

The neural and psychological mechanisms of yoga and mindfulness meditation

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VALORIZATION ADDENDUM

INTRODUCTION

The thesis “The neural and psychological mechanisms of yoga and mindfulness meditation” to which this valorization addendum belongs, investigated the neural and psychological mechanisms of mindfulness meditation and yoga in domains that are of particular relevance for society namely pain management, resilience building in young adults, and aging. Yoga and mindfulness meditation both are ancient practices that are concerned with fostering sustainable well-being (Feuerstein, 2008; McWilliams, 2014; Sengupta, 2012; Wallace & Shapiro, 2006). These ancient practices find many applications in modern society to increase well-being in health and disease (Chiesa & Serretti, 2009; Goyal et al., 2014). While the studies that are part of the thesis covered different domains and used different methods and levels of analysis, they all have in common that they indeed relate to how meditation and yoga can increase sustainable well-being or eudemonia.

With such a topic, valorization of the knowledge gained by this thesis is obvious and an integral part of the thesis. In the following, part of what already has been discussed in the thesis will be reiterated. First valorization of the thesis as a whole will be discussed before valorization of the individual chapters will be discussed in more detail. The general part assesses the relevance of the gained knowledge, target groups for whom the knowledge is relevant, possible activities and products to which this knowledge can be translated, the level of innovation of these applications, and implementation of the valorization plan. The part on individual chapters will elaborate more specifically on the relevance and innovation aspects of the gained knowledge.

GENERAL

Broadly speaking, the knowledge that was revealed in this thesis can be divided in two parts: 1) the effect of yoga and mindfulness meditation on well-being and 2) the mechanisms that underlie these effects. Each part of knowledge has its own valorization. Although part one was not the main focus of this thesis, it is inherent to part two; studies that investigate the mechanisms of how yoga and mindfulness meditation affect well-being also result in knowledge about the effects of these practices on well-being.

The support that we found for the positive effects of yoga and mindfulness meditation on well-being, is of value and relevant to anyone interested in practical tools to increase human well-being and foster a flourishing society. In particular it may be interesting for people who are professionally concerned with enhancing well-being, such as clinicians and coaches who are not yet working with yoga and

mindfulness meditation, but see the opportunity of new tools now. Others who are working with these practices already may benefit from our findings as they provide credibility to their practice.

The second part of knowledge gained through this thesis, the psychological and neural mechanisms of yoga and mindfulness meditation forms the core of this thesis. This knowledge is of direct value and relevance to teachers and practitioners of these practices. Having a better understanding of the practice one teaches or practices is useful as it increases credibility of the benefits of these practices. The uniqueness of the mechanisms that were revealed may be of value to clinicians as it suggests that yoga and mindfulness meditation really add something to other known interventions. In the longer run, understanding the psychological and neural mechanisms of mindfulness meditation and yoga also creates value for patients and clinicians in that it may contribute to the improvement of existing interventions and the development of new treatment procedures that capitalize on these mechanisms.

Products and activities that this mechanistic knowledge can be translated to include the development of novel teaching materials for teachers and teacher-trainers of yoga and mindfulness-based interventions, information materials for patients and clinicians and continuing education offers for clinicians. Furthermore, the revealed mechanisms can be used to develop new interventions for a variety of clinical disorders or to enhance well-being in healthy people. These interventions could be mindfulness-based behavioral interventions which use the in this thesis identified brain activation patterns and network architecture as success-indicators to further optimize the intervention. The identified brain activation patterns and network architecture can also be used for technology-based interventions such as neurofeedback and brain stimulation. Neurofeedback applications would initially be based on functional magnetic resonance imaging (fMRI) with translational possibilities to electroencephalography (EEG) and near-infrared spectroscopy (NIRS).

The innovation of updated teaching- and patient-materials as well as continuing education offers lies in the novelty and uniqueness of the revealed mechanisms and by supporting a shift from purely “evidence based” interventions to “mechanisms based” interventions; the novel materials not only emphasize that interventions work, but also show how they work. The innovation of the development of new interventions lies in the approach of directly targeting brain mechanisms, and particularly the newly identified mechanisms that were revealed in this thesis. Although meditation-based neurofeedback is already being used, these applications are not much science based and exclusively use EEG with its low spatial resolution. We provide science-based targets with high spatial resolution. A further innovation is that, if technology allows for it, we have network-based measures that could be used for feedback.

