Cultural Ripples and Brain Waves: Investigations into Mindfulness, Analytical Meditation, and Culture-Sensitive Research

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This dissertation consists of an umbrella paper and the following studies:

Study 1:
Moye, A., J., Stocker, E., & Englert, C. (to be submitted). The Volatile Effect of Short-Form Mindfulness Training on Self-Control in the SART

Study 2:
van Vugt, M. K., Pollock, J., Johnson, B., Gyatso, K., Norbu, N., Lodroe, T., Gyaltsen, T., Phuntsok, L., Thakchoe, J., Khechok, J., Lobsang, J., Tenzin, L., Gyaltsen, J., Moye, A., & Fresco, D. M. (2020). Inter-brain synchronization in the practice of Tibetan monastic debate. *Mindfulness, 11*(5), 1105–1119. https://doi.org/10.1007/s12671-020-01338-1

Study 3:
van Vugt, M. K., Moye, A., Pollock, J., Johnson, B., Bonn-Miller, M. O., Gyatso, K., Thakchoe, J., Phuntsok, L., Norbu, N., & Tenzin, L. (2019). Tibetan Buddhist monastic debate: Psychological and neuroscientific analysis of a reasoning-based analytical meditation practice. *Progress in Brain Research, 244*, 233–253. https://doi.org/10.1016/bs.pbr.2018.10.018

Study 4:
Moye, A., Donyö, L., Johnson, B., Thabkhe, T., Gyatso, K., Thakchoe, J., Soepa, J., & van Vugt, M. (in review). The Limits of Abstraction: Diversifying Cognitive Research Beyond WEIRD Populations through the Study and Inclusion of Tibetan Monks. *Journal of Experimental Psychology: General.*

Abstract

This thesis extensively explores contemplative practices, specifically focusing on analytical meditation (i.e., Tibetan monastic debate) and short-term mindfulness interventions. Surprisingly, Study 1 revealed that short-form mindfulness training did not notably enhance self-control or attention, prompting further investigation into the effectiveness of these interventions. Study 2 explores the impact of monastic debate on absorption (marked by increased frontal theta slopes) and increased inter-brain synchrony during agreement versus disagreement. Study 3 introduces a biobehavioral model, derived from dialogues with Tibetan monastics, suggesting that debate could potentially enhance cognitive control, regulate emotions, and foster social connectivity, integrating these assumptions among empirical findings and confirming predictions of the model through quantitative phenomenological analysis. In a deviation from the initial hypothesis, Study 4 found that Western students surpassed experienced Tibetan monks and novice monks in complex working memory, association memory, and logic tasks. This finding questions the supposed culture-fairness of these testing methods. The discussion delves into the benefits and limitations of secularized short-form mindfulness-based practices, suggesting that their effectiveness hinges on the context of implementation and individual comprehension and application. Further, it is proposed that the potential and challenges of integrating traditional contemplative practices, such as monastic debate, into contemporary psychological research and practice underscore the necessity for a culturally sensitive approach and adaptable methods when researching these practices. This approach additionally emphasizes the importance of collaboration with the practitioners themselves. The thesis concludes by advocating for the preservation and adaptation of Tibetan monastic practices and recognizing the potential benefits of including Tibetan samples in future research on psychological processes. This thesis yields valuable insights into the cognitive impacts of contemplative practices and their potential for psychological transformation and well-being.

Chapter 1: Introduction

> "Our minds are all we have. They are all we have ever had. And they are all we can offer others. This might not be obvious, especially when there are aspects of your life that seem in need of improvement – when your goals are unrealized, or you are struggling to find a career, or you have relationships that need repairing. But it's the truth. Every experience you have ever had has been shaped by your mind. Every relationship is as good or as bad as it is because of the minds involved. If you are perpetually angry, depressed, confused, and unloving, or your attention is elsewhere, it won't matter how successful you become or who is in your life – you won't enjoy any of it." Sam Harris (2014)

It might seem that the growing body of research on the beneficial effects of meditation (e.g., Afonso et al., 2020; Chiesa, 2010; Laukkonen & Slagter, 2021; Mind et al., 2012; Sedlmeier et al., 2012; Sumantry & Stewart, 2021) and mindfulness (Feruglio et al., 2021; Jinich-Diamant et al., 2020) already provides all the reasons one would need to prioritize mental training and cultivation: improved immune function, stress reduction, longevity, enhanced cognitive abilities, emotional regulation and many more (Brewer & Garrison, 2014; Moore & Malinowski, 2009; Tang et al., 2015, 2016). Yet, beyond these tangible mental and physical health benefits, there lies a more profound, less quantifiable motivation for such cultivation. Conscious experience (i.e., the mind), as Harris (2014) eloquently puts it, is the entirety of our human existence. It is the lens through which we perceive and construct reality, engage with others, the tool we use to navigate the complexities of life, and the canvas upon which our memories, emotions, and identities are painted. The quality and clarity of this lens, the effectiveness of this tool, the vibrancy of this canvas, all hinge on the state of our mind. Thus, one might argue that the cultivation of a healthy, resilient, and lucid mind is not just a means to an end, but an end in itself, worthy of the highest dedication and effort. The essential potential that contemplative training methods such as meditation and mindfulness-based practices extend is therefore not merely about achieving transient states of calm and well-being. Rather, they offer the possibility of a profound shift in the way we perceive and navigate the world (Lutz, Slagter, et al., 2008). They provide a path to restructuring an individual's cognitive and emotional patterns, enabling them to better understand and regulate their thoughts and feelings, as well as perceiving the world with enhanced clarity, compassion, and equanimity (Wallace, 2007). Contemplative cultivation further holds the promise of fostering a more mindful and compassionate society, in which individuals are not just focused on personal success and gratification, but also the well-being of others. When practiced diligently and sincerely, these practices can encourage a transition from a self-centered to an other-centered viewpoint, promoting empathy, kindness, and social connectedness (Condon et al., 2013; Fredrickson et al., 2008).

1.1 Contemplative practices and their multifaceted nature

The last two decades have seen an exponential rise in the empirical investigation of meditation and other contemplative practices (Van Dam et al., 2018). The primary focus of this expanding body of research has been on a select group of practices, specifically the cultivation of mindfulness through formal sitting meditation. However, a plethora of contemplative practices exist, each with its unique emphasis and intended outcomes. This broad group can be categorized into different families, each targeting distinct facets such as self-awareness, emotion, and cognition. Additionally, there are various modes of training within these families, ranging from some designed for introspection and solitary self-inquiry, while others are oriented towards exploration and transformation of the self in the context of dialogue and relationship. Each of these represents significant dimensions of contemplative practice, some of which have been largely overlooked within the empirical research community (Davidson & Dahl, 2017, 2018; Katyal et al., 2023).

Historically, contemplative practices have played a central role in religious, philosophical, and humanistic traditions. The earliest documented accounts originate from the Hindu traditions of Vedantism around 1500 BCE (Flood, 1996). However, it is plausible that the roots of contemplative practices extend even further back, as evidenced by analogous practices discernible in prehistoric cultures. Cave art dating back to 40,000 BCE depicts individuals in what appear to be meditative or trance-like states (Lewis-Williams, 2011), suggesting that the human inclination towards introspective and contemplative states may be an inherent aspect of our psychological makeup, deeply intertwined with our evolutionary history. Beginning in 1979 with the advent of Mindfulness-Based Stress Reduction (MBSR), a small subset of these practices has been secularized and introduced into Western mainstream, where they continue to gain popularity (Kabat-Zinn, 2003; Purser & Loy, 2013; Van Dam et al., 2018). At the same

time, their scientific credibility has increased significantly due to varied research conducted by cognitive scientists, neuroscientists, and psychologists.

Defining the boundaries of what constitutes contemplative practices is complex, but broadly speaking, these forms of training accentuate and foster self-awareness, self-regulation, and self-inquiry, thereby facilitating a process of psychological transformation (Davidson & Dahl, 2017; Walsh & Shapiro, 2006). These practices invariably involve some form of deliberate training and mental discipline, even when they incorporate physical movement or dialogue-based exercises. Despite the significant variations in context among the traditions that employ them, contemplative practices are generally framed as pragmatic techniques for giving rise to enduring well-being or inner flourishing. Unlike the majority of secularized contemplative trainings (e.g., mindfulness-based interventions), which were developed with the treatment of psychopathology in mind (e.g., depression, addiction, anxiety), traditional contemplative practices were predominantly formulated as methods for personal growth and self-understanding for individuals, already experiencing at least a medium degree of well-being and stability (Davidson & Dahl, 2018). As has been alluded to above, contemplative practices are therefore not reducible to mere therapeutic interventions (although a large body of research attests that this is one area in which they are consistently effective; see Goldberg et al., 2018; Grossman et al., 2004; Hofmann et al., 2010; Khoury et al., 2013; Walsh & Shapiro, 2006), but tools for enhancement and exploration of the full spectrum of human experience (Goleman & Davidson, 2018; Lutz, Slagter, et al., 2008). The form of such practices ranges from concentration and mindfulness exercises, to visualization and loving-kindness meditation, to contemplative prayer, chanting, and philosophical inquiry. It can therefore be said that contemplative practices encompass a wide array of training modalities extending far beyond solitary meditation. The frameworks within which these practices originated and still operate to this day are diverse and nuanced (e.g., Hinduism, Buddhism, Taoism, Christianity, Sufism, etc.), each with its unique concepts, ethics, and worldviews. Within most of these traditions there are introspective meditations that encourage inward reflection, interpersonal dialogues that foster intersubjective inquiry, and movement-based practices such as yoga and tai chi that integrate mind and body. Moreover, each practice targets different psychological processes, according to its design and intention (Davidson & McEwen, 2012; Kok & Singer, 2017; Tang et al., 2015). As such they are akin to physical exercises which target different muscle groups depending on the specific movement and form. Similarly, certain modes of contemplative training are specifically crafted to engage and refine meta-awareness and other attentional processes (Jankowski & Holas, 2014), while others are aimed at the cultivation of affective and social qualities such as equanimity and compassion. Yet another category employs the method of self-inquiry to foster a deeper understanding of the self and to facilitate insight into the phenomenological nature of existence (Harris, 2014; Varela et al., 2017; Wallace, 2007).

Therefore, it becomes incumbent upon researchers studying contemplative training to thoroughly consider both the specific mode of training and the particular family or tradition to which a contemplative practice is affiliated (Davidson & Dahl, 2017). Further, there is a growing body of research indicating that these diverse practices not only lead to different outcomes but correspond to distinct neural pathways, thereby eliciting disparate behavioral consequences (Kok & Singer, 2017). Emphasizing this diversity is particularly relevant in the wake of the burgeoning interest in mindfulness-based interventions within the empirical discourse pertaining to contemplative practices. Although recent years have witnessed a modest increase in the focus on interventions centered on loving-kindness and compassion (Galante et al., 2014), the vast domain of contemplative practices is still largely under-explored in contemporary research. There remain a multitude of contemplative practices, which have yet to be thoroughly studied, potentially harboring transformative capacities for individual and societal well-being. These practices span across a variety of traditions and modes of training, each with its unique benefits and potentials. For instance, practices like contemplative prayer, philosophical inquiry, and chanting may engage cognitive processes distinct from those engaged by mindfulness and loving-kindness meditation. These different contemplative practices may therefore offer unique pathways towards psychological transformation and well-being. Prominent researchers of the field such as Davidson and Dahl (2017) therefore implore their peers to diversify their investigation of contemplative interventions, advocating particularly for the inclusion of analytical meditation and other practices that employ self-inquiry as a key strategy.

Socrates is said to have claimed that the Delphic maxim, "Know thyself," (i.e., the pursuit of self-knowledge and introspection) sums up the essence of all wisdom and indeed, the ultimate goal of human life. Such assertions can be found among the teachings of various traditions, cultures and philosophies, reflecting a timeless and universal human quest for systematically understanding the human condition from the first-person perspective. Based on the anecdotal reports amassed over millennia (e.g., the

Upanishads, the works of Confucius, the writings of Augustine), of such traditions and contemporary empirical research attesting to robust and tangible effects (see, Afonso et al., 2020; Chiesa, 2010; Sedlmeier et al., 2012; Sumantry & Stewart, 2021), one might further derive that not only the quest and aspiration but also the possibility of moving towards the asserted ultimate outcome is near universal. The ultimate outcome being a state of optimal mental clarity and emotional regulation free from cognitive distortions resulting from a direct, non-conceptual, ineffable but undeniably transformative experience of the phenomenological nature of existence (Goleman & Davidson, 2018; Wallace, 2007). However, the universality of the aspiration (at a cultural level at least) and the ostensibly universal effect of systematic introspection on individuals does not imply a universal means of achieving it. The means of pursuing this goal, the practices engaged, the interpretations of the experiences, and the resultant transformations are likely to be shaped by a multitude of factors, moderators and boundary conditions. This likely includes individual characteristics such as personality traits, cognitive abilities, and emotional dispositions, as well as contextual factors such as culture, social environment, and the specific framing and implementation (e.g., span, spacing and intensity) of the chosen contemplative practice or intervention (Lindahl et al., 2017; West, 2016).

1.2 Research goals and objectives

In light of the above, it can be posited that a comprehensive understanding and appreciation of contemplative practices necessitates a broad, inclusive, and nuanced exploration of the many forms these practices take; a state which contemporary contemplative research has yet to achieve (Katyal et al., 2023). Therefore, the central aim of this thesis is to delve into this intricate world of contemplative practices, and to provide much needed theoretical and empirical insights into their diverse nature and effects. Specifically, this work will explore and compare two under-researched contemplative practices, such as analytical meditation and short-form mindfulness interventions, the latter of which has been gaining increasing attention in recent years. Despite their increasing popularity, these short-form interventions have not been thoroughly researched in terms of their effectiveness and potential benefits compared to more traditional, long-form (8 weeks or more) mindfulness practices. This thesis will critically examine the efficacy of these interventions, their potential pitfalls, and their place within the larger landscape of contemplative practices. Additionally, the dyadic and dynamic nature of analytical meditation, which is quite distinct from the more commonly studied contemplative practices (e.g., 8-week mindfulness-based interventions), presents an intriguing avenue for exploring the complex relationship between the components of a given contemplative training and its outcome effects. By examining analytical meditation in its original setting as well as in comparison to other contemplative practices, this thesis will contribute to a more nuanced and comprehensive understanding of the field of contemplative practices.

Finally, the ultimate goal of this investigation is not to prescribe a universal pathway to psychological transformation or to argue for the superiority of one practice over another, but rather to illuminate lesser-known parts of the diverse array of contemplative practices available and their varying effects. Recognizing that individual and societal well-being can be fostered through a multitude of paths, this thesis will offer insights that may help practitioners and researchers alike to navigate this complex landscape with a more informed and discerning perspective.

Chapter 2: Studying contemplative practices in the western context

Contemplative practices began to be studied and more widely embraced in Western cultures in the late 20th century, largely due to the work of pioneers such as Jon Kabat-Zinn and his Mindfulness-Based Stress Reduction (MBSR) program and subsequent Mind and Life Institute dialogues (Kabat-Zinn & Davidson, 2012). These efforts helped to open up the academic field and the general public to the potential benefits of these practices. In his work with chronic pain patients, Kabat-Zinn combined elements of Korean Zen, Burmese Vipassana meditation, and Indian Hatha yoga to create a secular, medically based mindfulness training that has since been shown to have significant impacts on various health outcomes, including stress reduction, pain management, and overall quality of life (Kabat-Zinn, 1982; Kabat-Zinn et al., 1985). The success of MBSR, and the subsequent proliferation of mindfulness-based interventions, is arguably one of the central reasons for the surge in empirical research on mindfulness and other contemplative practices. As noted in the introduction, this adaptation of traditional contemplative practices into a secular Western context only included a small subset of components from the original traditions and furthermore left out entire families and modes of practices, which are more prominent in traditions not included in the initial adaptation (e.g., practices found in Tibetan Buddhism such as analytical meditation and visualization practices). This resulted in a somewhat skewed representation of contemplative practice, neglecting components that might offer distinct but equally

valuable benefits by heavily favoring mindfulness conceptualized as an attention regulation strategy, with a focus on non-judgmental awareness of the present moment, while sitting or lying down with eyes closed.

While the adaptation of these practices has not been without controversy and misunderstanding – some critics argue that the process of "westernizing" these practices has led to a dilution of their original intent and efficacy (e.g., Purser & Loy, 2013) – the standardization and secularization of these practices have undeniably benefited research efforts by bounding an otherwise vast and complex field of study. It has enabled researchers to study a surveyable number of standardized practices defined in terms that are compatible with the vocabulary of Western cognitive science and psychology. This has allowed for a more systematic investigation of their mechanisms of action, outcomes, and potential applications in various contexts. Consequently, this broadened their accessibility and appeal, enabling a greater number of individuals to experience their benefits. Moreover, the increasing integration of these practices into mainstream healthcare and education has further catalyzed interest and research in this area. According to a widely cited comprehensive review by a notable group of researchers (Van Dam et al., 2018) this increase in attention has apparently even led to somewhat of a 'hype' regarding mindfulness and to a lesser degree other contemplative practices, sometimes overstating their benefits and underrepresenting their potential risks or limitations. And while part of the problem resides with the reporting in popular media, some of the blame can also be attributed to the scientific community.

2.1 The current state of research on mindfulness-based practices

There is for instance the problem of discordance in the rapidly expanded field, where a single, universally accepted definition of "mindfulness" remains elusive (Bodhi, 2011; Dreyfus, 2011; Dunne, 2011; Gethin, 2011). Often, the term "mindfulness" is used to refer to the cognitive *ability* of being consciously present and perceptive of circumstances as they unfold (Kabat-Zinn & Hanh, 2009). In other contexts, it might denote a structured *practice* that involves seated meditation, focusing on the breath or another selected object of attention. This ambiguity in defining complex constructs is not unprecedented, with similar discrepancies observed in studies of intelligence (Neisser et al., 1996) and happiness (Diener, 1984). Such discrepancies often result in inconsistent operationalization of the construct in empirical studies, thereby complicating the comparability of results across studies and the generalizability of their findings. Mindfulness, too, suffers from this lack of consensus despite numerous attempts to rectify this (Anālayo, 2003; Bishop et al., 2004; Bodhi, 2011; Brown et al., 2007; Dunne, 2011; Grabovac et al., 2011; Gunaratana, 2002; Hölzel et al., 2008; Malinowski, 2013; Shapiro et al., 2006; Vago & Silbersweig, 2012; Van Dam et al., 2018). It is often correlated with mental faculties such as attention, awareness, memory retention or discernment (Davidson & Kaszniak, 2015), yet these diverse aspects are seldom all represented in research practice (Goldberg et al., 2018; Manuel et al., 2017). Possibly the most frequently cited definition describes mindfulness as the cultivation of moment-to-moment awareness, achieved by directing attention in a specific manner, in the present moment, with as much openness, non-reactivity, and non-judgment as possible (Kabat-Zinn, 2011; Kabat-Zinn & Hanh, 2009). Nevertheless, this definition, while useful for Western audiences, has been criticized as reductionist and an operational one of convenience, accommodating primarily those constructs that are straightforwardly digestible to a Western perspective (Kabat-Zinn, 2011).

The term mindfulness has essentially become an umbrella term, encapsulating a wide array of practices and mental states, sometimes leading to confusion and misinterpretation (Grossman, 2011; Monteiro et al., 2015). A case in point is the equation of a self-reported questionnaire result with the characteristics of an individual who has engaged in decades of consistent practice of a specific meditation technique. Both, albeit differentiated by the depth and quality of their experience, are labeled as manifestations of 'mindfulness'. Another instance of this umbrella categorization is the indiscriminate use of the term to denote both a brief, 5-minute meditation session facilitated by a commonly used mobile application and a rigorous, 3-month meditation retreat. Both vastly different experiences are homogenized under the banner of 'mindfulness meditation' (Van Dam et al., 2018). In light of this prevailing ambiguity, Van Dam et al. (2018) propose a departure from the extensive, all-encompassing terminology and instead advocate for a more precise, delineated representation of the specific mental states, processes, and functions under investigation in the respective mindfulness study. To facilitate this shift, they offer a comprehensive, albeit not exhaustive, list of defining features to better characterize contemplative practices in future investigations.

2.2 Short-form mindfulness-based interventions

The first study presented in this thesis explores the efficacy and potential mechanisms of a short-form mindfulness-based practice/program (MBP); a form which has seen a rise in popularity in recent

years. These interventions are typically condensed versions of more traditional, lengthy mindfulness programs (e.g., MBSR) and are designed to allow for a more accessible introduction to mindfulness practices. Short-form MBPs can be grouped into a broader set of interventions sometimes referred to as "Spin-off" MBPs (Van Dam et al., 2018). These interventions exhibit significant variation in their content and form, primarily resulting from the modifications and adaptations they undergo to cater to the unique needs of the participant populations and the distinct objectives of individual researchers (see, Shonin et al., 2013). Given these modifications and the resulting heterogeneity, it is crucial to approach these interventions with rigorous scrutiny and caution, particularly when considering the deployment of adaptations of classical MBPs that have been minimally tested (Dimidjian & Segal, 2015; Van Dam et al., 2018).

Such caution is indeed warranted in the context of the short-form study we conducted. We specifically tailored the MBP to meet the unique requirements of the research context. This was mainly a result of the participants being acquaintances and friends of the two undergraduate students who were assigned the task of supervising the tests for their bachelor's theses. Given the absence of any compensation for their time, the intervention was crafted to be as brief and feasible as possible. Furthermore, as the participants' schedules did not allow for group meetings, the intervention had to be delivered entirely through an online platform. As such the study design can be said to be one of high risk as well as high potential. On one hand, the short duration and lack of in-person interaction could potentially limit the efficacy of the intervention, as previous research has suggested that the length and intensity of mindfulness training can significantly impact its effectiveness (Tang et al., 2015). On the other hand, the implications of a successful short-form MBP would be far-reaching, providing evidence for the possibility of an accessible, flexible, and cost-effective mindfulness tool that could be easily disseminated to a larger population. This mode of delivery, albeit a relatively recent development in the realm of MBPs, has seen some utilization (Bostock et al., 2019; Cavanagh et al., 2013; Dimidjian et al., 2014; Lim et al., 2015) but remains comparatively unexplored and necessitates further examination and validation. Exploration in this area is crucial, given that leading researchers in the field of contemplative science such as Davidson and Dahl (2018) have called for a paradigm shift in MBP delivery and data collection to large scale mobile technology platforms in order to achieve large samples and widespread dissemination. This shift, they argue, could address the recurring challenges faced in comparing MBP interventions across different sites and contexts, and the inherent difficulties in working with smaller sample sizes.

And while the design of the study was partially dictated by necessity and convenience, it was also intentionally structured to both replicate and extend the findings of Stocker, Englert, and Seiler (2019). In their study, from which we used many of the materials, they discovered that a brief MBP, consisting of two sessions lasting four minutes each, did not significantly alleviate the effects of ego depletion in the context of a physically demanding self-control task. This finding stands in contrast to results reported by Friese et al. (2012), who found that a brief MBP, delivered within the context of a three-day mindfulness introduction course, had a notable mitigating effect against ego depletion in a cognitive task, as measured by the d2 Test of Attention. Considering these disparate findings, we hypothesized that a more comprehensive and intensive mindfulness training could potentially exhibit a similar mitigating effect. The goal was not only to replicate previous findings but also to extend our understanding of the nuanced relationship between the intensity of mindfulness practices, ego depletion, and cognitive performance.

2.3 Summary and results of study 1

The experiment in study 1 engaged a total of 59 participants, all of whom lacked any prior exposure to meditation practices. These individuals were randomly divided into two primary groups: one was subjected to a two-week regimen of mindfulness training, requiring a daily 30-minute practice, while the other served as a control group that listened to an audiobook for the same duration each day. Furthermore, participants in both these primary groups were randomly directed to one of two conditions - depletion, which involved transcribing a text while withholding the letters 'e' and 'n', or non-depletion where transcription was performed without such constraints. Levels of self-control, evaluated using the Sustained Attention to Response Task (SART), were assessed at two distinct intervals: prior to the training, and after the two-week intervention period.

