and characters. Even in sleep, we are in and *of* the world, in time, space and with others. Most critically, dreams are embodied experiences, textured by memories and affect and involve the whole embodied and enactive subject. The dreamer is an active embodied agent in the dreamworld, not disconnected from the sleeping body and the outside world, but in a special relationship to them.

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Appendix 1.

Dream interviews administered at sleep onset and during REM/N2 awakenings

Appendix 2.

Open Peer Commentaries to Article I.