The valorization strategy has already been partially implemented. To facilitate updating of teaching materials for yoga and mindfulness teachers and teacher trainers, and to facilitate updated patient and clinician information materials, relevant parties were informed in various ways. Clinicians were informed through journals of medical professional associations, including *Ärztzeblatt* and *Report Psychologie* and presentations at clinical grand rounds such as the Department of Anesthesia of Massachusetts General Hospital. Furthermore, the gained knowledge was disseminated at various European and American accredited continuing education events for clinicians as well as yoga and mindfulness teachers and educators, including the Annual conference of the Center for Mindfulness at the University of Massachusetts Medical School. Patients were targeted through newsletters of patient associations such as *Deutsch Schmerzliga*. The general audience could learn about the studies through mainstream newspaper, radio and television outlets including *Huffington Post*, *USA Today*, *Stern*, *Deutschlandfunk*, and *3sat*(Scobel).

The improvement or development of interventions that rely on the in this thesis identified mechanisms is on my long-term research agenda. An important first step to more directly target the identified mechanisms is to disentangle skill and strategy involved in these mechanisms (Gard, 2014). This is exactly what is on my short-term research agenda and a research proposal regarding this topic is currently in preparation.

CHAPTER 2

Chapter 2 investigated the neural mechanisms of pain modulation through mindfulness using functional magnetic resonance imaging (fMRI). Mindfulness practitioners were able to strongly reduce pain unpleasantness and anticipatory anxiety through the state of mindfulness. In the brain this reduction in pain unpleasantness was associated with increased activation in the right posterior insula and decreased activation in the lateral prefrontal cortex. These findings revealed a unique mechanism of pain modulation through mindfulness, comprising increased sensory and decreased cognitive evaluative processing. The major novelty of this study is that it is the first study that revealed such a pattern of pain modulation during the state of mindfulness as compared to a state of rest.

As discussed in the general part of this document, there is great value in the finding that mindfulness meditation involves a unique mechanism for pain modulation as it suggests the potential for effective application in situations where other methods are not effective and it provides targets for the improvement of old and the development of new treatments.

Although the study in chapter 2 involved acute experimental pain it may generalize to chronic pain. This would be of great value relevance to patients, clinicians and society because chronic pain is an important problem for society as it has high prevalence and poses a huge burden in the form of reduced well-being to patients and in terms of financial costs to society. Estimates of prevalence rates are ranging from around 20% to more than 70% (Breivik, Collett, Ventafridda, Cohen, & Gallacher, 2006; Gureje, Von Korff, Simon, & Gater, 1998; Tsang et al., 2008; Wenig, Schmidt, Kohlmann, & Schweikert, 2009). In the US the prevalence of chronic pain has been estimated to be 43% (Tsang et al., 2008), meaning that over 116 million Americans are suffering from this condition, which is more than the number of Americans affected by heart disease, cancer and diabetes combined (IOM, 2011; Pizzo & Clark, 2012). In Germany the estimated annual cost of back pain is €49 billion, while in the US the annual cost of chronic pain is estimated to be up to \$635 billion (Gaskin & Richard, 2012). In addition to the high prevalence and the huge burden to patients and society, chronic pain is difficult to treat (Turk, Wilson, & Cahana, 2011) and has been conceptualized as public health challenge by the Institute of Medicine of the National Academies (2011).

CHAPTER 3

Chapter 3 investigated the effects of a yoga intervention on perceived stress and quality of life, as well as its underlying psychological mechanisms, in young adults who are in the challenging transition to college life. Participation in the yoga-based intervention resulted in reduced perceived stress and increased quality of life in young adults, thereby increasing well-being and resilience for mental illness in this at risk group. Well-being is negatively related to a number of variables, including mental health and suicidality in young adults (Valois, Zullig, Huebner, & Drane, 2001), while high levels of stress on the other hand contributes to psychopathology (Grant, McMahon, Dufy, Taylor, & Compas, 2009). College is a high risk period as young adults are particularly vulnerable to mental health problems and the transition to college is a challenging period (Conley, Travers, & Bryant, 2013; Reavley & Jorm, 2010). Despite the opportunity to support young adults in this critical phase of life, not many interventions have been developed and tested to foster well-being and resilience in this group, as opposed to children (Conley et al., 2013; Durlak, Weissberg, Dymnicki, Taylor, & Schellinger, 2011; Reavley & Jorm, 2010). Therefore the knowledge regarding the effects of yoga in young adults is relevant for this group as well as for providers of preventative health care and wellness providers who are interested in targeting this group. In the end prevention of (mental) illness in young adults will be of benefit for society as well.