In accordance with Van Dam et al.'s (2018) proposal to specifically characterize contemplative practices, the unique features of our intervention are reported as follows. The participants in the mindfulness condition were greeted with a text on the web page containing the guided meditation recordings. It outlined the concepts of mindfulness, the autopilot mode, how mindfulness can help break this automaticity, possible the benefits of practicing mindfulness and the difference between informal (during daily activities) and formal (dedicated and undistracted time for mindfulness exercises)

mindfulness practice. Other than this text-based introduction, participants received no context or possibilities to clarify any doubts or queries regarding the practice. The guided meditations which participants listened to every day were 30 minutes each and consisted of the three essential practices of the standard MBSR course: body scan, sitting meditation, and mindful yoga. The person recording the meditations had more than a decade of meditation experience including multiple retreats and an MBSR course. Further features can be found in table 1.

Table 1. Primary features of the short-form MBP in our study

Feature	Variation in Feature
Arousal	medium
Orientation (of attention)	inward
Spatial "dynamic" (of attention)	both fixed and moving
Temporal "dynamic" (of attention)	constant
Object (of attention)	specific
Aperture (of attention)	Mostly narrow and some intermediate
Effort	medium

The study's findings were unexpected. Contrary to our initial hypotheses, the mindfulness training failed to yield any significant enhancements in self-control or attention. Notably, some measures even indicated a decline in performance. The intervention did not significantly diminish omission or commission errors, nor did it improve overall performance. Instead, the mindfulness intervention led to an increase in the coefficient of variation, a metric indicating inattention, and resulted in lower self-reported self-control scores as compared to the control group, raising questions about the efficacy of short-term mindfulness interventions in enhancing attentional control.

The study also explored the effects of ego depletion, referring to the theory that self-control or willpower is dependent on a finite pool of mental resources that can be exhausted. The results revealed that ego depletion was associated with an increase in commission errors and inattention (RT coefficient of variation), particularly in the second measurement, partially validating the hypothesis that depletion would negatively impact performance. The non-significant impact on omission errors contradicted the ego depletion hypothesis. While the results do not suggest a buffering effect of mindfulness on ego depletion, it nevertheless contributes to the ongoing discourse on ego depletion, favoring the process model of self-control over the resource model due to the ability of changes in motivation and attention to better explain the observed outcomes.

Taken together, these findings challenge the hypothesis that short-form mindfulness interventions readily improve self-control and attention. Instead, they highlight the complexities involved in implementing and evaluating such interventions, particularly those delivered purely via online platforms.

Chapter 3: The mechanisms and effects of analytical meditation

3.1 The characteristics of analytical meditation

Analytical meditation encompasses the practice of monastic debate (*riglam*), but is sometimes also classified as "self-debate" in its non-dyadic form (which involves the practitioner engaging in a mental dialogue with themselves, exploring various perspectives and arguments on a particular topic; van Vugt, Moye, Pollock, et al., 2019), which is why the terms will be used interchangeably, underscoring that this contemplative practice has both classically meditative aspects (e.g., emotion regulation, focused attention) as well as more unusual ones such as the verbal, dyadic and physical. Unlike classically solitary MBP meditations, Analytical meditation, when practiced as monastic debate, is a dyadic practice that typically involves two participants: a challenger and a defender (Dreyfus, 2011; Liberman, 2015; Perdue, 1992, 2014), although it may involve multiple challengers and defenders. Analytical meditation has been an integral part of the Tibetan Buddhist Gelug tradition[1] for centuries, being devised in its current form by Chapa Chökyi Senge in the twelfth century (Liberman, 2007). It serves as a complement to meditation

[1] The Gelug tradition is one of the four main Buddhist schools in Tibet. The three other schools are the Nyingma, Kagyu, and Sakya, which have added debate to their curricula to varying degrees in the recent past.

practices aimed at stabilizing the mind through focus on a single object (*ché gom*)[2], such as mindfulness of breath or through objectless focus (*jok gom*). Unlike stabilizing meditation practices (i.e., focused attention meditation) that primarily quiet the mind, analytical meditation emphasizes insight; specifically into the causes and conditions of subjective experience in order to help practitioners eliminate unnecessary psychological suffering. The ultimate goal is to achieve enduring states of happiness and equanimity by eradicating harmful emotions and motivations, like anger and selfish desire, and fostering beneficial ones, such as compassion and altruism. This goal is pursued with a unitary focus, where every cultivated trait or skill, including logic and analytical abilities, is seen not as an end in itself but as a tool to further this objective. This point, as we later learned in the process of making sense of unexpected findings (see chapter 4.4), is particularly crucial because it differentiates analytical meditation from other cognitive practices that may also use similar mechanisms, such as Western forms of debate or logical reasoning exercises.

Tibetan monastic debate distinguishes itself from Western forms of debate not only in its physical setting, but also in its very essence. The objective is not to persuade the opponent of a particular viewpoint, but to uncover inconsistencies in their reasoning in order to facilitate their process of gaining first-person insights into the nature of reality[3]. A further difference concerns the topics, which revolve around Buddhist philosophical issues rather than current affairs or politically charged subjects. The debates take place in a formalized setting, with the defenders sitting and the challengers standing. The defender is tasked with maintaining a coherent intellectual stance, while the challenger strives to expose the defender to different perspectives of the argument, promoting clearer thinking. The challenger's role is two-fold: to identify the inconsistencies in the defender's argument and to attempt to refute the defender's claims, while the defender's duty is to counter the challenger's arguments and avoid logically untenable positions. Deductive logic offers some explanation for the nuances of the debate, but the outcome of the debate is not predetermined and it can therefore not be reduced to a purely logical process.

A distinctive physical form accompanies the debate with the challenger standing over the seated defender, clapping their hands together to mark a point of argument or a question. The clap is not just a dramatic element; it symbolizes the destruction of ignorance and the revelation of truth. The defender, in turn, is expected to respond to each point made by the challenger with measured calm, demonstrating both emotional and intellectual control. Standing is believed to sharpen the speed and clarity of thought, while keeping physically active (i.e., clapping, paired with energetic gestures) enables the monastics to sustain the debate for extended periods (Dreyfus, 2003).

Typically, the debate itself is preceded by a rigorous phase of memorization, wherein the participants immerse themselves in the philosophical texts currently relevant in their curriculum. These texts serve as the foundation for contemplation and form the subject matter for the ensuing debate (Dreyfus, 2003; van Vugt, Moye, Pollock, et al., 2019). Adequate memorization of the components and terms of the respective text is assessed at the beginning of a debate session, in a so-called counting debate. This ensures that both participants are well-versed in the subject matter through a collective recollection of the definitions, outline, and enumerations. This initial assessment is essentially a test of rote learning[4], which is followed by so-called logic debates, which require the participants to engage in a deep analysis of the concepts, arguments, and counter-arguments contained within and derivable from these texts and ones they have internalized earlier in the curriculum (Lama, 2018).

Although the majority of debaters are male monastics, the practice is not exclusive to them. Nuns, too, actively engage in these rigorous intellectual exercises, even though their involvement has not been as

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[2] The Gelug tradition teaches stabilizing mostly through theoretical discourse and there is typically no formal training offered, resulting in Gelukpas spending very little time on this endeavor, while training for many hours a day in analytical meditation.

[3] Although renowned Tibetan Buddhism scholars, like Hopkins (2001), have pointed out that intellectual dominance struggles, contrary to the debate's core purpose, can occur in Tibetan monastic debates. Furthermore, anthropologist and linguist Michael Lempert (2012), during his extensive stay at the Sera Monastery, identified ritualized aggression as a common feature in monastic debates and student discipline. Lempert posits that these aggressive acts, far from being wanton, are fundamental rituals fostering order and communal solidarity. However, contemporary societal norms and the Dalai Lama's progressive views have prompted conservative monasteries like Sera Jey to begin reforming these practices since the early 2000s. Reports of such animosity and discipline were partially corroborated in our discussions and interviews with monastics during fieldwork.

[4] It is however noteworthy that newer generations, particularly the non-Tibetan monastics among them, hold divergent views towards these traditions, especially in regards to the extensive memorization involved, being influenced by cultural exchanges and the nuances of modern learning methodologies. The implications of this evolution on the efficacy and essence of the practice warrant further investigation.

widely recognized or documented. And while our empirical research only involved monks, we also had the opportunity to interview several nuns. Their enthusiasm for the practice and their intellectual abilities were evident, underscoring the fact that the tradition of Tibetan monastic debate is not gender-exclusive.[5]

As with our short-form MBP, the unique features of analytical meditation are reported in accordance with Van Dam et al.'s (2018) proposal in table 2.

Table 2. Primary features of monastic debate

Feature	Variation in Feature
Arousal	high
Orientation (of attention)	both internal (memory and logic) and outward (opponents' words)
Spatial "dynamic" (of attention)	neither fixed nor moving as the focus is on the semantic
Temporal "dynamic" (of attention)	constant
Object (of attention)	many specific objects
Aperture (of attention)	Mostly narrow and some intermediate (semantic versus sensory focus)
Effort	high for novices, medium for adepts

3.2 Reasons for studying analytical meditation

The functions of such debates are manifold. They serve to incentivize participants to engage in deep memorization and learning (as failing to do so can lead to public embarrassment), to dispel any lingering doubts, to foster the development of critical thinking skills, and to facilitate the acquisition of a comprehensive, enduring, and holistic understanding of a specific subject matter. Furthermore, these insights gained in the context of such debates are said to be instrumental in nurturing traits of compassion and gentleness (Perdue, 2014; van Vugt, Moye, Pollock, et al., 2019). The debate process is moreover inherently social, involving continuous inter-subjective exchange and assessment of knowledge. Consequently, it is plausible that monastic individuals develop robust abilities to discern their counterpart's mental and emotional states, equipping them to identify and exploit any vulnerabilities in their argumentative stance. This social dimension, coupled with the intellectual rigor of the practice, is said to create an environment conducive to the refinement of critical thinking and empathetic engagement. Monastics can undergo training that lasts up to 25 years and typically engage in debate practice up to five hours a day to hone their cognitive and emotional skills. The training in Tibetan monastic debate, therefore, presents a fascinating blend of intellectual rigor, emotional training, and interpersonal dynamics, offering a rich terrain for exploring mechanisms of cognitive and emotional transformation. By exploring the subtleties of this ancient tradition, scientific research may inform modern practices in education, psychology, mental health, degenerative disease prevention in elderly populations, and personal development in general (van Vugt, Moye, Pollock, et al., 2019). Such research may further contribute to a broader understanding of cognitive and emotional processes and outcomes in individuals who commit to years of unwavering and rigorous focus on a given training. In a sense, this parallels the dedication observed in high-performance athletes who invest substantial amounts of time and energy in mastering a very specific skill, resulting in remarkable physical accomplishments and traits. While studies on long-term practitioners of more commonly known meditation forms, including mindfulness, transcendental, Zen and loving-kindness, have revealed a spectrum of impressive cognitive and emotional benefits (e.g., Grant et al., 2011; Lutz et al., 2004; Pagnoni & Cekic, 2007), the distinctive features of long-term Tibetan monastic debate suggest that this practice may yield divergent and novel long-term outcomes.

Especially the potential insights relevant to modern pedagogical practices (e.g., Pierce, 2021) were of particular interest at the outset of the still ongoing research project of which three of four studies presented in this thesis are a part. The main goals of this project are two-fold: to investigate the cognitive and emotional impact of long-term debate training, and to examine the mechanisms underlying single

[5] However, the issue of gender equality within Tibetan monastic orders continues to be intricate and unresolved. Tibetan monastic customs, including the Gelug tradition, have long permitted women to enter the nunhood, but the status conferred upon them and their progression opportunities have been historically restricted, in stark contrast to their male colleagues. Full recognition of nuns' studies was traditionally absent in Tibetan Buddhism. However, a recent shift towards inclusivity has observed some Tibetan nuns receiving such recognition.

sessions of debate practice. This project is particularly significant as it appears to be the sole endeavor currently producing empirical work on Tibetan monastic debate. As has been noted in the introduction of this thesis, the field of contemplative studies has been largely dominated by research on mindfulness and concentration meditation, predominantly practiced within Western contexts, with a particular emphasis on their clinical applications (Kabat-Zinn, 2003; Kuyken et al., 2015). While there has been some recent interest in exploring the fundamental principles and therapeutic potentials of compassion-based practices (Desbordes et al., 2012; Lutz, Brefczynski-Lewis, et al., 2008; Pace et al., 2009), the scope of these investigations remains fairly limited and has left a significant gap in our understanding of other contemplative practices (Davidson & Dahl, 2017), especially those embedded in a rich historical and cultural context such as Tibetan monastic debate. Even when considering the greater research feasibility of standardized and secularized contemplative practices such as MBPs, it is surprising how little research has been conducted on this topic, given the unique context and rich potential for understanding complex cognitive and emotional processes.

3.3 Summary and results of study 2

In study 2, we focused on the neural correlates of Tibetan monastic debate, with a particular focus on inter-brain synchronization and absorption. Electroencephalography (EEG) measurements (32-channels per participant at 512 Hz) and video recordings were captured simultaneously with the intent of subsequent identification and labeling of instances of agreement, disagreement, and other relevant categorizations. The data consisted of two batches: the exploratory dataset A with 26 participant pairs and the more controlled and internally reliable dataset B with 100 participant pairs. We chose to investigate frequency bands as opposed to time-locked measures such as event related potentials, as they are more suited to the dynamic (i.a., physically) and continuous nature of debate. Our primary areas of interest were frontal midline theta oscillations (often linked with absorption and cognitive control, as well sustained attention during meditation practices; Cavanagh et al., 2013), and inter-brain synchrony. In order to measure inter-brain synchrony, we employed EEG hyperscanning, a method that has proven useful in observing synchronization between two individuals' brains across various contexts such as during cooperative activities like a prisoner's dilemma task (Babiloni et al., 2007) or joint musical improvisation (Müller et al., 2013), as well as successful therapy interventions (Koole & Tschacher, 2016).

The analyses of our data revealed distinct outcomes in synchronization, specifically in the frontal alpha inter-brain synchronization, which showed significant differences between instances of agreement and disagreement. While this was the case in both the exploratory dataset A and more controlled dataset B, the effect of experience on this measure only manifested in dataset A. However, there was a significant interaction between experience and agreement/disagreement in dataset B, suggesting that more experienced monastics demonstrated a larger difference in frontal alpha synchronization when in agreement versus disagreement.

In addition, the analysis of mid-frontal theta oscillations presented a compelling pattern. In dataset A, the role of the debater did not significantly impact the slope of these oscillations (i.e., increase in z-transformed theta power). However, experience was found to lead to a steeper increase over the course of the debate, especially when debating with someone from a different class, a strong effect which was predicted by our monastic collaborators. The effect of experience on the slope was also observed in dataset B, especially for the Fz electrode. The type of debate (counting versus logic) did not significantly influence the theta oscillations, although a weak interaction was observed with experience. Experienced debaters showed a significant slope for both counting and logic debates while novices only showed this for logic debates, especially for the Fz electrode. Finally, we examined the correlation between theta oscillations and inter-brain synchronization. In dataset A, there was a significant positive correlation. However, in dataset B, this correlation was non-significant, with the bayes factor indicating some evidence for an absence of correlation, both in counting and logic debates.

Although not all hypotheses were confirmed, the overall pattern of neural findings is compatible with the idea that more experience in monastic debate leads to more efficient and focused cognitive processing, as well as an increased amount of distinction in synchronization during agreement and disagreement. This may imply that the long-term practice of Tibetan monastic debate not only influences cognitive abilities, but also interpersonal dynamics. The data furthermore contributes to the ongoing debate on the role of inter-brain synchrony in social interactions and collaborative tasks, providing compelling evidence that the level of agreement in a dyad can influence inter-brain synchronization. This implies that inter-brain synchrony tracks more than just shared attention in a given moment – it may also reflect the degree of associated information in working memory among interacting parties. The differential impact of debate type on theta power and inter-brain synchrony further underscores the complexity of

these interactions, hinting at a nuanced interplay between cognitive load, experience level, and the nature of the task at hand, which may modulate both theta power and the degree of inter-brain synchrony.

3.4 Summary and results of study 3

Study 3 consisted of a comprehensive review of the extant literature concerning monastic debate and analytical meditation, offering a thorough introduction to the practice, positioning it within the broader context of contemplative practices and other debate formats. Drawing from dialogues and interviews with Tibetan monastic collaborators and advanced students at Sera Jey Monastic University, alongside preliminary experimental work, we formulated an initial theory and biobehavioral model that sheds light on the psychological underpinnings of this practice, postulating that it engages the brain's memory and cognitive control systems, emotional regulation capabilities, and potentially gives rise to novel understandings of reality. We hypothesized that effective debating necessitates a robust set of skills, including but not limited to, reasoning and critical thinking, focused attention, working memory, emotional regulation, confidence in one's own reasoning abilities, and a sense of social connectedness.

In order to validate our theoretical model and our monastic collaborators' hypotheses, we conducted an in-depth quantitative analysis of debate events, contrasting logic debates with counting debates. This part of Study 3 examined the same video datasets as Study 2, but instead of investigating EEG data correlations, focused on a detailed examination of event categories within the videos. Our findings revealed that in logic debates, time spent in disagreement mirrored that of agreement, whereas counting debates predominantly involved agreement. The defender often faced more challenges than the challenger during the debates. Logic debates lead to more difficult situations for debaters compared to counting debates, with increased instances of both focus and distraction. Lastly, difficulty in memory recall was more frequently observed in counting debates. All these findings supported our predictions and validated our model.

We also turned our attention to the functional dimensions of the phenomenological matrix, a tool for classification developed by Lutz et al. (2015), and the position of monastic debate within these dimension, proposing that monastic debate, while not directly aligning with either the categories of focused attention meditation or open monitoring meditation, exhibits shared characteristics with both. In addition, we probed the potential applications of debate in Western educational systems and psychological health, proposing it as a potent pedagogical instrument for honing critical thinking skills and bolstering student motivation. Furthermore, we suggested the possibility of skills nurtured through debate contributing to well-being and acting as protective factors against depressive relapses. Finally, emphasizing the challenges inherent in examining monastic debate, we outlined the complexities of cultural sensitivity, language barriers, and the requisite development of novel measures that align with the mental habits and cognitive experiences of Tibetan monastics. We underscored the necessity for a collaborative methodology that incorporates monastics trained in scientific paradigms, thus ensuring a more comprehensive understanding of the practice.

Chapter 4: Abstraction and the importance of cross-cultural research

4.1 The Uniqueness of Tibetan Monastic Culture

As delineated in the last chapter, analytical meditation presents a unique and rich opportunity to study cognitive and emotional changes as well as the opportunity to expand the research on contemplative practices beyond the traditional focus on mindfulness and compassion meditation. However, not only the practice of debate, but also the collaborative research with and on Tibetan monastics, and thus the Tibetan monastic tradition as whole, provides a unique lens to explore human cognition and behavior in a distinct context. Tibetan culture, due to its geographical isolation in the Himalayas, has remained relatively untouched by Western influences for centuries, thereby offering a rare glimpse into a unique cultural and cognitive context. In addition, the Tibetan monastic culture is a prime example of a highly literate and distinctly non-western society that has fostered a sophisticated system of information processing, encompassing logical reasoning, philosophy, and psychology. The existing comparisons of psychological functions between Western and non-Western cultures (e.g., Cole, 1971; Ross & Millsom, 1970; Segall et al., 1963) often compare Western populations with non-literate or semi-literate societies, many of which do not prioritize the development of advanced information systems, such as the scientific method, mathematics, abstraction, and logical reasoning. Consequently, these comparisons may inadvertently reflect a Western bias towards academic education, rather than providing a comprehensive understanding of cognitive differences across cultures.

4.2 The WEIRD bias

Research conducted with participants from rare populations such as the Tibetan monastic one is valuable for a further reason: it offers a counterpoint to the Western-centric bias prevalent in cognitive science literature. This bias, often implicit, presents findings on cognitive capacities like attention, perception, memory, and decision making as culture-neutral, a perspective that is fundamentally flawed. The cultural context is not merely a backdrop against which cognitive functions unfold; it likely forms an integral part of these processes (Greenfield, 1997; Nisbett et al., 2001). Cultural environments may even shape fundamental functions such as elementary perception. For instance, Segall et al. (1963) found that non-Western participants were less susceptible to certain optical illusions. But there are also compelling findings in the realm of higher cognitive functions. For example, research has revealed significant cultural differences in the way individuals categorize objects (Masuda & Nisbett, 2001), reason about causality (Morris & Peng, 1994), and even perceive and remember events (Wang & Ross, 2007). Moreover, high level traits such as cognitive styles, seem to be culturally contingent as well. For instance, the dichotomy between holistic and analytic thinking, is one such cognitive style that is significantly influenced by cultural factors (Nisbett et al., 2001; Nisbett & Masuda, 2003), analytical thinking being more prevalent in Western cultures, while holistic thinking is more common in East Asian cultures.

It is in the context of such findings that the unrepresentative nature of publications in cognitive science and psychology as whole has led to the coining of the term 'WEIRD' (Western, Educated, Industrialized, Rich, Democratic) to describe the overwhelmingly dominant demographic in such research (Henrich et al., 2010). This term has gained traction in the field of cross-cultural research, underscoring the pressing need to diversify the samples used in psychological studies. The over-reliance on WEIRD populations raises concerns about the purported universality of many psychological phenomena. For instance, many aspects of cognitive functioning, emotional responses, and social behaviors are often extrapolated from a narrow slice of humanity, primarily Western psychology undergraduates.

4.3 Obstacles in field research

Even though the Tibetan monastic culture presents an invaluable control condition, it is not without its unique set of challenges. The setting of the Sera Jey monastic university in Bylakuppe, India, while rich in cultural heritage and tradition, posed an array of practical issues. During our fieldwork visits, issues such as the frequent power losses and the energetic clapping and stamping of the debaters during debates made it challenging to set up and maintain the EEG equipment. Additionally, the task of organizing debates and experiments in a foreign language, logistics intermediated through various monastic administrators and ultimately the translators on site presented considerable cross-cultural hurdles. Further, working together with our monastic collaborators was a complex endeavor, requiring meticulous attention to detail and a deep understanding of the cultural nuances and practices involved in the debates. On the part of our monastic collaborators an equal amount of patience, flexibility, and dedication was needed to understand and translate what the scientific requirements and protocols implied, that we involved them in. Thus, establishing and maintaining mutual trust and cultural sensitivity was and remains a constant and crucial endeavor in this project. Surprisingly, the greatest challenges were not the overt issues of EEG equipment maintenance or translation. Instead, the more subtle task of implementing and interpreting behavioral tasks emerged as the most significant cultural hurdle.

4.4 Summary and results of study 4

Study 4 provides an in-depth examination of three distinct behavioral tasks: complex working memory, association memory, and a logic task. These tasks were originally designed and implemented with the objective of gaining a better understanding of the outcomes of prolonged training in analytical meditation. The results, however, proved to be enigmatic. As such, the focus of the publication was redirected towards a detailed exploration of cross-cultural factors, which continue to influence the ongoing field research in unpredictable and challenging ways. Study 4 thus serves to document and provide commentary on the intricate process of conducting field research that is inherently cross-cultural in nature.

The three tasks consisted of a complex working memory (CWM) task, an association memory task (AM) and a logic task. In the CWM participants were asked to remember and recall a sequence of target locations while solving a spatial distractor task. The AM task required participants to remember pairs of unrelated words and later identify them among foils in a recognition test. The logic task was made up of multiple-choice questions requiring deductive reasoning of different types. The project has included more behavioral tasks to date (emotional regulation task, decentering task, dictator game and delay discounting), which proved to be similarly enigmatic and unexpected as the three tasks analyzed in detail in study 4. We however confined the study to the cognitive outcomes as they represent a broad yet

coherent set of measurements. Despite their differences, all these measures share a common thread - they assess the cognitive abilities that are central to analytical thinking and memory.

We initially hypothesized that the experienced Tibetan monks, due to their extensive training in analytical meditation, would outperform the novice monks and perform comparably to Western undergraduate students in all three tasks. Contrary to our expectations, the Western students significantly and clearly outperformed both groups of monks in all three measures. The novice monks, interestingly, outperformed the experienced monks in both the complex working memory task and the association memory task, but not in the logic task. The latter task, which most closely mirrors the monks' training, showed a slight, non-significant advantage for experienced monks. The differences in performance between the various groups frequently interacted with diverse variables, including span, flanker reaction time, condition, medium, and domain. This suggests that the observed group differences cannot be uniformly applied across all facets of the measures. The intricacies of these variations, therefore, also contribute to the respective literatures on complex working memory, association memory, and logic tasks, broadening our understanding of cognitive processes within and across different cultures.

Despite the overall pattern of results potentially implying that monastic training in analytical meditation is not particularly beneficial in enhancing cognitive performance (when measured through the lens of Western tasks), a more nuanced and ultimately more convincing interpretation emerged. When keeping in mind that neural and behavioral indices in a naturalistic setting (debating about actual topics relevant to the monastic curriculum) were in line with the expected improvements, it becomes clear that our data is also compatible with the hypothesis that monastic training fosters a distinct form of cognitive processing, which may not align with the norms and assumptions underlying Western cognitive tasks. Indeed, when re-examining our findings through the lens of cross-cultural differences, a compelling narrative surfaced. The discussion of study 4 argues that the familiarity with a given task and thus the similarity to the monks' day to day training significantly influenced the performance. The complex working memory (CWM) task as well as the association memory (AM) task deviated the most from the monks' typical cognitive exercises. The abstract visual stimuli in the CWM task and the arbitrary and meaningless word pairs in the AM task were far removed from the monks' usual training, which involves memorizing and debating meaningful, holistically embedded, verbally presented information. Crucially, these tasks showed the greatest deviation from our expectations. The logic task, in which the experienced monks' showed a non-significant trend of advantage over the novices and a smaller gap relative to the Western control group, was closer to the debaters' core Expertise. Study 4 goes into great detail how nuanced cross-cultural differences in theory and application of logic may have contributed to the monastic adepts' relative underperformance. And lastly, in the context of actual debate performance (which we assessed in detail via EEG and rating frequencies; Kaushik et al., 2022; van Vugt et al., 2020; van Vugt, Moye, Pollock, et al., 2019) the experienced monks' proficiency was evident, suggesting that the Western measures might lack the cultural and contextual specificity required to accurately assess their cognitive abilities. A key takeaway from our research was that, although we tried to account for cultural differences ahead of and during the research process (e.g., by extensively interviewing participants and including our monastic collaborators in every step of the process), many of our measurement tools were still inherently biased towards Western norms and assumptions. One such inherent bias may be the use of abstract stimuli and abstract settings, which we assumed would be helpful in removing cultural biases. However, it seems that the abstraction itself is a Western virtue and may not be as universal or culture-free as we initially thought. In the process of making sense of the unexpected results we learned that, abstracting and extrapolating beyond the monastic curriculum is not only unappreciated in the monastic tradition, but at times actively discouraged. The focus of the training is on the ultimate goal of eliminating suffering at a personal and fundamental level, and not on intellectual prowess or abstract thought as means in themselves. It therefore seems plausible, that even though our collaborators did their best to convey the emphasis on the importance of our research (i.a., for the Tibetan community) in their translations, that the abstract and foreign nature of our tasks, would have seemed not only unfamiliar but highly irrelevant to the monastic participants, leading to underperformance.

Chapter 5: General discussion and conclusion

This thesis set out to address a gap in the current understanding of contemplative practices, focusing on lesser-explored techniques such as analytical meditation and short-form mindfulness interventions. Through a deep dive into these practices, this work has sought to provide a more nuanced understanding of their effects, potential benefits, boundary conditions and limitations.

5.1 Benefits and limitations of secularized short-form MBPs

As reported, the findings of our short-form mindfulness intervention in the realm of self-control were contrary to our initial expectations. There were even indications of mindfulness leading to less self-control and attention. While this is unexpected, it does not necessarily suggest that mindfulness interventions, let alone contemplative practices as a whole, are ineffective. Instead, it highlights that the context in which contemplative practices are implemented, the manner in which they are understood and practiced by individuals can greatly impact their effectiveness. While the secularized and essentially trimmed versions of traditional forms (i.e., MBPs) have proven to be beneficial in various contexts, our findings add to arguments presented by van Dam et al. (2018), which indicate a ‚hype' around mindfulness practices that is not entirely supported by empirical evidence. Mindfulness is unlikely to be a silver bullet solution for all mental health and cognitive issues, and its effect may significantly vary based on the individual's understanding and application of the practice (Grossman, 2019).

Such understanding is likely to exhibit greater variability in 'spin-off' MBPs, such as short-form and brief MBPs, compared to their more traditional, as well as secularized long-form counterparts. The latter plausibly provide a more comprehensive and consistent experience of mindfulness, potentially leading to more stable and predictable outcomes. In contrast, the effects of short-form and brief MBPs on measures related to our study, have indeed been found to vary across different studies (Basso et al., 2019; Bennike et al., 2017; Creswell, 2017; Morrison et al., 2014), finding different patterns of effects in errors of omission, commission and reaction time coefficient of variation (RT CV). Such variation is not entirely unexpected, given the shorter duration and lack of standardization in these types of interventions.

Moreover, the aspiration to identify a 'sweet spot' between minimal duration, maximum scalability, feasibility, and effectiveness, while enticing, could be considered somewhat idealistic. It would indeed be surprising if a purely online format, offering a condensed exposure of just 7.5 hours over a two-week period, could generate robust effects on somewhat coarse and noisy behavioral measures such as self-control and attention. This is not to undermine the potential of such interventions in research and application (Davidson & Dahl, 2018), but rather to caution against over-expectation and underscore the need for further rigorous research to ascertain their true impact and optimal implementation. Thus, while our study may be seen as a venture of high stakes and potentially high returns, its outcomes did not align with our initial hypotheses. Nevertheless, it has offered us valuable insights into the intricate weave of factors that come into play when implementing mindfulness interventions, thus enriching our understanding of the field.

Our inability to corroborate our initial hypotheses can be broadly traced back to two main factors: the modification of our outcome task (a perceptual SART without embeddings) and the exclusively online delivery of the guided meditations over a relatively brief span of time. The observation that a slight modification to the SART was sufficient to neutralize the expected effect underscores a potentially fragile correlation between short-form MBPs and self-control as well as attention. Therefore, while secularized mindfulness appears suitable for Western audiences, it nevertheless seems to require specific delivery methods to ensure effectiveness. Specifically the in-person dialogue between the teacher and participants that characterizes the standard MBSR (Mindfulness-Based Stress Reduction) and MBCT (Mindfulness-Based Cognitive Therapy) course formats is likely indispensable to achieving effective outcomes (Crane et al., 2017). The significance of these aspects may be attributed to the fact that secularized mindfulness has been significantly simplified, streamlined and removed from its philosophical and psychological roots, while also being a foreign concept in the context of Western culture and thought (Grossman, 2019). Furthermore, even when guided by a qualified teacher and within the structured environment of an 8-week MBSR or MBCT course, numerous Western participants encounter challenges in fully comprehending and applying the concept of mindfulness in their daily lives to its fullest potential (Van Dam et al., 2018).

One way to reintroduce part of the network of accompanying practices and philosophical underpinnings that are integral to traditional mindfulness practices is through the inclusion of ethical aspects such as compassion (Monteiro et al., 2015), which, although implicit in classical secularized 8-week formats, have still been shown to benefit from explicit instruction and practice (Gilbert & Choden, 2013; Neff & Germer, 2013). This is reflected in the emergence of compassion-based interventions such as Compassion Focused Therapy (CFT) and Mindful Self-Compassion (MSC), which have been found to offer significant benefits in areas including emotional regulation, interpersonal relationships, and overall well-being (Gilbert & Irons, 2009; Neff & Germer, 2013). Such findings highlight the importance of fostering a more holistic approach to mindfulness, which includes cognitive, ethical and emotional components.

5.2 Relating MBPs and monastic debate

The capacity of traditional contemplative practices, such as monastic debate, to excel in providing the kind of broad framework of understanding and meaning, which may be missing in MBPs (especially brief and short-form online formats), is noteworthy. These practices, often characterized by their in-person dialogue (e.g., regular teacher-student interviews, group discussions and of course debate), provide a rich tapestry of interaction and engagement that may prove beneficial in fostering more profound and lasting changes. However, as our research indicated, the capacity of monastic debate to foster the qualities it is designed to enhance may not necessarily translate into broader applicability, at least when evaluated using Western measures of effectiveness, which is something that MBPs, particularly those of suitable duration, seem to achieve successfully (Crane et al., 2017). This implies that traditional contemplative practices may be highly effective within their own cultural and philosophical contexts, but that their efficacy may diminish when removed from these contexts and cultural paradigms.

This discrepancy may well reflect the underlying cultural differences that have shaped these respective practices. MBPs for instance, were developed with a general applicability in mind, designed to cater to a broad range of individuals irrespective of their cultural or philosophical backgrounds (Kabat-Zinn & Hanh, 2009), aimed at enhancing self-awareness, emotional regulation, and cognitive flexibility among other things, rather than targeting a specific and narrow long-term goal such as enlightenment. The streamlined format aimed at a broad audience, however, may come at the cost of a more nuanced and precise understanding that is often inherent in more traditional practices such as monastic debate, which is deeply embedded within a specific cultural and philosophical framework. It is a practice that has been honed and refined over centuries, and as such its effectiveness may be intrinsically linked to its historical context.

While our investigation substantiates that analytical meditation, particularly when practiced within a Tibetan monastic environment, demonstrates a distinct divergence from Western MBPs, it simultaneously reveals some convergence in the neural correlates of these practices (particularly frontal theta; Aftanas & Golocheikine, 2001; Kubota et al., 2001). This implies that despite many overt differences that characterize these contemplative practices, they engage similar cognitive processes, suggesting a shared foundation. Consequently, the benefits derived from these practices, while exhibiting diverse manifestations, might originate from common roots, thereby contributing to partially overlapping outcomes. Such congruity is not unanticipated given that focused attention, open monitoring, and analytical meditation forms are all practiced within a single Tibetan monastic tradition, complementing each other in an interplay refined over centuries. However, the intriguing aspect lies in the fact that the Western adaptations of these solitary practices, despite their deliberate cultural extraction and separation, also demonstrate compatibility, as indicated by their neural correlates.

5.3 Future directions for research and development

This interplay of convergence and divergence between Western MBPs and traditional contemplative practices has intriguing implications when considering possibilities for the evolution of the former as well as hinting at the potential for secular adaptations of the latter to retain a significant degree of effectiveness, notwithstanding our research showing limitations in previous attempts at generalization by monastic participants (study 4). The shared neural correlates between MBPs and analytical meditation offer a promising narrative, one that implies that the secular integrations may yet achieve considerable levels of efficacy. For instance, existing dyadic facets (i.e., interactive elements between two individuals) of current MBPs, such as mindful dialogue, may be enriched by the integration of elements derived from monastic debate. However, it would likely be spin-off MBPs, particularly brief and short-form variations, that could particularly profit from incorporating elements that allow for deeper clarification and comprehension of mindfulness principles, potentially enhancing their effectiveness by addressing a significant limitation inherent in their design - the lack of opportunities for individuals to explore and develop a thorough understanding of the mindfulness concept. By integrating components inspired by traditional practices like monastic debate, these interventions might be better equipped to offer a more comprehensive, nuanced understanding of mindfulness, thereby better equipping participants to apply mindfulness principles in their everyday lives. Mortlock et al.'s (2022) pilot study on 'team mindfulness training' is a prime example of such integration. This novel MBP aims to mitigate stress at both individual and group levels, which, as the authors acknowledge, is reminiscent of collective practices observed in traditional contemplative settings.

A further area, where the integration of analytical meditation would be particularly valuable, is the educational setting. This sector, which we identified as a promising avenue for the incorporation of monastic debate principles in study 3, presents significant demands regarding the fostering of critical thinking skills (Holmes et al., 2015) and enhancing student motivation (Pintrich, 2003). As proposed in

study 3, the practice of debate (if adequately modified for application outside the monastic context) could potentially serve as an innovative pedagogical tool for the cultivation of these vital skills. In the course of a debate, practitioners engage in a dynamic process of adopting multiple perspectives, thereby honing their ability to nimbly navigate complex philosophical terrains in response to their opponent's assertions. They are also trained to discern the implications of divergent argumentative trajectories, which are all essential for identifying inconsistencies in an opponent's logic – capacities that are arguably at the heart of critical thinking. Adding to this, the invigorating nature of debate, with its inherent competitive element, dynamic physical and theatrical structure, serves to infuse an element of enthusiasm into the typically abstract and demanding subject matters (Dreyfus, 2008) such as technical grammatical issues. As described by MacPherson (2000), this lively approach to learning transforms the pedagogical process from a monotonous system of logical connections into a vibrant practice that can captivate participants. Secular Tibetan secondary schools have already recognized the benefits of this method, incorporating the monastic style and rules of debate into their teaching strategies (Byłów-Antkowiak, 2017).

As outlined in study 3, analytical meditation may furthermore serve a pivotal role in bolstering mental health. Significant deficits contributing to conditions such as major depressive disorder, including an inability to decenter and compromises in working memory and emotional control (Bernstein et al., 2015; Disner et al., 2011; Fresco et al., 2007; Koster et al., 2011), could potentially be addressed through the integration of analytical meditation, as the ability to cultivate decentering, improve working memory, and enhance emotion regulation are among the potential benefits derived from this practice.

5.4 Issues of methodology and cultural appropriation

However, the path to such integration is fraught with challenges. In order to successfully implement these traditional practices within a Western framework, more research needs to be conducted to understand the core elements and thus their potential adaptability. But as outlined in chapter 4, the endeavor of studying monastic debate empirically, despite its inherent worth, poses significant difficulties in meeting the stringent requirements of contemporary scientific methodology. As we discussed in study 3, one of the main challenges concerns the selection of conventional outcome parameters, such as self-report instruments and behavioral indicators, routinely employed for Western undergraduate subjects. These may prove to be unsuitable for individuals from distinct cultural traditions and socio-cultural contexts (Davidson & Harrington, 2002; Henrich et al., 2010), potentially producing misinterpretations or unanticipated outcomes. The adaptation of such measures to other demographics therefore necessitates extensive testing with proficient multilingual associates from the respective communities (Davidson & Harrington, 2002; van Vugt, Moye, Pollock, et al., 2019). However, even following ample adjustment and calibration, the specter of Western academic bias (e.g., the value of abstraction) may still surreptitiously infiltrate the design, as we discovered upon retrospective analysis of our behavioral tasks in study 4. Furthermore, when tasks are excessively tailored to accommodate a specific cultural background, they risk losing their comparability to established Western benchmarks, thereby undermining the validity of potential cross-cultural comparisons. And while psychophysiological measures (e.g., EEG, heart rate, respiration, skin conductance, pupil dilation, cortisol levels, etc.) may offer a seemingly objective approach to bypass cultural biases, they too are not devoid of their own set of limitations. For instance, as we can attest, maintaining standardized conditions in the field, especially in remote and poorly equipped locations, can pose a significant logistical challenge, significantly compromising the reliability and validity of the data collected. The setting of the Sera Jey monastery where we conducted our studies, although supportive of our research, definitely stretched the boundary of our technical and organizational capabilities. Moreover, while these measures provide valuable insight into physiological responses, they can only offer a partial picture, as they are unable to capture the complexity and vastness of human experience. Lastly, just like self-report and behavioral measures, psychophysiological measures also need to be interpreted within the cultural and socio-historical contexts of their subjects, as they are ultimately bound to the meaning of the correlates they seek to measure, which may vary across diverse cultural groups (Chiao & Ambady, 2007). Further methodological hurdles include the difficulty of finding adequate control groups, the issue of language translation and interpretation (automatic translation services are not available for Tibetan and most of the monastics do not speak English and fluency in Tibetan among Western scientists is even rarer), and context specific differences in motivation between subjects in different cultures.

Another hurdle in incorporating monastic debate principles into Western settings, such as education, is the risk of cultural appropriation. Cultural appropriation, essentially, refers to the act of borrowing or imitating aspects of a culture by individuals from a different cultural background, often without understanding or respect for their original context (Ziff & Rao, 1997), which can lead to a number of harmful consequences, including the erasure of cultural identities, the reinforcement of

stereotypes, and the commodification of cultural practices (Rogers, 2006). In the context of developing adaptations for Western settings, this could manifest as a superficial or distorted representation, devoid of their original cultural and philosophical underpinnings; a challenge bearing a striking resemblance to the issues encountered during the initial introduction and adaptation of MBPs (Kabat-Zinn, 2003; Monteiro et al., 2015). If traditional contemplative practices are secularized, westernized and repackaged as mere cognitive tools, the aforementioned problem of commodification may arise, divorcing the practices from their original cultural and philosophical contexts, potentially leading to a scenario where these time-honored practices, refined over centuries by the respective communities, are exploited for profit and prestige without reciprocating adequately (e.g., profiting from the sale of apps, online courses, training programs, etc. by Western entities without fair or any compensation to the originating communities). Such a scenario not only undermines the authenticity and integrity of these practices but also raises significant ethical concerns, as it would not only disregard the intellectual property rights of the Tibetan community, but also risks perpetuating power imbalances between the West and non-Western cultures. Such wholesale transplantations may ultimately contribute to the marginalization and erasure of the rich cultural traditions that these practices originate from (a pressure already bearing down on many indigenous cultures including the Tibetan one due to globalization[6]), reducing them to mere commodities in the global marketplace (Carrette & King, 2004). However, not only the economic aspect, but also the dimension of prestige and recognition is at stake. When these practices are appropriated without due credit or understanding (e.g., the not so Tibetan 'the Tibetan book of the dead'; Lopez, 2011), it can contribute to the erasure of the originators' contributions, further exacerbating the power imbalance and leading to a form of 'cultural invisibility', where the original holders of the knowledge are sidelined in favor of Western interpretations and adaptations (Shome, 1996).

In order to attenuate the risks of cultural appropriation and address methodological obstacles, an exceptional level of cultural sensitivity and competency is paramount. Thus, as we have argued in depth in study 3, the inclusion of Tibetan monastics in the research team becomes an irrefutable necessity. This necessity is underscored by two principal reasons. First, due to their profound immersion in the Tibetan monastic tradition, these monastics provide invaluable insights into analytical meditation and debate, enabling the framing of precise and well-informed scientific inquiries. The second crucial factor centers on the practical necessity of overcoming the language barrier posed by the lack of fluency in Tibetan amongst Western scientists[7]. Bilingual monastics well-versed in Western languages therefore play an instrumental role, facilitating communication and instruction, as well as guiding their fellow monastics through the study procedures and translating the research findings back to the community. This final step is particularly important, ensuring that the community from which the knowledge originates remains informed and involved in the proceedings. Additionally, fostering a spirit of mutual respect and shared decision-making in the research process can help mitigate power imbalances and cultivate a more equitable, collaborative dynamic. The successful incorporation of monastics in the research process, in turn, necessitates their scientific training. The recent surge in initiatives aimed at enhancing the scientific education of Tibetan monastics (Desbordes & Negi, 2013; Hasenkamp & White, 2017; Sager, 2013) presents a valuable opportunity for cross-cultural collaborations in the exploration of monastic debate. This symbiotic model allows monastics, trained in the scientific method, not only to participate in the empirical investigation of monastic debate, but also to enrich their understanding of practical science applications. As we have posited in study 3, this dual-educational framework provides a central channel through which we can begin to unravel the complexities of monastic debate from a Western scientific perspective – notwithstanding its pre-existing elucidation within Tibetan Buddhist philosophy – while simultaneously offering tangible societal benefits across both Western and Eastern cultures. Conducting research in this manner not only contributes to building healthy, reciprocal relationships between different cultures, but can ideally also provide a new perspective on how traditional practices can be adapted for modern contexts without losing their original essence.

In the context of our research project, the aforementioned considerations were all taken to heart and implemented earnestly. The team was made up of diverse collaborators including a substantial number of Tibetan monastics from the very beginning, actively participating throughout the research

[6] Although, as outlined in previous footnotes, the influences of modernity on Tibetan monastic culture are likely to be a mixed blessing when taking the increased recognition of female monastics and the reformation of disciplinary practices into account.

[7] A non-mutually exclusive approach to addressing this issue is the inclusion of researchers of Tibetan Studies and Tibetology, renowned for their exceptional Tibetan language skills.

process and were thus included as equal contributors and co-authors on the majority of publications arising from this collaboration.

5.5 Innovation and flexibility in field research

Addressing the complexities of examining analytical meditation arguably requires a steadfast, resilient disposition, prepared to weather setbacks, whilst maintaining an active vigilance for potential misinterpretations. Yet, I would argue, it also demands an innovative spirit, as demonstrated by the unique amalgamation of methods and tools in the project. This includes the classification of EEG recordings from debating monks through video rating by our monastic collaborators. These were subsequently analyzed using machine learning approaches (Kaushik et al., 2022), and compared with the outputs of computational models; all while engaging in regular dialogue with the monastics. This fusion of traditional and modern methodologies as well as the collaborative, iterative nature of this approach, I would posit, is central for ensuring that the research remains grounded in authentic Tibetan practices, while also maximizing the potential for novel insights and theoretical development.

Thus, in light of the numerous methodological challenges, we opted to diversify our research methods early on in the project. One such method that proved highly effective was the application of the 'debate robot'. As elaborated in our previous discussions (van Vugt, Moye, & Sivakumar, 2019), computational modeling provides a potent tool for advancing our understanding of meditation (for instance focused attention meditation, Moye & Van Vugt, 2019). Consequently, Riegl and van Vugt (2020) harnessed this approach in their exploration of monastic debate. This 'debate robot' provided an enriched foundation for further deliberation and hypothesis formation with our Tibetan monastic collaborators. The novel use of computational modeling created a platform for the integration of traditional knowledge and modern research methods, enhancing the depth and breadth of our investigation.

Bridging the gap between traditional practices and modern methodologies, our next phase of research employed machine learning, delving into the exploration of EEG and video datasets (the same as studies 2 and 3), a process that not only reinforced our previous findings but also provided a more refined understanding of the intricate dynamics of attention and distraction during meditation. The results included significant changes in left frontal alpha, left parietal theta, and central delta when comparing instances of attention versus distraction. In addition, novice individuals displayed more distraction, suggesting debate training improves attention. The machine learning techniques, particularly the LSTM model, predicted attention and distraction states with high accuracy (up to 95.86%), highlighting the potential of these techniques in real-world settings. However, this success was largely dependent on the precision of annotation in dataset A, a fact underscored by the lower accuracy rates in the less meticulously annotated dataset B (mainly because as there was a broader range of labels). This underscores the pivotal role that our scientific training, close cooperation, and constant dialogue with the monastic raters played in ensuring data accuracy. Their expert insights and understanding were instrumental in achieving this precision, emphasizing the importance of such collaborations in research of this nature. Despite the precision of dataset B not fully meeting the stringent standards for high machine learning performance, we were nonetheless able to demonstrate that EEG data, when collected in real-world settings, can be used to predict attention states with high accuracy, showcasing the potential for innovative applications into Brain-Computer Interfaces and other everyday life settings.