An innovative aspect of this study is that it is the first time that a yoga-based program has been reported to increase self-compassion, and that the effects of such a program on quality of life and perceived stress are mediated by mindfulness and self-compassion. These findings suggest that yoga-based and mindfulness-based programs might share mechanisms, which could be of value to individuals that have interest in acquiring the skills of mindfulness and self-compassion, but are resistant to formal meditation techniques or have a preference for more physically engaging practices. Knowledge about the similarity in mechanisms may also be of value relevance to teachers and developers of interventions that rely on mindfulness and self-compassion. Finally, and mostly of interest to researchers, this similarity makes it possible to generate hypotheses about the effects of yoga-based programs based on the larger body of knowledge about the effects of mindfulness-based programs. Eventually, the mechanistic knowledge gained in this chapter may contribute to the development of more targeted and efficient programs to foster well-being and increase resilience.

CHAPTER 4–6

Chapter 4–6 focused on the growing problem of cognitive and neural decline in the rapidly aging society. The world population is rapidly aging, due to increases in life expectancy and the aging baby boom generation (Administration on Aging, 2012; United Nations, 2002). In Germany for instance more than 20% of the population is already older than 65 (Statistisches_Bundesamt, 2014). It is no surprise that the European Commission regards aging as one of the greatest social and economic challenges of the 21st century (European_Commission, 2014).

It is well-established that normal healthy aging is accompanied by decline in cognitive function (Salthouse, 2009; Tucker-Drob, 2011; Wilson, Beckett, Bennett, Albert, & Evans, 1999) and related declines in neural structure and activity (Morrison & Hof, 1997; Persson et al., 2006; Salat et al., 2004). The decline can progress to mild cognitive impairment (MCI) and dementia, which are characterized by limitations of daily functioning and typically result in a reduced quality of life. Therefore cognitive decline is an often feared aspect of aging. It is not only a burden for the affected individual but also for relatives and society (Deary et al., 2009; Plassman, Williams, Burke, Holsinger, & Benjamin, 2010).

The literature review in chapter 4 suggested that there is preliminary evidence that different forms of meditation can off-set age-related cognitive decline in a variety of domains. Chapter 5 investigated the neural and psychological mechanisms of off-set age-related decline in fluid intelligence in yoga and meditation practitioners. Fluid intelligence, which has high real-life relevance, indeed declined slower in yoga and

meditation practitioners than in controls. Global network analyses of resting state brain functional connectivity data, acquired with fMRI, revealed that the functional brain networks of the practitioners were more integrated and more resilient to damage than those of controls. It should be noted here that aging is typically associated with decreases in brain functional network integration (Achard & Bullmore, 2007). There were no differences in decline rate and network integration between yoga and mindfulness practitioners. Mindfulness was positively correlated with fluid intelligence and network integration and resilience, suggesting a mechanistic role in preserving cognition and brain function. Chapter 6 revealed that yoga and meditation practitioners had greater connectivity between the caudate and a wide range of brain regions while aging and mild cognitive impairment are associated with decreased caudate connectivity (Agosta et al., 2013; Klostermann, Braskie, Landau, O'Neil, & Jagust, 2012; Morbelli et al., 2012; Podell et al., 2012).

The finding of off-set decline in fluid intelligence in yoga and mindfulness-meditation practitioners is of value and relevance to aging individuals, their family, clinicians and society as a whole. Similarly, greater functional network integration, resilience and caudate connectivity in yoga and meditation practitioners than in controls is of value these groups as it they have been positively associated with cognitive function and negatively with aging (Achard & Bullmore, 2007; Agosta et al., 2013; Klostermann et al., 2012; Langer et al., 2012; Morbelli et al., 2012; Podell et al., 2012; van den Heuvel, Stam, Kahn, & Hulshoff Pol, 2009). Knowledge about the neural and mechanisms that were revealed in these chapters may in future be used to enhance and develop interventions to reduce age-related cognitive decline and transition to dementia.

The studies in chapter 5 and 6 are particularly innovative as they were a collaboration between fields and used novel analysis methods that had not been used in contemplative neuroscience before.

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