Of course, not all innovations yielded the intended outcomes. For instance, we invested considerable effort into the creation of an extensive rating schema. This schema was designed to encapsulate all standard responses and requisites that both challengers and defenders may present, such as requests for definitions, deriving consequences, giving reasons, quoting scripture, asking for explanation, accepting, asking why, rejecting the reason, rejecting the relevance of a reason, among others. Additionally, it aimed to capture varying emotional and cognitive states, ranging from unfocused to highly focused states, and from rigorous to jovial, fearful, recollective, uncertain, and so forth. While the development of this schema undoubtedly enhanced the understanding of the Western researchers in the team and fostered dialogues, its comprehensive nature may have rendered it too tedious for the monastic raters, leading to its underutilization, although the exact reason remains unclear. Nevertheless, this exercise underscored the importance of balancing comprehensive inquiry with practical applicability in cross-cultural research endeavors.

5.6 Preservation and adaptation: the future of Tibetan monastic practices

Given the discussed challenges and potential innovations to address them, this next section examines their implications for the continuity and evolution of Tibetan monastic practices. Navigating the research terrain of Tibetan monastic practices is admittedly a complex and challenging endeavor, laden

with both methodological and cultural intricacies. However, as indicated in the discussion thus far, the potential yield of such exploration is substantial, particularly regarding the development of adaptations and the elucidation of exceptional mental accomplishments. Beyond its intrinsic academic merits, such investigation further possesses the capacity to spark an increased interest in the relatively untapped research area of Tibetan monastic practices. Not only would this augment the breadth of literature on contemplative practices, but it might also be one small step in enhancing the representativeness of samples in cognitive science and psychology. This is especially significant given the aforementioned disproportionate reliance on WEIRD samples (Henrich et al., 2010), which poses a paradoxical hurdle while attempting to conduct research involving non-WEIRD samples, as exemplified by the Tibetan monastic community. In light of issues such as the absence of standardized benchmarks and appropriate task adaptations suitable for such unique populations, the methodological obstacles to successful investigation are magnified and the incentives to conduct research in the first place are diminished. Nevertheless, it is precisely through the initiation and perpetuation of such challenging lines of inquiry that methodological rigor can be extended to accommodate a broader spectrum of cultures, mental practices, and cognitive phenomena. Even though the preliminary forays into these populations may be fraught with complexities, they serve to pave the way for more nuanced research approaches and greater representativeness in empirical studies. These strides towards diversification entail an iterative process of refining our scientific investigations, encompassing not only the improvement of methodologies but also the broadening of our understanding of human cognition.

Ideally, Tibetan samples (lay and monastic) would be included in future research of general ostensibly universal cognitive processes, thus providing a more comprehensive understanding of the human mind and its capacities. As our research project has demonstrated, the significant contribution that samples drawn from Tibetan monastic communities can make extends beyond merely enhancing the cross-cultural psychology or Tibetan monastic research niches. Our investigations have yielded valuable insights in various fields, including the understanding of inter-brain synchronization in collaborative environments as well as the advancement of machine learning in the area of brain-computer interfaces (BCI's) with EEG data collected in naturalistic settings. This work provides not solely dense, empirical data, but also offers evidence that gaining generalizable insights from non-WEIRD samples is not only feasible but also holds promise for a more nuanced understanding of human cognition.

A surge in interest and research in the Tibetan community would, moreover, be particularly timely considering the imminent threat of rapid change and potential dissolution facing Tibetan culture and monastic traditions due to the forces of globalization and political pressures. The process of studying and documenting their rich practices such as monastic debate or putative postmortem meditation states (thukdam; Lott et al., 2021), alongside exploring their potential adaptations and applications in various contexts, could consequently serve as a vital contribution towards the preservation of this unique and invaluable cultural heritage. As the Tibetan monastic culture undergoes inevitable transformations, this research – if conducted with the appropriate cultural sensitivity – could potentially offer a lifeline, preserving the essence of these practices and ensuring their continuity.

5.7 Conclusion

This thesis has shed light on lesser-known aspects of contemplative practices, particularly Tibetan monastic debate and to a lesser degree short-form MBPs, and their potential benefits in fostering individual and societal well-being. The endeavor of bridging this research gap has yielded numerous valuable insights, while simultaneously illuminating plausible reasons for the relative lack of exploration in this area of contemplative practices. Short-form MBPs present a dichotomy of unpredictability and high potential rewards, making them a risky yet enticing area of study. On the other hand, the study of monastic debate necessitates an exceptional degree of cultural sensitivity, intense collaboration and dialogue, and relentless piloting under challenging field research conditions. The studies presented in this thesis have also underscored the importance of diversifying research methodologies and samples to gain a more comprehensive understanding of human cognition. This highlights the feasibility and value of drawing insights from non-WEIRD populations such as Tibetan monastic communities.

Thus, this work suggests that despite the great challenges inherent in studying less accessible contemplative practices, the potential benefits and insights they can offer are significant, one of them being the opportunity to reflect upon and unearth the latent biases not only in one's own research paradigms but also, by extrapolation, within contemporary scientific processes as a whole. In essence, such endeavors may promote an intellectual versatility that mirrors the multidimensional complexity inherent to the field of contemplative practices. Through this exploration of the 'road less traveled', we may thus confront our own assumptions and limitations. This in itself can reveal a broader view of the

scientific process and its potential trajectory. Having practiced monastic debate, I find the process of scientific inquiry to bear striking similarities with the rigorous intellectual discipline required in analytical meditation. Both pursuits are precise intellectual endeavors, requiring comprehensive cognitive engagement and a readiness to challenge ingrained beliefs and assumptions. Ideally, each of these pursuits may contribute to improved capacities of critical thinking and a refined understanding of the human mind, be it through the lens of intersubjectivity as seen in scientific exploration, or from a first person perspective as experienced in contemplative practices (Wallace, 2007).

References

Afonso, R. F., Kraft, I., Aratanha, M. A., & Kozasa, E. H. (2020). Neural correlates of meditation: A review of structural and functional MRI studies. *Frontiers in Bioscience-Scholar*, *12*(1), 92–115. https://doi.org/10.2741/S542

Aftanas, L. I., & Golocheikine, S. A. (2001). Human anterior and frontal midline theta and lower alpha reflect emotionally positive state and internalized attention: High-resolution EEG investigation of meditation. *Neuroscience Letters*, *310*(1), 57–60. https://doi.org/10.1016/S0304-3940(01)02094-8

Anālayo, S. (2003). *The Direct Path to Realization, Birmingham*. Windhorse Publications.

Babiloni, F., Cincotti, F., Mattia, D., Fallani, F. D. V., Tocci, A., Bianchi, L., Salinari, S., Marciani, M., Colosimo, A., & Astolfi, L. (2007). High resolution EEG hyperscanning during a card game. *29th Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, 4957–4960.

Basso, J. C., McHale, A., Ende, V., Oberlin, D. J., & Suzuki, W. A. (2019). Brief, daily meditation enhances attention, memory, mood, and emotional regulation in non-experienced meditators. *Behavioural Brain Research*, *356*, 208–220. https://doi.org/10.1016/j.bbr.2018.08.023

Bennike, I. H., Wieghorst, A., & Kirk, U. (2017). Online-based Mindfulness Training Reduces Behavioral Markers of Mind Wandering. *Journal of Cognitive Enhancement*, *1*(2), 172–181. https://doi.org/10.1007/s41465-017-0020-9

Bernstein, A., Hadash, Y., Lichtash, Y., Tanay, G., Shepherd, K., & Fresco, D. M. (2015). Decentering and related constructs: A critical review and metacognitive processes model. *Perspectives on Psychological Science*, *10*(5), 599–617.

Bishop, S. R., Lau, M., Shapiro, S., Carlson, L., Anderson, N. D., Carmody, J., Segal, Z. V., Abbey, S., Speca, M., & Velting, D. (2004). Mindfulness: A proposed operational definition. *Clinical Psychology: Science and Practice*, *11*(3), 230–241.

Bodhi, B. (2011). What does mindfulness really mean? A canonical perspective. *Contemporary Buddhism*, *12*(1), 19–39.

Bostock, S., Crosswell, A. D., Prather, A. A., & Steptoe, A. (2019). Mindfulness on-the-go: Effects of a mindfulness meditation app on work stress and well-being. *Journal of Occupational Health Psychology*, *24*(1), 127–138.

Brewer, J. A., & Garrison, K. A. (2014). The posterior cingulate cortex as a plausible mechanistic target of meditation: Findings from neuroimaging. *Annals of the New York Academy of Sciences*, *1307*(1), 19–27.

Brown, K. W., Ryan, R. M., & Creswell, J. D. (2007). Mindfulness: Theoretical foundations and evidence for its salutary effects. *Psychological Inquiry*, *18*(4), 211–237.

Bylów-Antkowiak, K. (2017). *"Others before self": Tibetan pedagogy and childrearing in a Tibetan children's village in the Indian Himalaya* [Thesis, University of St Andrews]. https://research-repository.st-andrews.ac.uk/handle/10023/11352

Carrette, J., & King, R. (2004). *Selling Spirituality: The silent Takeover of Religion*. Routledge.

Cavanagh, K., Strauss, C., Cicconi, F., Griffiths, N., Wyper, A., & Jones, F. (2013). A randomised controlled trial of a brief online mindfulness-based intervention. *Behaviour Research and Therapy*, *51*(9), 573–578.

Chiao, J. Y., & Ambady, N. (2007). Cultural neuroscience: Parsing universality and diversity across levels of analysis. In S. Kitayama & D. Cohen (Eds.), *Handbook of Cultural Psychology* (pp. 237–254). Guilford.

Chiesa, A. (2010). Vipassana Meditation: Systematic Review of Current Evidence. *The Journal of Alternative and Complementary Medicine*, *16*(1), 37–46. https://doi.org/10.1089/acm.2009.0362

Cole, M. (1971). *The Cultural Context of Learning and Thinking: An Exploration in Experimental Anthropology*. Basic Books.

Condon, P., Desbordes, G., Miller, W. B., & DeSteno, D. (2013). Meditation increases compassionate responses to suffering. *Psychological Science*, *24*(10), 2125–2127.
Crane, R. S., Brewer, J., Feldman, C., Kabat-Zinn, J., Santorelli, S., Williams, J. M. G., & Kuyken, W. (2017). What defines mindfulness-based programs? The warp and the weft. *Psychological Medicine*, *47*(6), 990–999. https://doi.org/10.1017/S0033291716003317
Creswell, J. D. (2017). Mindfulness Interventions. *Annual Review of Psychology*, *68*(1), 491–516. https://doi.org/10.1146/annurev-psych-042716-051139
Davidson, R. J., & Dahl, C. J. (2017). Varieties of contemplative practice. *JAMA Psychiatry*, *74*(2), 121–123.
Davidson, R. J., & Dahl, C. J. (2018). Outstanding Challenges in Scientific Research on Mindfulness and Meditation. *Perspectives on Psychological Science*, *13*(1), 62–65. https://doi.org/10.1177/1745691617718358
Davidson, R. J., & Harrington, A. (2002). *Visions of compassion: Western scientists and Tibetan Buddhists examine human nature*. Oxford University Press, USA.
Davidson, R. J., & Kaszniak, A. W. (2015). Conceptual and methodological issues in research on mindfulness and meditation. *American Psychologist*, *70*(7), 581–592. https://doi.org/10.1037/a0039512
Davidson, R. J., & McEwen, B. S. (2012). Social influences on neuroplasticity: Stress and interventions to promote well-being. *Nature Neuroscience*, *15*(5), 689–695.
Desbordes, G., & Negi, L. (2013). A new era for mind studies: Training investigators in both scientific and contemplative methods of inquiry. *Frontiers in Human Neuroscience*, *7*, 741–741. https://doi.org/10.3389/fnhum.2013.00741
Desbordes, G., Negi, L. T., Pace, T. W., Wallace, B. A., Raison, C. L., & Schwartz, E. L. (2012). Effects of mindful-attention and compassion meditation training on amygdala response to emotional stimuli in an ordinary, non-meditative state. *Frontiers in Human Neuroscience*, *6*, 292.
Diener, E. (1984). Subjective well-being. *Psychological Bulletin*, *95*(3), 542–575.
Dimidjian, S., Beck, A., Felder, J. N., Boggs, J. M., Gallop, R., & Segal, Z. V. (2014). Web-based mindfulness-based cognitive therapy for reducing residual depressive symptoms: An open trial and quasi-experimental comparison to propensity score matched controls. *Behaviour Research and Therapy*, *63*, 83–89.
Dimidjian, S., & Segal, Z. V. (2015). Prospects for a clinical science of mindfulness-based intervention. *American Psychologist*, *70*(7), 593–620.
Disner, S. G., Beevers, C. G., Haigh, E. A. P., & Beck, A. T. (2011). Neural mechanisms of the cognitive model of depression. *Nature Reviews Neuroscience*, *12*(8), 467–477. https://doi.org/10.1038/nrn3027
Dreyfus, G. (2003). *The sound of two hands clapping: The education of a Tibetan Buddhist monk*. University of California Press.
Dreyfus, G. (2011). Is mindfulness present-centred and non-judgmental? A discussion of the cognitive dimensions of mindfulness. *Contemporary Buddhism*, *12*(1), 41–54.
Dreyfus, Georges. (2008). What is Debate for? The Rationality of Tibetan Debates and the Role of Humor. *Argumentation*, *22*(1), 43–58. https://doi.org/10.1007/s10503-007-9079-2
Dunne, J. (2011). Toward an understanding of non-dual mindfulness. *Contemporary Buddhism*, *12*(1), 71–88.
Feruglio, S., Matiz, A., Pagnoni, G., Fabbro, F., & Crescentini, C. (2021). The Impact of Mindfulness Meditation on the Wandering Mind: A Systematic Review. *Neuroscience & Biobehavioral Reviews*, *131*, 313–330. https://doi.org/10.1016/j.neubiorev.2021.09.032
Flood, G. D. (1996). *An introduction to Hinduism*. Cambridge University Press.
Fredrickson, B. L., Cohn, M. A., Coffey, K. A., Pek, J., & Finkel, S. M. (2008). Open hearts build lives: Positive emotions, induced through loving-kindness meditation, build consequential personal resources. *Journal of Personality and Social Psychology*, *95*(5), 1045–1062.
Fresco, D. M., Moore, M. T., van Dulmen, M. H. M., Segal, Z. V., Ma, S. H., Teasdale, J. D., & Williams, J. M. G. (2007). Initial Psychometric Properties of the Experiences Questionnaire: Validation of a Self-Report Measure of Decentering. *Behavior Therapy*, *38*(3), 234–246. https://doi.org/10.1016/j.beth.2006.08.003
Friese, M., Messner, C., & Schaffner, Y. (2012). Mindfulness meditation counteracts self-control depletion. *Consciousness and Cognition*, *21*(2), 1016–1022.
Galante, J., Galante, I., Bekkers, M.-J., & Gallacher, J. (2014). Effect of kindness-based meditation on health and well-being: A systematic review and meta-analysis. *Journal of Consulting and Clinical Psychology*, *82*(6), 1101.

Gethin, R. (2011). On some definitions of mindfulness. *Contemporary Buddhism*, *12*(1), 263–279.
Gilbert, P. & Choden. (2013). *Mindful compassion*. Hachette UK.
Gilbert, P., & Irons, C. (2009). Shame, self-criticism, and self-compassion in adolescence. *Adolescent Emotional Development and the Emergence of Depressive Disorders*, *1*, 195–214.
Goldberg, S. B., Tucker, R. P., Greene, P. A., Davidson, R. J., Wampold, B. E., Kearney, D. J., & Simpson, T. L. (2018). Mindfulness-based interventions for psychiatric disorders: A systematic review and meta-analysis. *Clinical Psychology Review*, *59*, 52–60.
Goleman, D., & Davidson, R. J. (2018). *Altered traits: Science reveals how meditation changes your mind, brain, and body*. Penguin.
Grabovac, A. D., Lau, M. A., & Willett, B. R. (2011). Mechanisms of mindfulness: A Buddhist psychological model. *Mindfulness*, *2*, 154–166.
Grant, J. A., Courtemanche, J., & Rainville, P. (2011). A non-elaborative mental stance and decoupling of executive and pain-related cortices predicts low pain sensitivity in Zen meditators. *PAIN®*, *152*(1), 150–156. https://doi.org/10.1016/j.pain.2010.10.006
Greenfield, P. M. (1997). You can't take it with you: Why ability assessments don't cross cultures. *American Psychologist*, *52*(10), 1115–1124.
Grossman, P. (2011). Defining mindfulness by how poorly I think I pay attention during everyday awareness and other intractable problems for psychology's (re) invention of mindfulness: Comment on Brown et al.(2011). *Psychological Assessment*, *23*(4), 1034–1040.
Grossman, P. (2019). On the porosity of subject and object in 'mindfulness' scientific study: Challenges to 'scientific' construction, operationalization and measurement of mindfulness. *Current Opinion in Psychology*, *28*, 102–107. https://doi.org/10.1016/j.copsyc.2018.11.008
Grossman, P., Niemann, L., Schmidt, S., & Walach, H. (2004). Mindfulness-based stress reduction and health benefits: A meta-analysis. *Journal of Psychosomatic Research*, *57*(1), 35–43.
Gunaratana, V. H. M. (2002). Mindfulness in Plain English. *Simon and Schuster*.
Harris, S. (2014). *Waking up: A guide to spirituality without religion*. Simon and Schuster.
Hasenkamp, W., & White, J. R. (2017). *The monastery and the microscope: Conversations with the Dalai Lama on mind, mindfulness, and the nature of reality*. Yale University Press.
Henrich, J., Heine, S. J., & Norenzayan, A. (2010). The weirdest people in the world? *Behavioral and Brain Sciences*, *33*(2–3), 61–83. https://doi.org/10.1017/s0140525x0999152x
Hofmann, S. G., Sawyer, A. T., Witt, A. A., & Oh, D. (2010). The effect of mindfulness-based therapy on anxiety and depression: A meta-analytic review. *Journal of Consulting and Clinical Psychology*, *78*(2), 169.
Holmes, N. G., Wieman, C. E., & Bonn, D. A. (2015). Teaching critical thinking. *Proceedings of the National Academy of Sciences*, *112*(36), 11199–11204. https://doi.org/10.1073/pnas.1505329112
Hölzel, B. K., Ott, U., Gard, T., Hempel, H., Weygandt, M., Morgen, K., & Vaitl, D. (2008). Investigation of mindfulness meditation practitioners with voxel-based morphometry. *Social Cognitive and Affective Neuroscience*, *3*(1), 55–61.
Hopkins, P. J. (2001). Tibetan Monastic Colleges. Rationality versus the Demands of Allegiance. In T. Dodin (Ed.), *Imagining Tibet. Perceptions, Projections and Fantasies*. Wisdom Publications.
Jankowski, T., & Holas, P. (2014). Metacognitive model of mindfulness. *Consciousness and Cognition*, *28*, 64–80. https://doi.org/10.1016/j.concog.2014.06.005
Jinich-Diamant, A., Garland, E., Baumgartner, J., Gonzalez, N., Riegner, G., Birenbaum, J., Case, L., & Zeidan, F. (2020). Neurophysiological Mechanisms Supporting Mindfulness Meditation–Based Pain Relief: An Updated Review. *Current Pain and Headache Reports*, *24*(10), 56–56. https://doi.org/10.1007/s11916-020-00890-8
Kabat-Zinn, J. (1982). An outpatient program in behavioral medicine for chronic pain patients based on the practice of mindfulness meditation: Theoretical considerations and preliminary results. *General Hospital Psychiatry*, *4*(1), 33–47.
Kabat-Zinn, J. (2003). Mindfulness-based interventions in context: Past, present, and future. *Clinical Psychology: Science and Practice*, *10*(2), 144–156.
Kabat-Zinn, J. (2011). Some reflections on the origins of MBSR, skillful means, and the trouble with maps. *Contemporary Buddhism*, *12*(1), 281–306.
Kabat-Zinn, J., & Davidson, R. (2012). *The mind's own physician: A scientific dialogue with the Dalai Lama on the healing power of meditation*. New Harbinger Publications.
Kabat-Zinn, J., & Hanh, T. N. (2009). *Full catastrophe living: Using the wisdom of your body and mind to face stress, pain, and illness*. Delta.

Kabat-Zinn, J., Lipworth, L., & Burney, R. (1985). The clinical use of mindfulness meditation for the self-regulation of chronic pain. *Journal of Behavioral Medicine*, *8*, 163–190.

Katyal, S., Lumma, A.-L., Goldin, P. R., & Roy, S. (2023). Editorial: The varieties of contemplative experiences and practices. *Frontiers in Psychology*, *14*. https://www.frontiersin.org/articles/10.3389/fpsyg.2023.1232999

Kaushik, P., Moye, A., van Vugt, M. K., & Roy, P. P. (2022). Decoding the cognitive states of attention and distraction in a real-life setting using EEG. *Scientific Reports*, *12*(1), 20649.

Khoury, B., Lecomte, T., Fortin, G., Masse, M., Therien, P., Bouchard, V., Chapleau, M.-A., Paquin, K., & Hofmann, S. G. (2013). Mindfulness-based therapy: A comprehensive meta-analysis. *Clinical Psychology Review*, *33*(6), 763–771.

Kok, B. E., & Singer, T. (2017). Phenomenological fingerprints of four meditations: Differential state changes in affect, mind-wandering, meta-cognition, and interoception before and after daily practice across 9 months of training. *Mindfulness*, *8*(1), 218–231.

Koole, S. L., & Tschacher, W. (2016). Synchrony in psychotherapy: A review and an integrative framework for the therapeutic alliance. *Frontiers in Psychology*, *7*, 862.

Koster, E. H. W., De Lissnyder, E., Derakshan, N., & De Raedt, R. (2011). Understanding depressive rumination from a cognitive science perspective: The impaired disengagement hypothesis. *Clinical Psychology Review*, *31*(1), 138–145. https://doi.org/10.1016/j.cpr.2010.08.005

Kubota, Y., Sato, W., Toichi, M., Murai, T., Okada, T., Hayashi, A., & Sengoku, A. (2001). Frontal midline theta rhythm is correlated with cardiac autonomic activities during the performance of an attention demanding meditation procedure. *Cognitive Brain Research*, *11*(2), 281–287. https://doi.org/10.1016/S0926-6410(00)00086-0

Kuyken, W., Hayes, R., Barrett, B., Byng, R., Dalgleish, T., Kessler, D., Lewis, G., Watkins, E., Brejcha, C., Cardy, J., & others. (2015). Effectiveness and cost-effectiveness of mindfulness-based cognitive therapy compared with maintenance antidepressant treatment in the prevention of depressive relapse or recurrence (PREVENT): A randomised controlled trial. *The Lancet*, *386*(9988), 63–73.

Lama, D. (2018). *Science and Philosophy in the Indian Buddhist Classics: The Physical World*. Simon and Schuster.

Laukkonen, R. E., & Slagter, H. A. (2021). From many to (n)one: Meditation and the plasticity of the predictive mind. *Neuroscience & Biobehavioral Reviews*, *128*, 199–217. https://doi.org/10.1016/j.neubiorev.2021.06.021

Lempert, M. (2012). *Discipline and debate: The language of violence in a Tibetan Buddhist monastery*. University of California Press.

Lewis-Williams, D. (2011). *The mind in the cave: Consciousness and the origins of art*. Thames & Hudson.

Liberman, K. (2007). *Dialectical practice in Tibetan philosophical culture: An ethnomethodological inquiry into formal reasoning*. Rowman & Littlefield Publishers.

Liberman, K. (2015). The logic is made to dance. Rhythm in Tibetan debating. *Etnografia e Ricerca Qualitativa*, *8*(3), 383–398.

Lim, D., Condon, P., & DeSteno, D. (2015). Mindfulness and compassion: An examination of mechanism and scalability. *PloS One*, *10*(2), e0118221.

Lindahl, J. R., Fisher, N. E., Cooper, D. J., Rosen, R. K., & Britton, W. B. (2017). The varieties of contemplative experience: A mixed-methods study of meditation-related challenges in Western Buddhists. *PloS One*, *12*(5), e0176239.

Lopez, D. S. (2011). *"The Tibetan Book of the Dead" A Biography*. Princeton University Press.

Lott, D. T., Yeshi, T., Norchung, N., Dolma, S., Tsering, N., Jinpa, N., Woser, T., Dorjee, K., Desel, T., & Fitch, D. (2021). No detectable electroencephalographic activity after clinical declaration of death among Tibetan Buddhist meditators in apparent Tukdam, a putative postmortem meditation state. *Frontiers in Psychology*, *11*, 599190.

Lutz, A., Brefczynski-Lewis, J., Johnstone, T., & Davidson, R. J. (2008). Regulation of the neural circuitry of emotion by compassion meditation: Effects of meditative expertise. *PloS One*, *3*(3), e1897.

Lutz, A., Greischar, L. L., Rawlings, N. B., Ricard, M., & Davidson, R. J. (2004). Long-term meditators self-induce high-amplitude gamma synchrony during mental practice. *Proceedings of the National Academy of Sciences*, *101*(46), 16369–16373.

Lutz, A., Jha, A. P., Dunne, J. D., & Saron, C. D. (2015). Investigating the phenomenological matrix of mindfulness-related practices from a neurocognitive perspective. *The American Psychologist*, *70*(7), 632–658.

Lutz, A., Slagter, H. A., Dunne, J. D., & Davidson, R. J. (2008). Attention regulation and monitoring in meditation. *Trends in Cognitive Sciences*, *12*(4), 163–169.
MacPherson, S. (2000). *A path of learning: Indo-Tibetan Buddhism as education* [PhD Thesis]. University of British Columbia.
Malinowski, P. (2013). Neural mechanisms of attentional control in mindfulness meditation. *Frontiers in Neuroscience*, *7*, 8. https://doi.org/10.3389/fnins.2013.00008
Manuel, J. A., Somohano, V. C., & Bowen, S. (2017). Mindfulness practice and its relationship to the Five-Facet Mindfulness Questionnaire. *Mindfulness*, *8*, 361–367.
Masuda, T., & Nisbett, R. E. (2001). Attending holistically versus analytically: Comparing the context sensitivity of Japanese and Americans. *Journal of Personality and Social Psychology*, *81*(5), 922–934.
Mind, Network (MLERN), L. E. R., J. Davidson, R., Dunne, J., Eccles, J. S., Engle, A., Greenberg, M., Jennings, P., Jha, A., Jinpa, T., & Lantieri, L. (2012). Contemplative practices and mental training: Prospects for American education. *Child Development Perspectives*, *6*(2), 146–153.
Monteiro, L. M., Musten, R. F., & Compson, J. (2015). Traditional and contemporary mindfulness: Finding the middle path in the tangle of concerns. *Mindfulness*, *6*, 1–13.
Moore, A., & Malinowski, P. (2009). Meditation, mindfulness and cognitive flexibility. *Consciousness and Cognition*, *18*(1), 176–186.
Morris, M. W., & Peng, K. (1994). Culture and cause: American and Chinese attributions for social and physical events. *Journal of Personality and Social Psychology*, *67*(6), 949–971.
Morrison, A. B., Goolsarran, M., Rogers, S. L., & Jha, A. P. (2014). Taming a wandering attention: Short-form mindfulness training in student cohorts. *Frontiers in Human Neuroscience*, *7*, 897.
Moye, A. J., & Van Vugt, M. K. (2019). A computational model of focused attention meditation and its transfer to a sustained attention task. *IEEE Transactions on Affective Computing*, *12*(2), 329–339. https://doi.org/10.1109/taffc.2019.2908172
Müller, V., Sänger, J., & Lindenberger, U. (2013). Intra-and inter-brain synchronization during musical improvisation on the guitar. *PloS One*, *8*(9), e73852.
Neff, K. D., & Germer, C. K. (2013). A Pilot Study and Randomized Controlled Trial of the Mindful Self-Compassion Program. *Journal of Clinical Psychology*, *69*(1), 28–44. https://doi.org/10.1002/jclp.21923
Neisser, U., Boodoo, G., Bouchard Jr, T. J., Boykin, A. W., Brody, N., Ceci, S. J., Halpern, D. F., Loehlin, J. C., Perloff, R., & Sternberg, R. J. (1996). Intelligence: Knowns and unknowns. *American Psychologist*, *51*(2), 77–101.
Nisbett, R. E., & Masuda, T. (2003). Culture and point of view. *Proceedings of the National Academy of Sciences*, *100*(19), 11163–11170.
Nisbett, R. E., Peng, K., Choi, I., & Norenzayan, A. (2001). Culture and systems of thought: Holistic versus analytic cognition. *Psychological Review*, *108*(2), 291–310.
Pace, T. W., Negi, L. T., Adame, D. D., Cole, S. P., Sivilli, T. I., Brown, T. D., Issa, M. J., & Raison, C. L. (2009). Effect of compassion meditation on neuroendocrine, innate immune and behavioral responses to psychosocial stress. *Psychoneuroendocrinology*, *34*(1), 87–98.
Pagnoni, G., & Cekic, M. (2007). Age effects on gray matter volume and attentional performance in Zen meditation. *Neurobiology of Aging*, *28*(10), 1623–1627.
Perdue, D. (1992). *Debate in Tibetan Buddhism*. National Geographic Books.
Perdue, D. (2014). *The course in Buddhist reasoning and debate: An Asian approach to analytical thinking drawn from Indian and Tibetan sources*. Shambhala Publications.
Pierce, B. D. (2021). Translating Monastic Lessons to Teaching Undergraduate Biology. *Frontiers in Communication*, *6*, 731497.
Pintrich, P. R. (2003). A motivational science perspective on the role of student motivation in learning and teaching contexts. *Journal of Educational Psychology*, *95*(4), 667–686.
Purser, R. E., & Loy, D. (2013). Beyond McMindfulness. *Huffington Post*. https://www.huffpost.com/entry/beyond-mcmindfulness_b_3519289
Riegl, S., & van Vugt, M. K. (2020). A Computational Cognitive Model of Reasoning in Tibetan Buddhist Monastic Debate. *Proceedings of the 18th International Conference on Cognitive Modeling*, 216–222.
Rogers, R. A. (2006). From cultural exchange to transculturation: A review and reconceptualization of cultural appropriation. *Communication Theory*, *16*(4), 474–503.
Ross, B. M., & Millsom, C. (1970). Repeated memory of oral prose in Ghana and New York. *International Journal of Psychology*, *5*(3), 173–181.

Sager, B. (2013). *Beyond the robe: Science for monks and all it reveals about Tibetan monks and nuns*. PowerHouse Books.
Sedlmeier, P., Eberth, J., Schwarz, M., Zimmermann, D., Haarig, F., Jaeger, S., & Kunze, S. (2012). The psychological effects of meditation: A meta-analysis. *Psychological Bulletin*, *138*(6), 1139–1171.
Segall, M. H., Campbell, D. T., & Herskovits, M. J. (1963). Cultural differences in the perception of geometric illusions. *Science*, *139*(3556), 769–771.
Shapiro, S. L., Carlson, L. E., Astin, J. A., & Freedman, B. (2006). Mechanisms of mindfulness. *Journal of Clinical Psychology*, *62*(3), 373–386.
Shome, R. (1996). Postcolonial interventions in the rhetorical canon: An "other" view. *Communication Theory*, *6*(1), 40–59.
Shonin, E., Van Gordon, W., & Griffiths, M. D. (2013). Mindfulness-based interventions: Towards mindful clinical integration. *Frontiers in Psychology*, *4*, 194.
Stocker, E., Englert, C., & Seiler, R. (2019). Self-control strength and mindfulness in physical exercise performance: Does a short mindfulness induction compensate for the detrimental ego depletion effect? *Journal of Applied Sport Psychology*, *31*(3), 324–339.
Sumantry, D., & Stewart, K. E. (2021). Meditation, Mindfulness, and Attention: A Meta-analysis. *Mindfulness*, *12*(6), 1332–1349. https://doi.org/10.1007/s12671-021-01593-w
Tang, Y.-Y., Hölzel, B. K., & Posner, M. I. (2015). The neuroscience of mindfulness meditation. *Nature Reviews Neuroscience*, *16*(4), 213–225.
Tang, Y.-Y., Tang, R., & Posner, M. I. (2016). Mindfulness meditation improves emotion regulation and reduces drug abuse. *Drug and Alcohol Dependence*, *163*, 13–18.
Tobias Mortlock, J., Carter, A., & Querstret, D. (2022). Extending the Transformative Potential of Mindfulness Through Team Mindfulness Training, Integrating Individual With Collective Mindfulness, in a High-Stress Military Setting. *Frontiers in Psychology*, *13*. https://www.frontiersin.org/articles/10.3389/fpsyg.2022.867110
Vago, D. R., & Silbersweig, D. A. (2012). Self-awareness, self-regulation, and self-transcendence (S-ART): A framework for understanding the neurobiological mechanisms of mindfulness. *Frontiers in Human Neuroscience*, *6*. https://doi.org/doi.org/10.3389/fnhum.2012.00296
Van Dam, N. T., Van Vugt, M. K., Vago, D. R., Schmalzl, L., Saron, C. D., Olendzki, A., Meissner, T., Lazar, S. W., Kerr, C. E., Gorchov, J., Fox, K. C. R., Field, B. A., Britton, W. B., Brefczynski-Lewis, J. A., & Meyer, D. E. (2018). Mind the hype: A critical evaluation and prescriptive agenda for research on mindfulness and meditation. *Perspectives on Psychological Science*, *13*(1), 36–61.
van Vugt, M. K., Moye, A., Pollock, J., Johnson, B., Bonn-Miller, M. O., Gyatso, K., Thakchoe, J., Phuntsok, L., Norbu, N., & Tenzin, L. (2019). Tibetan Buddhist monastic debate: Psychological and neuroscientific analysis of a reasoning-based analytical meditation practice. *Progress in Brain Research*, *244*, 233–253.
van Vugt, M. K., Moye, A., & Sivakumar, S. (2019). Computational modelling approaches to meditation research: Why should we care? *Current Opinion in Psychology*, *28*, 49–53.
van Vugt, M. K., Pollock, J., Johnson, B., Gyatso, K., Norbu, N., Lodroe, T., Gyaltsen, T., Phuntsok, L., Thakchoe, J., Khechok, J., Lobsang, J., Tenzin, L., Gyaltsen, J., Moye, A., & Fresco, D. M. (2020). Inter-brain synchronization in the practice of Tibetan monastic debate. *Mindfulness*, *11*(5), 1105–1119.
Varela, F. J., Thompson, E., & Rosch, E. (2017). *The embodied mind, revised edition: Cognitive science and human experience*. MIT press.
Wallace, B. A. (2007). *Contemplative science: Where Buddhism and neuroscience converge*. Columbia University Press.
Walsh, R., & Shapiro, S. L. (2006). The meeting of meditative disciplines and Western psychology: A mutually enriching dialogue. *American Psychologist*, *61*(3), 227–239.
Wang, Q., & Ross, M. (2007). Culture and memory. *Handbook of Cultural Psychology*, *18*, 645–667.
West, M. A. (2016). *The psychology of meditation: Research and practice*. Oxford University Press.
Ziff, B. H., & Rao, P. V. (1997). *Borrowed power: Essays on cultural appropriation*. Rutgers University Press.

Thesis declaration

I hereby declare that this doctoral thesis on mindfulness, analytical meditation, and culture-sensitive research is my original work and has not been submitted for the award of a degree in any other institution. All resources, whether print or digital, used in the preparation of this thesis, have been duly acknowledged. Any instances of quoted and paraphrased material have been clearly indicated and referenced according to the APA 7. I affirm that all research procedures involving human subjects were approved by the appropriate ethics committee and were conducted in compliance with ethical standards.

Recognizing the growing potential of artificial intelligence in academic research, I acknowledge the use of the large language model, GPT-4, in this writing of this thesis. GPT-4 played a role in the proofreading, creative input, and rephrasing of content, enhancing the linguistic quality of the thesis and ensuring clarity and coherence in the presentation of my research. It should be noted that while GPT-4 provided valuable linguistic support, the intellectual content, analysis, and conclusions drawn in this thesis are entirely my own.

The Volatile Effect of Short-Form Mindfulness Training on Self-Control in the SART

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We have no known conflict of interest to disclose.

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Abstract

Our study explored the dynamics of self-control, the effects of a short-form 7-hour mindfulness intervention, and the ego depletion effect in the context of the process and the resource models of self-control. A total of 59 participants with no prior meditation experience were randomly assigned to either a mindfulness-based stress reduction (MBSR) training group, practicing 30 minutes daily for 2 weeks, or a control group that listened to an audiobook during the same period. Self-control levels were assessed at two time points: before the training (baseline) and after the 2-week intervention (follow-up). The results indicated that the mindfulness group did not show a significant improvement in self-control compared to the control group as measured by omission and commission errors as well as overall performance. Attentional consistency as measured by the coefficient of variation of the response times (RT CV) however, showed an unexpected and significant decline in the mindfulness group compared to the control group, which poses questions about the effectiveness of short-term mindfulness interventions in improving attentional control. While the results do not indicate a buffering effect of mindfulness on the ego depletion effect, our data can nevertheless contribute to the ego depletion literature, lending support to the process model of self-control over the resource model. This is due to changes in motivation and attention being better able to account for the findings. Taken together, these results suggest that the effect short-term mindfulness training may be particularly sensitive to contextual factors such as the particular version of the self-control task, the spacing of the sessions (e.g., across 4 weeks versus 2 weeks), in person versus purely online training and emphasis on accompanying qualities such as non-judgmental acceptance and compassion. This implies that while short-form mindfulness interventions are certainly practical from a research perspective, a robust and sustainable effect on self-control and attention may require a longer duration of practice, possibly with a more comprehensive approach that integrates more of mindfulness' core elements.

Keywords: Self-control, Mindfulness, Ego Depletion, Process Model, Resource Model, Mindfulness-Based Stress Reduction (MBSR), Sustained Attention to Response Task (SART), Coefficient of Variation of Response Times (RT CV), Short-form Mindfulness Intervention.

Self-control plays a crucial role in daily life, and its absence has been associated with various detrimental outcomes such as smoking, drinking, poor eating habits, and cheating (Baumeister & Vohs, 2004). Enhancing self-control has thus become a significant area of interest for researchers and practitioners alike (Baumeister et al., 1994; Moffitt et al., 2011). Various strategies have been proposed to improve self-control, including cognitive restructuring, mindfulness, and goal-setting (Inzlicht et al., 2021). One such strategy, mindfulness meditation, has gained considerable attention in recent years due to its potential in promoting self-control (Tang et al., 2015) and will be the focus of this study.

Self-control and Ego Depletion

Baumeister et al. (1994) proposed a model that has been foundational for the field of self-control research. This model asserts that exercising self-control depletes a limited resource referred to as self-control strength. This process is also known as ego depletion. According to this model, individuals have a finite amount of self-control strength that can be expended, and once depleted, their ability to exert self-control diminishes. A large number of studies have supported this notion, finding that the performance in the second task decreases noticeably when two self-control tasks are completed consecutively (Baumeister et al., 1994; Muraven & Baumeister, 2000). This suggests that engaging in self-control efforts may temporarily weaken one's capacity for subsequent self-control.

Interestingly, Muraven and Baumeister (2000) initially found that ego depletion only impacts tasks that require self-control, while effortful (e.g., mathematical) tasks that did not demand self-control seemed unaffected. This implied that the resource depletion specifically targets self-control abilities, rather than general cognitive or physical capacities. Furthermore, Muraven et al. (1998) found that emotional suppression and unsolvable puzzles, both of which involve self-control, draw upon the same resource, indicating that self-control strength is a domain-general resource that can be utilized across various tasks and situations.

Baumeister's model also suggests that self-control behaves like a muscle, which can be strengthened through regular exercise and training (Baumeister et al., 1994). This idea has been supported by research, demonstrating that individuals can improve their self-control abilities through consistent practice. For example, Muraven, Baumeister, and Tice (1999) conducted a three-week study that showed improved self-control in subjects after training in tasks requiring self-control. Participants who engaged in regular self-control exercises, such as resisting sweets or maintaining good posture, exhibited increased self-control strength and a reduced vulnerability to ego depletion.

Criticism and Revision of the Ego Depletion Effect

Even though the field of ego depletion has been influential and widely studied, it has faced increasing criticism and challenges in recent years. An initial meta-analysis by Hagger, Wood, Stiff, and Chatzisarantis (2010) supported the ego depletion effect, reporting a medium-to-large effect size. However, a subsequent meta-analysis by Carter and McCullough (2015) raised concerns about the presence of publication bias and the reliability of the ego depletion effect. Moreover, a meta-analysis conducted by Carter and McCullough (2014) found evidence of publication bias and small-study effects. In response, Hagger et al. (2016) conducted a large-scale, pre-registered replication study involving 23 laboratories across the world. Surprisingly, the results of this collaborative effort failed to provide robust evidence for the ego depletion effect, casting doubt on the strength and generalizability of the phenomenon, suggesting that the ego depletion literature may have been influenced by selective reporting of results.

In addition to the concerns about replicability, the theoretical underpinnings of ego depletion have also been questioned. Critics argue that the model lacks specificity regarding the nature of the self-control resource and the mechanisms by which it becomes depleted (Inzlicht &

Schmeichel, 2012; Kurzban, 2010). Some alternative theories have been proposed, such as the process model of self-control (Inzlicht et al., 2014), which posits that self-control relies on shifts in motivation and attention rather than a depletable resource. Another alternative is the opportunity cost model (Kurzban et al., 2013), which suggests that individuals disengage from self-control tasks when they perceive more rewarding alternatives are available, rather than due to a depletion of self-control resources.

As a result, Baumeisters' ego depletion model has undergone significant revisions and expansions to account for the various factors that may influence ego depletion beyond self-control exertion. This broader perspective now encompasses mentally demanding tasks and executive functions that may also contribute to the depletion of self-control resources (Vohs & Baumeister, 2016). The perception of the complexity of the processes involved in self-control and ego depletion has thus evolved, and even proponents of the original model are increasingly considering an interplay of multiple factors (rather than one unitary self-control resource) in determining the outcomes of self-control efforts.

In conclusion, the research field on self-control and ego depletion has undergone significant changes and developments over the years, culminating in what many might call an uproar of debate and reconsideration. Despite the challenges and criticisms, the study of self-control remains an important area of investigation, as the significant implications for understanding human behavior, decision-making, and overall well-being remain the same. Moreover, as the debate over the true effect size and nature of ego depletion continues, gathering more high-quality, and transparent research will be crucial in refining and resolving the understanding of this complex phenomenon. As Friese, Loschelder, Gieseler, Frankenbach and Inzlicht (2019) note in their recent review of the arguments for and against the ego depletion effect: despite hundreds of studies finding substantial evidence for ego depletion, a backlash of numerous replications and meta-analyses raising serious challenges and doubts, neither side can claim a clear victory yet. It is therefore too early to dismiss the ego depletion hypothesis altogether and conducting research in this area is worthwhile for several reasons. First, a better understanding of self-control and ego depletion (be it the unitary kind implied by the resource model or more nuanced processes amounting to a similar effect) can inform interventions and strategies to help individuals improve their self-control abilities. For instance, validating which factors contribute to reduced self-control may help individuals develop coping mechanisms to maintain self-control during challenging situations. Furthermore, given that the basic ego depletion theory underlying the promising effects of self-control training has been challenged, it is essential to also revisit the effectiveness of these interventions and refine them based on updated theoretical insights. Second, exploring alternative explanations and models of self-control, such as the process model and the opportunity cost model, can lead to a more nuanced and comprehensive understanding of the factors that influence self-control and its limitations. This can, in turn, contribute to the development of more targeted and effective interventions for enhancing self-control in various contexts, such as addiction, procrastination, and emotional regulation. Third, continued research in this area can help clarify the boundaries and conditions under which ego depletion may or may not occur. Identifying specific moderators and contextual factors that influence the strength and occurrence of ego depletion can contribute to a more refined and accurate understanding of the phenomenon, ultimately leading to more effective applications of this knowledge in real-world settings.

Definition and Effects of Mindfulness

Given the controversy and complexity surrounding the ego depletion model, researchers have sought to explore other avenues and techniques that may enhance self-control. One promising approach is the practice of mindfulness, which has gained increasing attention in both research and applied settings in recent years (Brown et al., 2007; Tang et al., 2015).

Mindfulness is commonly defined as the state of being present and fully aware of one's thoughts, feelings, and experiences in a non-judgmental manner (Kabat-Zinn & Hanh, 2009). The construct originates from ancient Buddhist traditions and has been adapted for use in contemporary psychological interventions. Although there is a wide range of mindfulness practices and techniques, they generally share a focus on cultivating present moment awareness, non-judgmental acceptance, and affective attitudes such as self-compassion (Shapiro et al., 2006; Van Dam et al., 2018). The range of definitions associated with mindfulness is broad as well, which is surely partly due to its origin in a highly intertwined and complex philosophical context. Secularizing and operationalizing mindfulness for a modern scientific context has retained some aspects of the original sophisticated structures, while others have been modified, simplified or completely removed (e.g., ethics, Monteiro et al., 2015). The amount of modification and abstraction from the original context has varied among researchers and practitioners. Thus, there remains significant debate on the most appropriate definition of this construct (Anālayo, 2019; Bodhi, 2011; Dreyfus, 2011; Gethin, 2011; Grossman, 2019; Van Dam et al., 2018).

One way to attempt to get to the essence of what being mindful means, is to consider it as a process of developing metacognitive awareness (Kok & Singer, 2017; Vago & Silbersweig, 2012). Being mindful involves keeping some continuum in mind, such as what one's intention was (e.g., to focus on the breath and repeatedly bring the attention back to it when it wanders). The capacity to metacognitively retain and return to a focus of attention entails at least two components: a minimal level of general metacognitive awareness of current mental processes (e.g., knowing that there is restlessness or worries that are beginning to overtake the current focus), and the ability to purposefully direct attention, enabling it to stay on the chosen object of focus even when it is less salient than the various internal and external distractions of a busy world and mind. The second component has also been aptly described as sustained non-distraction (Brown & Ryan, 2004; Dreyfus, 2011; Wallace & Shapiro, 2006). In this sense being mindful is a basic necessity and capacity of everyday life as it would be impossible to finish reading this sentence without a minimal amount of continued attention and intention. A basic level of mindfulness is therefore quite ordinary and requires no special training. However, the cultivation of mindfulness through various practices aims to enhance and deepen this metacognitive capacity and it is at this level that a multitude of factors begin to become necessary for sustained development. Qualities such as patience, curiosity, non-judgment, and ethical/affective components (including but not limited to self-compassion) are often emphasized as key components in the cultivation of mindfulness (Neff & Germer, 2013; Siegel, 2007). These qualities not only support the development of mindfulness itself but also contribute to the positive outcomes observed in individuals who engage in regular mindfulness practice. For instance, learning to more readily embody a non-judgmental and accepting stance towards internal or external stimuli (e.g., thoughts, emotions, physical sensations) enables a more sustainable monitoring process, as there is less friction and resistance in the perception and regulation of these stimuli. This in turn benefits overall mental health, as it reduces stress and anxiety, promotes emotional regulation, and enhances self-awareness and self-compassion (Hölzel et al., 2011; Keng et al., 2011). So, while the core process of mindfulness itself may be comparatively simple, the cultivation and maintenance of mindfulness as a skill and way of being requires the integration and development of various cognitive, perceptual, emotional, and ethical qualities. It has therefore been proposed that being mindful (beyond the basic level that is) is not so much a state or trait but a way of life (Grossman, 2011, 2019).

Mindfulness and Self-control

Given the breadth of factors and qualities involved in mindfulness cultivation, it is not surprising that its potential benefits extend to numerous aspects of psychological functioning, one of them being self-control. It has been proposed that mindfulness may improve self-control by increasing attentional focus, emotional regulation, and cognitive flexibility (Hölzel et al., 2011;

Tang et al., 2015). Several studies have provided empirical support for the positive effects of mindfulness on self-control (Friese et al., 2012; Ostafin et al., 2013). For example, practicing mindfulness has been shown to reduce impulsive decision-making (Kirk et al., 2011) and improve emotional regulation (Arch & Craske, 2006).

There are a number of ways in which mindfulness is thought to enhance self-control. First, by promoting non-judgmental awareness of one's thoughts and emotions, mindfulness can help individuals recognize and accept their internal experiences without being overwhelmed or controlled by them (Bishop et al., 2004). This increased self-awareness can enable individuals to better identify and manage their impulses and emotions, leading to improved self-control (Baer, 2003). Second, training in mindfulness has been linked to increased activation in brain regions associated with attention and executive functioning, such as the prefrontal cortex (Creswell et al., 2007; Tang et al., 2015). This indicates that mindfulness cultivation enhances attentional capacity, which in turn may allow individuals to maintain focus on their goals and resist distractions or temptations that could undermine their self-control efforts. Third, mindfulness has been shown to promote cognitive flexibility. This is essentially the capacity to modify and alter one's thoughts and actions in response to dynamic circumstances and requirements (Moore & Malinowski, 2009). Such increased flexibility can help individuals navigate challenges and setbacks more effectively, making them more resilient in maintaining self-control in the face of adversity (Teper et al., 2013).

Another way to integrate the plausible mechanisms through which mindfulness enhances self-control is by considering the aforementioned process model of self-control (Inzlicht et al., 2014). According to this model, self-control involves a dynamic interplay between three key components: attention, motivation, and emotion. Mindfulness may contribute to each of these components, thereby facilitating self-control. One might argue that attention regulation is at the core of mindfulness practice. Motivation and emotion, on the other hand, are closely linked to the non-judgmental and self-compassionate aspects of mindfulness. As discussed above, mindfulness training can help individuals learn how to regulate their response to unpleasant emotions more effectively (Arch & Craske, 2006), which in turn can support their motivation to persist in self-control efforts (Garland et al., 2009). Furthermore, qualities such as curiosity and patience, which are cultivated in mindfulness practice, may essentially reduce the amount of motivation and willpower that is necessary to exert self-control in the first place (Wallace, 2011), arguably making it a more sustainable and effective process overall.

In light of not only these potential benefits but many more general ones, several interventions have been developed to teach and cultivate mindfulness skills, with the aim of enhancing well-being and reducing stress. Among the most well-known and widely used of these interventions is Mindfulness-Based Stress Reduction (Kabat-Zinn et al., 1985), an eight-week program that combines mindfulness meditation, yoga, and group discussions to foster self-awareness, emotional regulation, and stress reduction. Other mindfulness-based interventions include Mindfulness-Based Cognitive Therapy (MBCT; Teasdale et al., 2000), which integrates mindfulness practices with cognitive therapy techniques to prevent relapse in individuals with a history of depression, and Acceptance and Commitment Therapy (ACT; Hayes et al., 1999), which uses mindfulness and acceptance strategies to promote psychological flexibility and value-driven behavior.

The effectiveness of mindfulness-based interventions, as well as the role of dispositional mindfulness in fostering self-control and associated outcomes, is substantiated by a growing body of empirical evidence. This evidence suggests that both the practice of mindfulness (Andersen et al., 2021; Virone, 2023) and the inherent trait of mindfulness (Calvete et al., 2022; Charoensukmongkol & Aumeboonsuke, 2016; Cheung & Ng, 2019; Reid et al., 2014) can significantly contribute to the enhancement of self-control and related outcomes. For instance, a randomized controlled trial demonstrated superior performance by the MBSR cohort on the Attention Network Test (Jha et al., 2007). While this assessment does not directly gauge self-

control, it is nevertheless relevant due to its measurement of executive functioning - a critical component of self-control.

It is important to note that the effectiveness of mindfulness-based interventions likely depends on the time scale involved. Typically, these programs encompass practices spanning over weeks or months. The most common format (MBSR and MBCT) consists of eight weekly meetings of approximately two hours each, in addition to an intensive day-long session typically held in the sixth week and 45 minutes of daily home practice (approximately 26 hours in total; Kabat-Zinn et al., 1985; Teasdale et al., 2000). However, there has been a recent surge in studies investigating shorter spans, which can be generally categorized into short-form and brief interventions (Carmody & Baer, 2009). Short-form interventions, compress the usual eight-week program, commonly to around four weeks. Brief interventions, on the other hand, typically consist of a single session of exercises introducing and cultivating mindfulness within a timeframe that may be as short as 5 minutes (e.g., Zeidan et al., 2010). The results from these shorter interventions have been varied, with some research indicating their effectiveness in fostering mindfulness and self-control (Bennike et al., 2017; Friese et al., 2012; Morrison et al., 2014), while others suggest that a more extended period of practice may be required for significant enhancements (Stocker et al., 2019). Despite the varying results, the exploration of these abridged formats of mindfulness intervention possesses considerable value, not only in terms of research feasibility and logistical simplification, but also in establishing proofs of concept that that a particular outcome (e.g., self-control) can benefit from mindfulness in principle. Establishing that transfer of learning from shorter mindfulness interventions (especially the brief forms) to real-world situations is robust, sustainable and meaningful, may therefore not be the main merit of such studies. Rather, these condensed forms of mindfulness intervention may serve as a preliminary step towards understanding the potential benefits and mechanisms of mindfulness, paving the way for more comprehensive and extended interventions that are more likely to result in significant and lasting improvements in self-control and associated outcomes.

Self-Control in the Sustained Attention Response Task

The Sustained Attention Response Task (SART; Robertson et al., 1997b) is a widely used measure of self-control and attentional capacity. In the SART, participants are typically presented with a series of single-digit numbers and are instructed to respond as quickly and accurately as possible to each number, except for a designated target number, to which they must withhold their response. It is worth noting that mindfulness trainings are commonly brought into conjunction with the SART as a means of measuring mind-wandering with the latter construct (Belardi et al., 2022; Giannandrea et al., 2019; Morrison et al., 2014; Mrazek et al., 2012; Rahl et al., 2017; Somaraju et al., 2023). In fact it appears that the SART is the most widely employed paradigm for studying mind-wandering (Hawkins et al., 2019). Such research has shown that mindfulness training can reduce the propensity for mind wandering, which in turn is thought to play a central role in the performance in the SART (Morrison et al., 2014; Mrazek et al., 2012).

However, the SART also lends itself well to investigating the effects of mindfulness on self-control, as it requires participants to maintain focus and inhibit prepotent responses over an extended period of time, which aligns with the attention regulation and impulse monitoring aspects of mindfulness practice. The task demands sustained attention and response inhibition, as participants must continuously monitor their performance and resist the urge to respond automatically to the target. Valentine and Sweet (1999) were among the first to investigate the relationship between mindfulness and performance on the SART. They found that individuals with higher levels of self-reported mindfulness exhibited better performance on the task, as indicated by fewer errors of commission (i.e., responding to the infrequent target number) and omission (i.e., failing to respond to one of the frequent non-target numbers). Errors of omission generally indicate a more pronounced distraction and lack of attention, while errors of commission reflect a failure to inhibit an automated response (Robertson et al., 1997a). The

overall accuracy of the SART test reflects both error types, providing an indicator of multiple types of attentional performance as a whole (with errors of omission being more heavily weighted in this metric due to their greater number). A more nuanced measure of performance on the SART is the response time variability, which can provide insights into flickers of inattention and impulsivity too small to result in overt errors (Bastian & Sackur, 2013; Mrazek et al., 2012; Seli et al., 2013). Studies have found that individuals with higher levels of mindfulness tend to exhibit lower response time variability, suggesting a more consistent and stable attentional focus (Cheyne et al., 2009). This suggests that mindfulness training may enhance performance on the SART not only by reducing the propensity for mind-wandering but also by stabilizing attentional control.

Research questions and hypotheses

The present study aims to further investigate the relationship between mindfulness and self-control, specifically focusing on the effects of mindfulness training on performance in the Sustained Attention Response Task (SART). In doing so we furthermore aim to shed more light on the complexities surrounding the heated debate over ego depletion by examining whether mindfulness practice can mitigate or counteract the effects of ego depletion on self-control performance. To this end, we conducted a randomized controlled trial comparing the effects of a 2-week mindfulness training similar to MBSR with a control condition. Both conditions were further divided into two groups: one that experienced an ego depletion task prior to the SART and one that did not. The design of our study therefore expands and partially replicates previous research by Stocker, Englert and Seiler (2019), who found that a brief mindfulness intervention (two sessions of 4 minutes each) did not significantly buffer the effects of ego depletion on a subsequent physical task requiring self-control. The materials and procedures for the questionnaires and the ego-depletion task were identical to those used in the study by Stocker et al. (2019). Given that a brief mindfulness intervention in the context of a 3-day mindfulness introduction course in Friese et al.'s (2012) study had a significant buffering effect against ego depletion in a cognitive task (d2 Test of Attention), we hypothesized that a longer and more intensive mindfulness training might have a similar buffering effect in the context of the SART. Specifically, we expected that:

1. Participants in the mindfulness training group would show significantly better performance on the SART compared to those in the control group, as indicated by fewer errors of commission, omission as well as overall performance.
2. Participants in the ego depletion condition would show would lower performance on the SART compared to non-depletion condition, providing further support for the limited resource model of self-control.
3. The decline in self-control performance due to ego depletion would be less pronounced for participants who have undergone mindfulness training, suggesting a potential buffering effect of mindfulness practice on ego depletion.
4. After the 2-week mindfulness training, participants in the meditation group would report significantly better mood scores compared to the control group, indicating that mindfulness practice may enhance emotional well-being and coping strategies in response to challenging situations.

Methods

Subjects

The sample consisted of 59 participants aged 14 to 56 years (M = 24.1, SD = 10.5), with 38 females and 21 males. Seventeen participants were students from Interlaken High School,

while the remaining participants were from the surrounding community. Participation was voluntary and without compensation. Two subjects dropped out of the experiment.

Design

The present study used a mixed 2 x 2 x 2 design. Time-out (meditation versus audiobook) and ego-depletion (depletion versus non-depletion) were the between-subjects variables, while time (baseline and follow-up) was a within-subjects factor, thus yielding four experimental groups. Participants were randomly assigned and completed pre- and post-measurement assessments with questionnaires at both baseline and follow-up.

Materials

Participants were presented with the materials in the pre- and follow-up assessments on various laptop models, using OpenSesame 3 software (Mathôt et al., 2012), completing questionnaires, an ego-depletion task, or a writing exercise, and lastly, the SART.

Trait Mindfulness Assessment

The trait mindfulness of participants was measured using the Comprehensive Inventory of Mindfulness Experience (CHIME; Bergomi et al., 2014). This inventory contains 37 items (e.g., "When my mood changes, I notice it immediately" and "In the ups and downs of life, I am warm toward myself"), which participants rated on a six-point scale ranging from 1 (almost never) to 6 (almost always). The time frame for these ratings was the two weeks preceding the assessment.

Trait Self-Control Assessment

Trait self-control was assessed using the short version of the Self-Control Scale (SCS-K-D) developed by Bertrams and Dickhäuser (2009). This questionnaire consists of 13 items (e.g., "Pleasant activities and pleasures sometimes prevent me from doing my work" and "I say inappropriate things"), which participants rated for accuracy on a scale from 1 (not at all) to 5 (extremely). Participants were instructed to rate the statements based on how true they were for them, as the questionnaire was designed to measure their self-control at the trait level.

Trait Openness Assessment

The Rammstedt and John (2005) version of the Big Five Inventory (BFI-K) was used to measure trait openness. It consisted of five items, like "I appreciate artistic and aesthetic impressions" and "I am profound, and I like to think about things". Participants responded on a scale from 1 (not at all) to 5 (extremely). Self-control and openness items were intermixed in a single questionnaire.

Affective Mood Assessment

Participants' emotional state was assessed using the Positive and Negative Affect Schedule (PANAS; Krohne et al., 1996) featuring 10 positive (e.g., enthusiastic, determined) and 10 negative (e.g., distressed, guilty) affective items, all rated on a 5-point scale (1 = not at all; 5 = extremely).

Ego Depletion Task

In order to induce ego depletion, participants were instructed to transcribe a text displayed on the screen as quickly and accurately as possible, omitting the letters 'e' and 'n'. The text was presented one sentence at a time; after pressing the 'Enter' key, a new sentence would appear for transcription. This procedure continued for six minutes before being ended automatically. The text used was from the city chronicle of Bern, which has been used before to induce ego depletion (Stocker et al., 2019).

Transcription Exercise

As a control condition, participants the non-depletion condition completed the same transcription exercise as previously described, but without the additional task of omitting specific letters, removing the requirement to inhibit certain targets ensures a suitable comparison to the ego-depletion task.

Sustained Attention to Response Task (SART)

Participants completed a 3-min practice and a 21-min main test for the SART. The trial began with a black, blank background for 150 ms, then a randomly-generated word for 150 ms, followed by a mask for 300 ms. The screen stayed black for a further 600 ms, during which the software measured subjects' responses. Finally, the screen stayed black for an 800 ms interval before the next trial began in the same way, with the total word presentation time at 2000 ms. Participants had to quickly identify if the first letter of a given word was capitalized or not, pressing the 'F' key for lowercase words and not pressing any key for uppercase words. The words were 4-9 characters long and the font size was randomized. During the practice run, 69 words were shown consecutively, and the incorrect responses were accompanied by a feedback tone. The main test presented 621 words with no auditory feedback, as per instructions. The test was split into three blocks, each containing 207 words and with a 10-second break in between. Out of the total 621 words, 13% were target words, which participants had to resist pressing the 'F' key for. It is worth noting that most studies employing the SART use a version with single digits, in which all single digits except the "3" are go-trials. We chose to use the so-called perceptual word version of the SART (McVay & Kane, 2009), which relies on word stimuli but unlike the semantic word SART version, the meaning of the words are irrelevant for the response. It is employed to induce mind-wandering (McVay & Kane, 2009; Yang et al., 2022) related to previously recorded (e.g., with a personal concerns inventory) personal concerns, which are covertly embedded in the word sequences. This embedding did however not take place in our study as adding another questionnaire to the already long list of measurements would have extended the duration of the experiment too much, potentially causing fatigue and affecting the results. We expected the random sequences of words, unrelated to personal concerns as they were, to nevertheless stimulate some degree of mind-wandering.

Meditation materials

Participants in the meditation condition received daily 30-minute guided meditations at home, following the principles of MBSR. These meditations aimed to cultivate mindfulness, encourage nonjudgmental present-moment awareness, and reinforce incorporating mindfulness into daily life. Additionally, participants were instructed to incorporate mindfulness into their daily lives and reflect on how meditation or mindfulness could alter their perception of their environment.

Audiobook materials

Participants in the audiobook condition consumed a 30-minute excerpt from the book "Sapiens: A Brief History of Humankind" each day. The content was chosen for its engaging and thought-provoking nature, which however did not promote mindfulness in any way. Through the online platform, these participants were also instructed to consider the book's content's relevance to their daily lives and surroundings. This exercise was incorporated to ensure comparability with the meditation condition.

Procedure

The study included a baseline-test, a two-week intervention (either meditation or audiobook), and a follow-up-test. Participants were welcomed at the start and given instructions and consent forms. Questionnaires were used to gather demographic data, and assessments were administered to evaluate mindfulness, self-control, and PANAS. Additionally, individual Motivation and openness questions were posed.

After a practice run familiarizing participants with the Sustained Attention to Response Task (SART), a five-minute break was given to prevent fatigue from the questionnaires. Following the break, the participants did the either the ego-depletion task or the copying exercise (control condition). After participants completed the ego-depletion task or the copying exercise, a series of questions were asked to assess how exhausted they felt.

After the ego-depletion task, participants took the SART. Upon completion, they took the PANAS and answered questions on motivation. The experimenter then debriefed and gave participants instructions to either meditate or listen to an audiobook for 14 days, emphasizing the importance of daily engagement for the experiment to be successful. These tasks were provided through a website, and the experimenter clarified how to access audio files. They were also informed they would have to answer more questions after the first week of the intervention. Participants in both groups were instructed to complete their exercises in a quiet setting, and were given freedom to choose when to do so. After the first week, participants were asked questions to gauge their adherence to the audio files and daily exercises. Due to concerns for standardization and logistic feasibility, participants in the mindfulness condition received their instruction and comprehension of the practice exclusively through an introductory text on the website and the accompanying guided audio files. Given the nature of the intervention, there was no avenue for these participants to seek further clarification or understanding. Similarly, the audiobook condition also relied solely on the audio content, with no provision for additional clarification.

Results

Manipulation Checks

An evaluation of the mindfulness training's effectiveness over the two-week period was conducted by examining the mean values obtained from the CHIME mindfulness scale. A 2 x 2 (intervention x time) mixed ANOVA was performed, and both homoscedasticity (Levene's test at baseline: $F(1, 55) = 2.080$, $p = .155$; Levene's test at follow-up: $F(1, 55) = 1.220$, $p = .273$) and normal distribution of residuals were confirmed. The ANOVA results revealed a significant interaction between time and intervention ($F(1, 55) = 4.370$, $p = .041$, $\eta 2 = .068$), suggesting that participants in the meditation condition rated themselves as more mindful after two weeks compared to those in the audiobook condition, confirming the effectiveness of the mindfulness training.

The effectiveness of the depletion task in inducing ego-depletion was assessed using a 2 x 2 (depletion x time) mixed model on self-reported depletion items. Three out of five items showed significant differences between the depleted and non-depleted groups (F's > 52.891, p's < 0.031). Post-hoc Welch's t-tests and Bayes factors further supported these findings, indicating

that the depletion task was successful in inducing some aspects of ego-depletion. Specifically, participants in the depleted condition (compared to the non-depleted condition) reported:

- similar levels of overall exhaustion
  (baseline: $t(51.858) = -0.200$, $p = 0.842$, Bayes Factor$_{10} = 0.279$, $d = -0.054$;
  follow-up: $t(43.932) = -0.498$, $p = 0.621$, Bayes Factor$_{10} = 0.305$, $d = -0.137$)
- the task itself to be significantly more exhausting at the baseline measurement
  (baseline: $t(50.884) = -2.409$, $p = 0.020$, Bayes Factor$_{10} = 2.844$, $d = -0.656$;
  follow-up: $t(47.762) = -1.415$, $p = 0.163$, Bayes Factor$_{10} = 0.634$, $d = -0.387$)
- more difficulty in following the instructions
  (baseline: $t(51.406) = -2.726$, $p = 0.009$, Bayes Factor$_{10} = 5.328$, $d = -0.742$;
  follow-up: $t(41.729) = -3.167$, $p = 0.003$, Bayes Factor$_{10} = 16.046$, $d = -0.869$).
- a higher need to regulate their writing habits
  (baseline: $t(51.995) = -5.169$, $p < 0.001$, Bayes Factor$_{10} = 3956.250$, $d = -1.407$;
  follow-up: $t(51.792) = -3.741$, $p < 0.001$, Bayes Factor$_{10} = 59.610$, $d = -1.019$)
- similar perceptions of their performance on the transcription task
  (baseline: $t(48.927) = 0.180$, $p = 0.858$, Bayes Factor$_{10} = 0.278$, $d = 0.049$;
  follow-up: $t(50.222) = 0.205$, $p = 0.838$, Bayes Factor$_{10} = 0.279$, $d = 0.056$).

In summary, the depletion task used in this study appears to have successfully induced at least some aspects of ego-depletion in participants, as evidenced by the significant differences in self-reported task exhaustiveness (at baseline), task difficulty, and the need to regulate writing habits. Bayes factors provide additional information for the non-significant findings, showing that the data is more likely under the null hypothesis for overall exhaustion (moderate evidence) and perceived performance on the transcription task (moderate evidence) and inconclusive for the exhaustiveness of the task at the follow-up measurement, indicating that more data is needed for a conclusive interpretation.

Self-control in the SART

Three mixed logistic regression and one linear mixed regression analyses were performed to investigate the effect mindfulness and ego depletion on the performance in the Sustained Attention to Response Task (SART). One model was constructed for errors of omission and another for errors of commission. The third logistic model analyzed the overall performance, which is a composite score of both types of errors, weighted heavily towards the omission model as it contains more trials. The dependent variable was the performance (correct vs. incorrect) on a trial-by-trial basis. As the instructions in the SART emphasize responding both accurately and quickly, the reaction time was included as a covariate in the model (see, Seli et al., 2013). In order to provide a predictor that was independent of the respective errors (commission errors imply a reaction time where there shouldn't be one and omission errors necessarily imply no reaction time), and one that captured the general speed of responding prior to a given error, a rolling mean of the reaction time over the last five trials was calculated (with exponentially decreasing weights for the older trials and a decay factor of 0.5). The third model analyzed the coefficient of variation of the reaction time on a trial-by-trial basis, predicting the standard deviation divided by the mean of the last five trials (again with exponentially decreasing weights and a decay factor of 0.5).

Omission errors

The results of the go-trials model indicated that none of the main factors of interest or any of their interactions significantly predicted omission errors in the SART (all p's > .088). The

control variables weighted reaction time (B = 3.647, z = 13.280, p < 0.001) and age (B = 0.019, z = 3.382, p = 0.001) showed significant effects, suggesting that slower responses and older age were associated with better performance. Measurement time (B = 0.066, z = 1.703, p = .088) showed a trend towards significance, indicating that participants showed better performance at the follow-up measurement relative to the baseline ($M_{Baseline}$ = 0.956, $M_{Follow\text{-}up}$ = 0.959). The hypotheses regarding the effect of mindfulness training and ego depletion on omission errors were not supported by the data. The positive effect of slower reaction times on performance was not explicitly hypothesized (as it is not a main factor of interest), but is consistent with the SART literature (Manly et al., 1999; Robertson et al., 1997b), which reports a speed-accuracy trade-off. The fact that older participants did better on average, is however contrary to expectations, as previous research has suggested that SART performance tends to decline with age (Robertson et al., 1997a).

Commission errors

The model for the no-go trials showed that of the main factors of interest, only the interaction of depletion and measurement time significantly predicted commission errors in the SART (B = -0.368, z = -2.065, p = .039). Specifically, there was very little difference between depletion and non-depletion groups at the baseline measurement ($M_{Non\text{-}depletion}$ = 0.923, $M_{Depletion}$ = 0.922), but a larger difference emerged at the follow-up measurement ($M_{Non\text{-}depletion}$ = 0.944, $M_{Depletion}$ = 0.920), indicating that the depletion had a greater impact on commission errors over time. The hypotheses regarding the effect of mindfulness training and ego depletion on commission errors were therefore only partially supported by the data.

The control variable of weighted reaction time (B =-4.568, z = -13.725, p < .001) also significantly predicted commission errors. Contrary to expectations (and to the pattern found with omission errors), slower reaction times (which are typically associated with better performance) were found to be associated with a higher number of commission errors. For reasons of parsimony and model fit the control variable age was not included in the model as it did not significantly contribute to the prediction of commission errors.

Overall performance

The overall performance was evaluated by taking into account both omission and commission errors. The results showed that the effects found separately for omission and commission errors were both significant in the overall performance. Measurement time, which had only indicated a trend towards significance in the omission error model, showed a clear effect on overall performance (B = 0.077, z = 2.311, p = 0.021), indicating that overall performance improved from the first to the second measurement ($M_{Basline}$ = 0.945, $M_{Follow\text{-}up}$ = 0.949). The interaction of depletion and measurement time was also significant (B = -0.148, z = -2.226, p = 0.026), indicating that depletion had a reversed effect depending on the measurement time. Specifically, the depletion led to an increase in performance at the first measurement ($M_{Non\text{-}depletion}$ = 0.941; $M_{Depletion}$ = 0.949), but a decrease at the second measurement ($M_{Non\text{-}depletion}$ = 0.949; $M_{Depletion}$ = 0.948). The control variable reaction time was not significant (B = 0.321, z = 1.643, p = 0.100), which makes sense given that the go and no-go trials had opposite effects of reaction time, cancelling out any potential effects.

Coefficient of variation

The results of the CV analysis showed that of the main factors of interest mindfulness (B = 0.016, t(49.042) = 2.446, p = 0.018), measurement time (B = -0.002, t(65'798.484) = -2.408, p = 0.016), the interaction of depletion and measurement time (B = 0.009, t(65'798.484) = 6.155, p <

.001) and the interaction of mindfulness and measurement time (B = 0.008, t(65'798.484) = 5.808, p < .001) were all significantly associated with the coefficient of variation. Taken together these effects indicate that the RT CV was slightly lower at the follow-up measurement ($M_{Baseline}$ = 0.123; $M_{Follow\text{-}up}$ = 0.121), that the ego depletion effect was more pronounced at the second measurement time ($M_{\text{Non-depletion}}$ = 0.114; $M_{\text{Depletion}}$ = 0.129) relative to the first measurement ($M_{\text{Non-depletion}}$ = 0.120; $M_{\text{Depletion}}$ = 0.126) and that the control intervention lowered the RT CV ($M_{Baseline}$ = 0.117; $M_{Follow\text{-}up}$ = 0.111) compared to the mindfulness intervention, which raised it ($M_{Baseline}$ = 0.129; $M_{Follow\text{-}up}$ = 0.131). It is important to note that the RT CV is a measure of inattention, with higher levels indicating greater inattention. Therefore, these results suggest that mindfulness and ego depletion both increase this measure of inattention over time. The hypothesis regarding the effect of ego depletion on the coefficient of variation was partially supported by the data. Specifically, the ego depletion hypothesis was supported in the sense that the depletion condition resulted in higher CV over time, indicating that the depletion manipulation increased inattention more at the second measurement with a trend for overall increase (B = 0.011, t(49.041) = 1.633, p = 0.109). The mindfulness training, in contrast, had an opposite effect to the hypothesis, with the mindfulness intervention leading to an in increase in RT CV associated inattention over time, while the control condition lowered it suggesting that mindfulness training may not be as effective as anticipated in reducing inattention, at least in the context of the SART task.

PANAS

The hypothesis regarding the effect of mindfulness training and ego depletion on PANAS scores was tested with a linear mixed model for each of the two subscales: Positive Affect (PA) and Negative Affect (NA).

The results showed that there was a significant main effect of measurement time on PA (B = -0.196, t(158.083) = -3.597, p < 0.001), indicating lower positive affect for all groups at the follow-up measurement ($M_{Baseline}$ = 1.745, $M_{Follow\text{-}up}$ = 1.549). The was an overall negative effect of the pre- vs. post-measurement recording of the PANAS (B = -0.635, t(158.083) = -11.643, p < 0.001), suggesting a decrease in positive affect after the text transcription and SART tasks. There was a trend for this effect to be attenuated at the second measurement (B = 0.190, t(158.083) = 1.744, p = 0.083; baseline: M_{Pre}= 2.111, M_{post} = 1.380; follow-up: M_{Pre} = 1.819, M_{post} = 1.279). None of the effects concerning mindfulness were significant (all p's > 0.238).

The NA model showed a strong effect of measurement time (B = -0.122, t(158.083) = -2.236, p = 0.027), indicating that there was an decrease in negative affect for all groups at the follow-up measurement ($M_{Baseline}$ = 0.419, $M_{Follow\text{-}up}$ = 0.297). The main effect of mindfulness vs control condition also became significant (B = -0.176, t(53.086) = -2.053, p = 0.045), suggesting that there were baseline differences in negative affect as the interaction with measurement time did not show a significant effect (B = -0.009, t(158.183) = -0.130, p = 0.896).

Taken together, these findings suggest that the mindfulness intervention did not have a significant effect on either the positive of negative affect, rejecting the hypothesis that mindfulness training would result in improved PANAS scores.

Self-control questionnaire

The results of the self-control questionnaire were analyzed using a linear mixed model. Neither the main effect of mindfulness condition on self-control scores (B = 0.066, t(53) = 0.834, p = 0.408), nor the main effect of measurement time (B = 0.035, t(53) = 1.251, p = 0.216) were significant. However, there was a significant interaction effect between mindfulness condition and measurement time (B = -0.170, t(53) = -2.996, p = 0.004), suggesting that the mindfulness intervention had a different effect on self-control over time compared to the control condition. Specifically, the mindfulness condition showed a decrease in self-control scores from the baseline to the follow-up measurement ($M_{Baseline}$ = 2.216, $M_{Follow\text{-}up}$ = 2.167), while the control condition

showed a slight increase ($M_{Baseline}$ = 2.064, $M_{Follow\text{-}up}$ = 2.185). This finding contradicts the initial hypothesis that mindfulness training would enhance self-control over time.

Discussion

The analysis of the data generated in this study yielded unexpected results regarding the effects of mindfulness training and ego depletion on indicators of attention, affect, and self-control. While mindfulness training has been widely touted as a tool to enhance focus and reduce stress, the data from this study suggest that its effects might be more complex and context-dependent than previously assumed.

First, the results showed that mindfulness training was not significantly associated with a reduction in omission or commission errors in the SART nor with improved overall performance. Moreover, in terms of affect, the mindfulness intervention did not have a significant effect on either positive or negative affect, rejecting the hypothesis that mindfulness training would result in improved PANAS scores. The mindfulness intervention did however increase the coefficient of variation, a measure of inattention, in comparison to the control condition and lead to decreased self-reported self-control scores compared to the control group. Both significant effects are contrary to the expected outcomes, suggesting that mindfulness training, at least in the context of this study, did not have the expected positive effects on attention, affect or self-control.

Second, the finding that ego depletion was associated with increased commission errors over time, especially in the follow-up measurement, partially supported the hypothesis that depletion would impair performance. This was corroborated by the overall performance results, which showed a significant interaction of depletion and measurement time, indicating that depletion slightly increased performance at the first measurement but decreased it at the second. Moreover, the coefficient of variation showed the same pattern, indicating a trend towards increased inattention at the follow-up measurement relative to the baseline. This suggests that, consistent with the ego depletion hypothesis, cognitive resources are indeed depleted by the depletion task, leading to impaired performance on the SART. The only indicator that did not support the ego depletion hypothesis was the lack of a significant effect on omission errors.

Third, the hypothesis that the mindfulness intervention could buffer against the effects of ego depletion was not supported by the data. Given that none of the three-way interactions were significant and that the effects of mindfulness (two-way interactions), when significant, where contrary to the predicted direction, it can be concluded that mindfulness training did not significantly mitigate the effects of ego depletion in this study. This is in line with Stocker et al.'s (2019) findings, which also reported no significant buffering effects of a shorter mindfulness intervention (two sessions of 4 minutes each) without in person instruction on a physical self-control task. Their research as well as the results of the current study stand in contrast to research by Friese et al. (2012), which did find a significant buffering effect of a brief mindfulness intervention in a cognitive task.

Paradoxical Effects of Mindfulness

One of the more surprising findings in this study was the paradoxical effect of mindfulness on self-control and more generally attention. Contrary to the hypothesis, mindfulness training did not result in any significant improvements in self-control or attention. In fact, the mindfulness condition showed a decrease in some measures.

Omission errors, which are associated with complete disengagement (sometimes referred to as perceptual decoupling) from the task and thus the strongest form of lapses in attention, were not significantly reduced by the mindfulness vs. control group manipulation. Both groups showed similar performances at follow-up. A similar short-form intervention (Morrison et al., 2014) did find a significant effect of their intervention in such errors following their mindfulness

exercises (7h over 7 weeks) versus the control group (wait-list), but this interaction was mainly driven by the decrease in the non-active control group from baseline to follow-up while the mindfulness group maintained their performance. The discrepancy to our data could therefore be due to differences regarding the control group, which was active in our study as opposed to the wait-list condition in Morrison et al.'s study. Another study (Bennike et al., 2017) found that a similar mindfulness intervention (7.5h total in a 4-week app program) with an active control group (app-based brain training program) did not significantly reduce omission errors (for both groups), which is in line with our findings. It therefore seems that short-term mindfulness training may not be sufficient to reduce lapses at such a coarse level any further, which are already very rare in a population of healthy adults to begin with.

Errors of commission, which indicate a failure to inhibit a prepotent response, were also not significantly reduced in the mindfulness condition. According to the rhythmic-race model (Hawkins et al., 2019) such failures occur when the time taken to recognize the need for response inhibition exceeds the time it takes for the automatic response to be executed. The reliance on an automatic strategy is thought to indicate a lack of monitoring and conscious control. Compared to the complete disengagement that omission errors are associated with, commission errors represent an intermediate level of engagement with a somewhat active (i.e., perceptually coupled) yet distracted (i.e., metacognitively decoupled) engagement with the task. While the 7h short-form intervention by Morrison et al. (Morrison et al., 2014) also did not find a significant effect on commission errors, other short-term mindfulness interventions have shown a significant reduction in such errors (Bennike et al., 2017) as have longer-term interventions (Giannandrea et al., 2019). However, it is worth pointing out that the accuracies for no-go trials in Morrison et al.'s and Bennike et al.'s studies were much lower (between 44.51% and 68.3% per cell), while our task produced performances between 87.33% and 93.88% per cell. The omission errors showed no such deviation between our study and the others. The lower performance rates in the aforementioned studies indicates a more challenging task, which could potentially allow for the detection of a more pronounced effect of mindfulness training on performance. In contrast, the relative ease of the tasks in our study, as indicated by the high performance rates, may have made it more difficult to discern any potential benefits of mindfulness training. The SART in our study differed from the more standard version in the aforementioned short-form mindfulness studies in that it used capitalized and non-capitalized words instead of numbers. Our version also differed from other perceptual word version SARTs (McVay & Kane, 2009; Yang et al., 2022) in that no personal concerns were implicitly embedded in the words. This may have unwittingly produced a task that was less likely to induce mind-wandering, thereby reducing the likelihood of commission errors and making it more challenging to observe any potential improvements due to mindfulness.

Given that no significant intervention effect was observed for omission and commission errors, it is unsurprising that the overall performance measure (total correct responses) also did not show a significant difference between the mindfulness and control group. This lack of intervention effect on overall performance further supports the conclusion that short-form mindfulness training does not significantly improve self-control and attention in the perceptual word SART without personal concerns embeddings.

As regards to the coefficient of variation of reaction time (RT CV), our findings also indicated a paradoxical effect of mindfulness. While it is generally assumed that a higher RT CV is indicative of greater inattention, our data showed an increase in the RT CV in the mindfulness group while the control group decreased slightly. This is contrary to the expectation that mindfulness training would improve attention and thus reduce RT CV, which is what the study by Morrison et al. (2014) found for their short-form mindfulness intervention. However, Bennike et al.'s (2017) short-from intervention did not find a significant effect for RT CV, suggesting that the impact of mindfulness on this performance measure may be nuanced and dependent on contextual factors, such as the specific mindfulness practices employed and the spacing of the training period (Bennike et al.'s 7.5h app based training was spread across four weeks while

Morrison et al.'s 7h took 7 weeks). When considering the unexpected decrease in attentional consistency associated with RT CV in our study it is worth noting that this effect only became significant in the context of the fine-grained trial-by-trial analysis with a linear mixed model. When we replicated the analysis with aggregates per subject, we did not find any significant effects of any sort, which is in line with Bennike et al.. This poses the question if the trial-by-trial analysis is more sensitive and thus better suited to detect subtle effects of mindfulness training on attentional performance, which might also have surfaced in the unexpected direction in Bennike et al.'s study. It also raises the question about the nature of the inconsistency in attention that is reflected in the increased RT CV. The trial-by-trial measure is sensitive to fluctuations in RT on the scale of 3-5 trials, while the aggregation per subject measure is a mix of such short scales with overall task trends (e.g., gradual increase of speed throughout the task). Given that most studies associating RT CV with increased attentional fluctuation and mind-wandering have done so with subject averaged data (Bastian & Sackur, 2013; Mrazek et al., 2012; Seli et al., 2013), it is worth considering whether the trial-by-trial measure is capturing a different aspect of attentional fluctuation, which may not necessarily be associated with mind-wandering or inattention in the same way. Our results pose the question if short-term mindfulness training, if assessed at the trial-by-trial level, actually leads to a different type of response time fluctuation, possibly more akin to increased flexibility and adaptability in response times (e.g., as a result of an increased awareness of moment-to-moment changes in cognitive and emotional states), rather than increased inattention or mind-wandering. However, as the perceptual word SART without personal concerns embeddings produced unexpected results in other measures (e.g., unusually high performance in the no-go trials), our data is arguably not suitable for supporting answers generalizable to the broader SART literature. As such, our findings should be interpreted with caution until further research (e.g., with more classical SART version) can provide a more definitive understanding of the interplay between short-from mindfulness training and attentional performance at the trial-by-trial level.

Lastly, the mindfulness intervention led to unexpected results in the self-reported measures of the PANAS and the self-control questionnaire, with no significant effects found for the former and significant effects in the latter but opposite to what was predicted. The lack of significant changes in the PANAS scores suggests that short-term mindfulness training did not significantly affect participants' mood states, which is inconsistent with previous studies that have reported improvements in mood following mindfulness training (Keng et al., 2011; Khoury et al., 2013). The unexpected results in the self-control questionnaire, where the mindfulness group reported lower self-control follow-up compared to the control group, is also contrary to previous research that has indicated mindfulness training can enhance self-control (Tang et al., 2007).

These surprising findings may be due to a number of factors. For example, there is the issue that mindfulness training has been associated with increased introspective awareness, which might have led participants in the mindfulness group to become more aware of their lack of self-control, resulting in lower self-reported scores (Brown & Ryan, 2004; Grossman, 2011) and effects cancelling out in the PANAS. The increase in introspective awareness commonly associated with mindfulness complicates the interpretation of self-report measures in general. The fact that self-reported mindfulness via the CHIME questionnaire did significantly improve for the mindfulness group but not the control group can be integrated into this theory by assuming an expectation effect counteracting increased introspective skepticism. Alternatively, the unexpected results could be attributed to the relatively short duration of the mindfulness training.

Taken together the results and variable comparisons with other studies may be tempt the conclusion that short-form mindfulness interventions, including the one employed in our study, are inconsistent at improving attentional control or at least highly dependent on the specifics of the intervention or the nature of the task in how they do so (e.g., different patterns in error types and RT CV differences). One might furthermore be inclined to suggest that the potential benefits of mindfulness training may only become apparent when it is applied consistently over a longer

period. However, this picture is complicated by studies with an even shorter mindfulness intervention such as the one by Rahl et al. (2017), which found that three 20-minute sessions of guided audio recordings over three days lead to significant improvements in the overall performance of a 6-min number SART. Yet the catch was that this was only the case for the condition in which mindfulness was presented with an emphasis on acceptance, suggesting that under the right conditions, mindfulness interventions can indeed yield significant improvements in attentional control even over short periods of time.

This leads to the question of what differentiates effective from ineffective short-form mindfulness interventions. One possibility is that the effectiveness of the intervention is tied to the specific mindfulness practices employed. For example, certain practices may be more effective at increasing attentional control, while others may be better suited to reducing stress or improving emotional regulation. A meta-analysis by Carmody and Baer (2009) found no effect of total in-class hours spent in the given mindfulness based programs (spanning 4-10 sessions and 6-28 total hours) on psychological distress, suggesting that duration may not be a key determinant for this outcome. The authors also pointed out that there were not enough studies to address other measures, leaving the question of the relationship between duration and self-control largely unanswered.

Another possibility is that the effectiveness of the intervention is tied to the duration or frequency of the training sessions. For instance, shorter, less frequent sessions may be more effective than longer, more frequent ones. Furthermore, the nature of the task used to assess the effectiveness of the intervention may also play a significant role. As our study and others have shown, different tasks may yield different patterns of results, potentially reflecting the differential impacts of mindfulness training on different aspects of cognitive functioning.

Ego Depletion Effects

In addition to the unexpected findings from mindfulness intervention, the study also observed intriguing results related to ego depletion effects. As predicted, participants in the depletion condition showed more errors of commission, more overall errors and higher RT CV. However, this was only the case in follow-up measurement relative to baseline, posing the question as to why these effects were not statistically significant at the initial measurement. While the lack of statistical significance regarding the errors of omission at both baseline and follow-up can be explained with the same rationale as the one used for the mindfulness intervention results (a ceiling effect implied by the coarse level of the measure), the lack of significant changes for the other measures at baseline remains puzzling. That is, when considering the finding from the vantage point of the resource model of self-control (Baumeister et al., 1998; Muraven & Baumeister, 2000), which posits that self-control resources are unitary and are depleted after exerting effort. Given that the two measurements were spaced two weeks apart, a buildup and maintenance of ego depletion effects over this period is highly unlikely. The comparative simplicity of the resource model, which arguably constitute its appeal, also restricts its capacity to account for more complex patterns of findings such as the ones observed in our study. The most likely explanation in the finite resource paradigm is that both the mindfulness and control intervention depleted participants in the days prior to the follow-up measurement (more than they had naturally been prior to baseline). Such an effect is however implausible as, even if listening to an audiobook or a guided meditation were an exhausting task, which it is arguably not, the follow-up measurement took place at least 24h after the last day of the respective intervention. The patterns are therefore more compatible with theories that have more degrees of freedom such as the process model of self-control (Inzlicht et al., 2014), which predicts a dependency in self-control on multiple factors. For instance, the process model can make sense of the baseline to follow-up differences in depletion by positing changes in motivation, attention, and emotion. Specifically, according to the process model changes in self-control are mediated by a shift in task priorities such as so-called 'have-to' goals being replaced by 'want-to' goals when

participants feel they have invested enough in a given task. This in turn is driven by unpleasant emotions (tasks such as the transcription task and the SART are unrewarding and boring) and leads to shifts in attention (in this case away from the SART and towards mind-wandering or other forms of distraction). While a unitary account of self-control similar to a reservoir of willpower cannot explain an effect spanning across two weeks, a theory about motivation can, as the latter is dependent on a narrative and the framing that the respective participant constructs. It is therefore plausible that the participants in the depletion condition (who like the others were not compensated in any way) may have felt that they fulfilled their duties as conscientious subjects more so than participants of the regular transcription task, which could have led to a relative decrease in motivation and a shift in attention towards more desirable or rewarding activities at the follow-up measurement. These changes in motivation and attitude could have then resulted in a decrease in performance on the SART, manifesting as an apparent ego depletion effect. There was a tendency for participants in all conditions to perform better at follow-up in various measures (less omission errors, overall errors, RT CV), which can be integrated into this theory by positing that the initial exposure to the task at baseline may have primed participants to better understand and adapt to the task demands during the subsequent exposure at follow-up. This improved familiarity with the task could have in turn led to the observed improvement in performance. Furthermore, the novelty of the task at baseline could have elicited a certain degree of arousal and interest in the participants, which may have boosted the performance in both conditions overshadowing potential effects of the depletion manipulation. This potential novelty would have been absent or significantly reduced at follow-up, allowing for a more accurate reflection of the manipulation. Additionally, it is also possible that the participants may have employed different strategies during the task at follow-up as a result of their initial exposure. For example, they may have learned to better manage their attention resources or developed more effective methods for dealing with boredom or fatigue. These changes could have contributed to the improved performance observed at follow-up, while allowing for an interaction with reduced motivation in the depletion condition.

Regarding the possible shift in strategies (in essence a shift in attention), it would be an ironic twist if the mindfulness intervention enabled participants to better decouple from the task (e.g., by focusing on the breath and not the task) due to more acutely felt negative emotions, which is a common first effect of mindfulness training on sensations of all valences. So, while it remains unclear if the trial-by-trial RT CV does indeed indicate the same kind of attentional inconsistency found in other studies, a process model account could integrate why both the depletion condition as well as the mindfulness intervention led to higher values of this parameter.

Lastly, since the effect of mindfulness was either too small to be significant or opposite the predicted direction, it is unsurprising that the three-way interactions of measurement time, depletion and mindfulness did not become significant in any of the models. This does however not rule out a possible buffering effect of mindfulness on ego depletion, however the latter may be mediated (e.g., via the mechanisms of the process model). The main reason being that the paradoxical results of the intervention indicate that either the training was inadequate to induce the expected changes in mindfulness or that the measures used to assess the effects of the mindfulness intervention were not sensitive enough or otherwise misconstrued for the research question. The absence of the three-way interaction should therefore not be taken as definitive evidence against the potential of mindfulness to buffer ego depletion effects. Instead, it suggests that the operationalization of mindfulness and its measurement in this study may need to be reconsidered.

Secondary Findings

Apart from the discussed oddities of unexpectedly high performance in the no-go trials, which in themselves indicate an anomaly in the SART paradigm, there were two more findings, which need to be explained. The first is the surprising finding that older participants showed less

errors of omission, which is contrary to the common expectation that scores on the SART (Robertson et al., 1997a) along with cognitive performance in general and decreases with age. This could mean that the older participants were more motivated and conscientious than the younger participants who were probably more used to taking part in psychological experiments, which as predicted by the process model of self-control would have an important impact on performance. Such an effect would further highlight that the effect of both mindfulness and depletion manipulations appear to be highly contextual (e.g., the embedding of personal concerns in the SART) and dependent on individual participant characteristics. The second anomalous finding concerns the finding that faster reaction times (in the preceding 5 trials) predicted less errors of commission. This is contrary to both the literature and the speed-accuracy tradeoff found for the errors of omission. When further taking into account the unusually high performance in commission errors, it suggests that the no-go trials in this version of the SART were so easy that the automatic response posited by models such as the rhythmic race model (Hawkins et al., 2019) or the dual process model (Hofmann et al., 2009) was sufficient for detecting and solving the no-go trials. This implies that the participants were not required to mobilize additional cognitive resources to successfully complete the task, which could explain the apparent lack of effect of the depletion manipulation on this measure. The relative ease of the task could also explain why the mindfulness intervention did not have the expected effect. If the task did not require a high level of cognitive effort, then the proposed benefits of mindfulness, such as improved attention regulation and increased cognitive flexibility, would not have been needed and therefore not evident in the results. This could mean that the mindfulness intervention would only show significant effects in more demanding tasks, where the benefits of improved cognitive functioning would be more apparent. Research has shown that mind-wandering and the underlying shifts in motivation postulated by the process model are more likely when tasks are either too easy or too difficult (Mrazek et al., 2012). It would appear that the perceptual word SART without embedded personal concerns falls into the intermediate area, where measurements are less sensitive. This indicates that the perceptual word SART was not the most suitable task for the current study and that future research should consider using more cognitively demanding tasks to investigate the effects of mindfulness and ego depletion.

Implications and Future Directions

The findings from our study provide new insights into the complex dynamics of self-control and the potential impacts of mindfulness interventions. They also underscore the importance of considering the context in which self-control is exerted and the potential for fluctuations in motivation and attention. This has important implications for the design of future studies and interventions aimed at enhancing self-control and cognitive functioning. In the ongoing debate over ego depletion out results suggest that the concept of ego depletion might not be as universally applicable as assumed by advocates of the resource model. Instead, our study corroborates the arguments criticizing the resource model and highlight that ego depletion effects may be contingent on a variety of factors, including the narrative/framing in the participants mind, the nature of the task at hand, the individual's motivational state, and the context in which the task is performed.

Our findings also highlight the need for more rigorous and nuanced approaches to the study of mindfulness interventions. While the effects of mindfulness in this study were either too small to be significant or contrary to expectations, it should not be taken as evidence against the potential benefits of mindfulness. Instead, it underscores the importance of refining our operationalization and measurement of mindfulness, as well as the need to consider the specific contexts and tasks in which mindfulness is applied. Essentially, our findings suggest that alterations to our outcome task, specifically a perceptual SART devoid of any embedded personal concerns, and the delivery method of our guided meditations, conducted exclusively online over a brief period, without the possibility of clarification or in-person guidance, were enough to

undermine our initial hypotheses. This not only highlights the delicate and potentially unstable relationship between short-form mindfulness-based programs and markers of self-control and attention, but also emphasizes the need for careful task and methodological design in future investigations.

One potential direction for future research is to explore the mechanisms underlying the observed changes in motivation and attention in order to determine the precise effects of mindfulness on self-control, and how these might interact with the former factors. It would also be beneficial to explore the potential role of other related constructs, such as self-compassion, acceptance, and non-judgement, which are often cultivated alongside mindfulness in traditional practices. These constructs could potentially contribute to a more comprehensive understanding of the complex interplay between mindfulness, motivation, and self-control. Especially in the context of short-form mindfulness trainings where the time to develop deep mindfulness skills is limited, the emphasis on such accompanying constructs might play a significant role in buffering against ego depletion and facilitating a more robust effect.

References

Anālayo, B. (2019). Adding historical depth to definitions of mindfulness. *Current Opinion in Psychology*, *28*, 11–14. https://doi.org/10.1016/j.copsyc.2018.09.013

Andersen, E., Geiger, P., Schiller, C., Bluth, K., Watkins, L., Zhang, Y., Xia, K., Tauseef, H., Leserman, J., Gaylord, S., & Girdler, S. (2021). Effects of Mindfulness-Based Stress Reduction on Experimental Pain Sensitivity and Cortisol Responses in Women with Early Life Abuse: A Randomized Controlled Trial. *Psychosomatic Medicine*, *83*(6), 515–527. https://doi.org/10.1097/PSY.0000000000000889

Arch, J. J., & Craske, M. G. (2006). Mechanisms of mindfulness: Emotion regulation following a focused breathing induction. *Behaviour Research and Therapy*, *44*(12), 1849–1858.

Baer, R. A. (2003). Mindfulness training as a clinical intervention: A conceptual and empirical review. *Clinical Psychology: Science and Practice*, *10*(2), 125–143.

Bastian, M., & Sackur, J. (2013). Mind wandering at the fingertips: Automatic parsing of subjective states based on response time variability. *Frontiers in Psychology*, *4*, 573.

Baumeister, R. F., Bratslavsky, E., Muraven, M., & Tice, D. M. (1998). Ego depletion: Is the active self a limited resource? *Journal of Personality and Social Psychology*, *74*(5), 1252.

Baumeister, R. F., Heatherton, T. F., & Tice, D. M. (1994). *Losing control: How and why people fail at self-regulation.* Academic Press.

Baumeister, R. F., & Vohs, K. D. (2004). *Handbook of self-regulation*. Guilford Press New York:

Belardi, A., Chaieb, L., Rey-Mermet, A., Mormann, F., Rothen, N., Fell, J., & Reber, T. P. (2022). On the relationship between mind wandering and mindfulness. *Scientific Reports*, *12*(1), 7755.

Bennike, I. H., Wieghorst, A., & Kirk, U. (2017). Online-based Mindfulness Training Reduces Behavioral Markers of Mind Wandering. *Journal of Cognitive Enhancement*, *1*(2), 172–181. https://doi.org/10.1007/s41465-017-0020-9

Bergomi, C., Tschacher, W., & Kupper, Z. (2014). Konstruktion und erste Validierung eines Fragebogens zur umfassenden Erfassung von Achtsamkeit. *Diagnostica*, *60*(3), 111–125.

Bertrams, A., & Dickhäuser, O. (2009). Messung dispositioneller selbstkontroll-kapazität: Eine deutsche adaptation der kurzform der self-control scale (SCS-KD). *Diagnostica*, *55*(1), 2–10.

Bishop, S. R., Lau, M., Shapiro, S., Carlson, L., Anderson, N. D., Carmody, J., Segal, Z. V., Abbey, S., Speca, M., & Velting, D. (2004). Mindfulness: A proposed operational definition. *Clinical Psychology: Science and Practice*, *11*(3), 230–241.

Bodhi, B. (2011). What does mindfulness really mean? A canonical perspective. *Contemporary Buddhism*, *12*(1), 19–39.

Brown, K. W., & Ryan, R. M. (2004). Perils and promise in defining and measuring mindfulness:

Observations from experience. *Clinical Psychology: Science and Practice*, *11*(3), 242–248. https://doi.org/10.1093/clipsy.bph078

Brown, K. W., Ryan, R. M., & Creswell, J. D. (2007). Mindfulness: Theoretical foundations and evidence for its salutary effects. *Psychological Inquiry*, *18*(4), 211–237.

Calvete, E., Royuela-Colomer, E., & Maruottolo, C. (2022). Emotion dysregulation and mindfulness in non-suicidal self-injury. *Psychiatry Research*, *314*, 114691. https://doi.org/10.1016/j.psychres.2022.114691

Carmody, J., & Baer, R. A. (2009). How long does a mindfulness-based stress reduction program need to be? A review of class contact hours and effect sizes for psychological distress. *Journal of Clinical Psychology*, *65*(6), 627–638.

Carter, E. C., Kofler, L. M., Forster, D. E., & McCullough, M. E. (2015). A series of meta-analytic tests of the depletion effect: Self-control does not seem to rely on a limited resource. *Journal of Experimental Psychology: General*, *144*(4), 796.

Carter, E. C., & McCullough, M. E. (2014). Publication bias and the limited strength model of self-control: Has the evidence for ego depletion been overestimated? *Frontiers in Psychology*, *5*, 823.

Charoensukmongkol, P., & Aumeboonsuke, V. (2016). Does mindfulness enhance stock trading performance?: The moderating and mediating effects of impulse control difficulties. *International Journal of Work Organisation and Emotion*, *7*(4), 257–274.

Cheung, R. Y. M., & Ng, M. C. Y. (2019). Mindfulness and Symptoms of Depression and Anxiety: The Underlying Roles of Awareness, Acceptance, Impulse Control, and Emotion Regulation. *Mindfulness*, *10*(6), 1124–1135. https://doi.org/10.1007/s12671-018-1069-y

Cheyne, J. A., Solman, G. J., Carriere, J. S., & Smilek, D. (2009). Anatomy of an error: A bidirectional state model of task engagement/disengagement and attention-related errors. *Cognition*, *111*(1), 98–113.

Creswell, J. D., Way, B. M., Eisenberger, N. I., & Lieberman, M. D. (2007). Neural correlates of dispositional mindfulness during affect labeling. *Psychosomatic Medicine*, *69*(6), 560–565.

Dreyfus, G. (2011). Is mindfulness present-centred and non-judgmental? A discussion of the cognitive dimensions of mindfulness. *Contemporary Buddhism*, *12*(1), 41–54. https://doi.org/10.1080/14639947.2011.564815

Friese, M., Loschelder, D. D., Gieseler, K., Frankenbach, J., & Inzlicht, M. (2019). Is ego depletion real? An analysis of arguments. *Personality and Social Psychology Review*, *23*(2), 107–131.

Friese, M., Messner, C., & Schaffner, Y. (2012). Mindfulness meditation counteracts self-control depletion. *Consciousness and Cognition*, *21*(2), 1016–1022.

Garland, E., Gaylord, S., & Park, J. (2009). The role of mindfulness in positive reappraisal. *Explore*, *5*(1), 37–44.

Gethin, R. (2011). On some definitions of mindfulness. *Contemporary Buddhism*, *12*(1), 263–279.

Giannandrea, A., Simione, L., Pescatori, B., Ferrell, K., Olivetti Belardinelli, M., Hickman, S. D., & Raffone, A. (2019). Effects of the Mindfulness-Based Stress Reduction Program on Mind Wandering and Dispositional Mindfulness Facets. *Mindfulness*, *10*(1), 185–195. https://doi.org/10.1007/s12671-018-1070-5

Grossman, P. (2011). Defining mindfulness by how poorly I think I pay attention during everyday awareness and other intractable problems for psychology's (re) invention of mindfulness: Comment on Brown et al.(2011). *Psychological Assessment*, *23*(4), 1034–1040.

Grossman, P. (2019). On the porosity of subject and object in 'mindfulness' scientific study: Challenges to 'scientific' construction, operationalization and measurement of mindfulness. *Current Opinion in Psychology*, *28*, 102–107. https://doi.org/10.1016/j.copsyc.2018.11.008

Hagger, M. S., Chatzisarantis, N. L., Alberts, H., Anggono, C. O., Batailler, C., Birt, A. R., Brand, R., Brandt, M. J., Brewer, G., & Bruyneel, S. (2016). A multilab preregistered replication

of the ego-depletion effect. *Perspectives on Psychological Science*, *11*(4), 546–573.
Hagger, M. S., Wood, C., Stiff, C., & Chatzisarantis, N. L. (2010). Ego depletion and the strength model of self-control: A meta-analysis. *Psychological Bulletin*, *136*(4), 495–525.
Hawkins, G. E., Mittner, M., Forstmann, B. U., & Heathcote, A. (2019). Modeling distracted performance. *Cognitive Psychology*, *112*, 48–80.
Hayes, S. C., Strosahl, K. D., & Wilson, K. G. (1999). *Acceptance and commitment therapy* (Vol. 6). Guilford press New York.
Hofmann, W., Friese, M., & Strack, F. (2009). Impulse and self-control from a dual-systems perspective. *Perspectives on Psychological Science*, *4*(2), 162–176.
Hölzel, B. K., Lazar, S. W., Gard, T., Schuman-Olivier, Z., Vago, D. R., & Ott, U. (2011). How does mindfulness meditation work? Proposing mechanisms of action from a conceptual and neural perspective. *Perspectives on Psychological Science*, *6*(6), 537–559.
Inzlicht, M., & Schmeichel, B. J. (2012). What is ego depletion? Toward a mechanistic revision of the resource model of self-control. *Perspectives on Psychological Science*, *7*(5), 450–463.
Inzlicht, M., Schmeichel, B. J., & Macrae, C. N. (2014). Why self-control seems (but may not be) limited. *Trends in Cognitive Sciences*, *18*(3), 127–133.
Inzlicht, M., Werner, K. M., Briskin, J. L., & Roberts, B. W. (2021). Integrating models of self-regulation. *Annual Review of Psychology*, *72*, 319–345.
Jha, A. P., Krompinger, J., & Baime, M. J. (2007). Mindfulness training modifies subsystems of attention. *Cognitive, Affective, & Behavioral Neuroscience*, *7*(2), 109–119.
Kabat-Zinn, J., & Hanh, T. N. (2009). *Full catastrophe living: Using the wisdom of your body and mind to face stress, pain, and illness*. Delta.
Kabat-Zinn, J., Lipworth, L., & Burney, R. (1985). The clinical use of mindfulness meditation for the self-regulation of chronic pain. *Journal of Behavioral Medicine*, *8*, 163–190.
Keng, S.-L., Smoski, M. J., & Robins, C. J. (2011). Effects of mindfulness on psychological health: A review of empirical studies. *Clinical Psychology Review*, *31*(6), 1041–1056.
Khoury, B., Lecomte, T., Fortin, G., Masse, M., Therien, P., Bouchard, V., Chapleau, M.-A., Paquin, K., & Hofmann, S. G. (2013). Mindfulness-based therapy: A comprehensive meta-analysis. *Clinical Psychology Review*, *33*(6), 763–771.
Kirk, U., Downar, J., & Montague, P. R. (2011). Interoception drives increased rational decision-making in meditators playing the ultimatum game. *Frontiers in Neuroscience*, *5*, 49.
Kok, B. E., & Singer, T. (2017). Phenomenological fingerprints of four meditations: Differential state changes in affect, mind-wandering, meta-cognition, and interoception before and after daily practice across 9 months of training. *Mindfulness*, *8*(1), 218–231.
Krohne, H. W., Egloff, B., Kohlmann, C.-W., & Tausch, A. (1996). Positive and negative affect schedule–German version. *Diagnostica*.
Kurzban, R. (2010). Does the brain consume additional glucose during self-control tasks? *Evolutionary Psychology*, *8*(2), 244–259.
Kurzban, R., Duckworth, A., Kable, J. W., & Myers, J. (2013). An opportunity cost model of subjective effort and task performance. *Behavioral and Brain Sciences*, *36*(6), 661–679.
Manly, T., Robertson, I. H., Galloway, M., & Hawkins, K. (1999). The absent mind: Further investigations of sustained attention to response. *Neuropsychologia*, *37*(6), 661–670.
Mathôt, S., Schreij, D., & Theeuwes, J. (2012). OpenSesame: An open-source, graphical experiment builder for the social sciences. *Behavior Research Methods*, *44*, 314–324.
McVay, J. C., & Kane, M. J. (2009). Conducting the train of thought: Working memory capacity, goal neglect, and mind wandering in an executive-control task. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *35*(1), 196–204.
Moffitt, T. E., Arseneault, L., Belsky, D., Dickson, N., Hancox, R. J., Harrington, H., Houts, R., Poulton, R., Roberts, B. W., Ross, S., & others. (2011). A gradient of childhood self-control predicts health, wealth, and public safety. *Proceedings of the National Academy of Sciences*, *108*(7), 2693–2698.
Monteiro, L. M., Musten, R. F., & Compson, J. (2015). Traditional and contemporary

mindfulness: Finding the middle path in the tangle of concerns. *Mindfulness*, *6*, 1–13.
Moore, A., & Malinowski, P. (2009). Meditation, mindfulness and cognitive flexibility. *Consciousness and Cognition*, *18*(1), 176–186.
Morrison, A. B., Goolsarran, M., Rogers, S. L., & Jha, A. P. (2014). Taming a wandering attention: Short-form mindfulness training in student cohorts. *Frontiers in Human Neuroscience*, *7*, 897.
Mrazek, M. D., Smallwood, J., & Schooler, J. W. (2012). Mindfulness and mind-wandering: Finding convergence through opposing constructs. *Emotion*, *12*(3), 442–448.
Muraven, M., & Baumeister, R. F. (2000). Self-regulation and depletion of limited resources: Does self-control resemble a muscle? *Psychological Bulletin*, *126*(2), 247.
Muraven, M., Baumeister, R. F., & Tice, D. M. (1999). Longitudinal improvement of self-regulation through practice: Building self-control strength through repeated exercise. *The Journal of Social Psychology*, *139*(4), 446–457.
Neff, K. D., & Germer, C. K. (2013). A Pilot Study and Randomized Controlled Trial of the Mindful Self-Compassion Program. *Journal of Clinical Psychology*, *69*(1), 28–44. https://doi.org/10.1002/jclp.21923
Ostafin, B. D., Kassman, K. T., & Wessel, I. (2013). Breaking the cycle of desire: Mindfulness and executive control weaken the relation between an implicit measure of alcohol valence and preoccupation with alcohol-related thoughts. *Psychology of Addictive Behaviors*, *27*(4), 1153–1158.
Rahl, H. A., Lindsay, E. K., Pacilio, L. E., Brown, K. W., & Creswell, J. D. (2017). Brief mindfulness meditation training reduces mind wandering: The critical role of acceptance. *Emotion*, *17*(2), 224.
Rammstedt, B., & John, O. P. (2005). Kurzversion des big five inventory (BFI-K). *Diagnostica*, *51*(4), 195–206.
Reid, R. C., Di Tirro, C., & Fong, T. W. (2014). Mindfulness in patients with gambling disorders. *Journal of Social Work Practice in the Addictions*, *14*(4), 327–337.
Robertson, I. H., Manly, T., Andrade, J., Baddeley, B. T., & Yiend, J. (1997a). Oops!': Performance correlates of everyday attentional failures in traumatic brain injured and normal subjects. *Neuropsychologia*, *35*(6), 747–758.
Robertson, I. H., Manly, T., Andrade, J., Baddeley, B. T., & Yiend, J. (1997b). *Sustained attention to response task*. American Psychological Association.
Seli, P., Jonker, T. R., Cheyne, J. A., & Smilek, D. (2013). Enhancing SART validity by statistically controlling speed-accuracy trade-offs. *Frontiers in Psychology*, *4*, 265.
Shapiro, S. L., Carlson, L. E., Astin, J. A., & Freedman, B. (2006). Mechanisms of mindfulness. *Journal of Clinical Psychology*, *62*(3), 373–386.
Siegel, D. J. (2007). Mindfulness training and neural integration: Differentiation of distinct streams of awareness and the cultivation of well-being. *Social Cognitive and Affective Neuroscience*, *2*(4), 259–263. https://doi.org/10.1093/scan/nsm034
Somaraju, L. H., Temple, E. C., Cocks, B., & Bizo, L. A. (2023). Are Mindfulness and Mind-Wandering Opposite Constructs? It Depends on How Mindfulness is Conceptualised. *Psychological Reports*, *Advance online publication*. https://doi.org/10.1177/00332941231152391
Stocker, E., Englert, C., & Seiler, R. (2019). Self-control strength and mindfulness in physical exercise performance: Does a short mindfulness induction compensate for the detrimental ego depletion effect? *Journal of Applied Sport Psychology*, *31*(3), 324–339.
Tang, Y.-Y., Hölzel, B. K., & Posner, M. I. (2015). The neuroscience of mindfulness meditation. *Nature Reviews Neuroscience*, *16*(4), 213–225.
Tang, Y.-Y., Ma, Y., Wang, J., Fan, Y., Feng, S., Lu, Q., Yu, Q., Sui, D., Rothbart, M. K., & Fan, M. (2007). Short-term meditation training improves attention and self-regulation. *Proceedings of the National Academy of Sciences*, *104*(43), 17152–17156.
Teasdale, J. D., Segal, Z. V., Williams, J. M. G., Ridgeway, V. A., Soulsby, J. M., & Lau, M. A.

(2000). Prevention of relapse/recurrence in major depression by mindfulness-based cognitive therapy. *Journal of Consulting and Clinical Psychology*, *68*(4), 615–623.

Teper, R., Segal, Z. V., & Inzlicht, M. (2013). Inside the mindful mind: How mindfulness enhances emotion regulation through improvements in executive control. *Current Directions in Psychological Science*, *22*(6), 449–454.

Vago, D. R., & Silbersweig, D. A. (2012). Self-awareness, self-regulation, and self-transcendence (S-ART): A framework for understanding the neurobiological mechanisms of mindfulness. *Frontiers in Human Neuroscience*, *6*, 1–30. https://doi.org/10.3389/fnhum.2012.00296

Valentine, E. R., & Sweet, P. L. G. (1999). Meditation and attention: A comparison of the effects of concentrative and mindfulness meditation on sustained attention. *Mental Health, Religion & Culture*, *2*(1), 59–70. https://doi.org/10.1080/13674679908406332

Van Dam, N. T., Van Vugt, M. K., Vago, D. R., Schmalzl, L., Saron, C. D., Olendzki, A., Meissner, T., Lazar, S. W., Kerr, C. E., Gorchov, J., Fox, K. C. R., Field, B. A., Britton, W. B., Brefczynski-Lewis, J. A., & Meyer, D. E. (2018). Mind the hype: A critical evaluation and prescriptive agenda for research on mindfulness and meditation. *Perspectives on Psychological Science*, *13*(1), 36–61.

Virone, M. L. (2023). The Use of Mindfulness to Improve Emotional Regulation and Impulse Control among Adolescents with ADHD. *Journal of Occupational Therapy, Schools, & Early Intervention*, *16*(1), 78–90. https://doi.org/10.1080/19411243.2021.2009081

Vohs, K. D., & Baumeister, R. F. (2016). *Handbook of Self-Regulation, Third Edition: Research, Theory, and Applications*. Guilford Publications.

Wallace, B. A. (2011). *Minding closely: The four applications of mindfulness*. Shambhala Publications.

Wallace, B. A., & Shapiro, S. L. (2006). Mental balance and well-being: Building bridges between Buddhism and Western psychology. *American Psychologist*, *61*(7), 690–701.

Yang, H., Paller, K. A., & van Vugt, M. (2022). The steady state visual evoked potential (SSVEP) tracks "sticky" thinking, but not more general mind-wandering. *Frontiers in Human Neuroscience*, *16*, 892863.

Zeidan, F., Johnson, S. K., Diamond, B. J., David, Z., & Goolkasian, P. (2010). Mindfulness meditation improves cognition: Evidence of brief mental training. *Consciousness and Cognition*, *19*(2), 597–605.

Inter-brain synchronization in the practice of Tibetan monastic debate

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Abstract

Objectives: Although mindfulness meditation is the familiar and researched form of mental training derived from Buddhism, it represents but one form of practice. Monastic debate is an interactive and dyadic analytical meditation practice that originates from the Tibetan Buddhist tradition where monastics seek to jointly deepen their understanding of complicated philosophical issues. To date, monastic debate and analytic meditation have yet to be examined in the context of scientific investigation.

Methods: In the current study, we examined the neural correlates of this analytical meditation practice by means of hyperscanning electroencephalography, a method well-suited for examining social interactions.

Results: Consistent with the idea that analytical meditation helps to train concentration, we observed that over the course of the debate, mid-frontal theta oscillations—a correlate of absorption—increased significantly. This increase was stronger for more experienced monks as compared to monks at the beginning of their education. In addition, we found evidence for increases in synchrony in frontal alpha oscillations between paired debaters during moments of agreement as compared to disagreement on a set of premises.

Conclusions: Together, these findings provide an initial understanding of Tibetan monastic debate and analytical meditation using neuroscientific methods.

Keywords: hyperscanning, monastic debate, Tibetan Buddhism, meditation, concentration, analytical meditation

Word count: 8127

Inter-brain synchronization in the practice of Tibetan monastic debate

Although mindfulness has seen a meteoric rise in attention and investigation within the scientific discourse, meditation is far from a monolithic practice even within the Buddhist tradition (e.g., Dahl, Lutz, & Davidson, 2015). To date, neuroscientific and psychological investigations of meditation have emphasized the clinical intervention of mindfulness meditation (Kabat-Zinn, 2003; Kuyken et al., 2015), together with different variants of concentration meditation and awareness meditation practiced by predominantly Western practitioners (Lutz, Slagter, Dunne, & Davidson, 2008). Western science has also recently begun to investigate the basic and clinical facets of compassion practices (Desbordes et al., 2012; Lutz, Greischar, Perlman, & Davidson, 2009; Pace et al., 2013). A commonality of all these researched forms of meditation is that they are practiced independently, and thus, are amenable to investigation using similar scientific methodology. However, concentrative and compassion meditation reflect only a small sampling of the many contemplative practices that derive from Buddhism. Many more contemplative practices have yet to be investigated using rigorous scientific methodology (van Vugt et al., 2019).

Monastic debate has been practiced in many Tibetan monasteries and nunneries, and especially within the Gelug tradition of Tibetan Buddhism. This current form of Tibetan monastic debate was developed in the 12th century by Chapa Chökyi Senge (Liberman, 2007, p. 51). Monastic debate is a form of analytical meditation that complements meditation practices intended to stabilize the mind via focus on a single object (such as mindfulness of the breath). In contrast to stabilizing meditation practices that calm the mind, the stated objective of analytical meditation is to develop insight into the causes and conditions of subjective experience to assist the practitioner uproot suffering, and in turn, to achieve more lasting happiness by eradicating destructive emotions (such as anger) and to develop beneficial emotions (such as compassion).

At a Buddhist monastic university, analytical meditation is preceded by memorization of relevant philosophical texts, which provide the material for the contemplations, and the topic that is utilized during monastic debate (Dreyfus, 2003). Debate may serve several functions: to learn; to clear up doubts; to develop critical thinking skills; to acquire a long-lasting, holistic and comprehensive understanding of some topic; and to increase compassion and gentleness (van Vugt et al., 2019).

The dyadic practice of debate consists most often of a dialectical interaction between a "challenger" and a "defender" (Dreyfus, 2003; Liberman, 2015; Perdue, 1992), although in some instances, there can be multiple challengers and defenders. In their collaborative interaction, the defender is bound to maintain a consistent intellectual position, whereas the challenger is guiding the defender to see different angles on the argument and to think more clearly. More specifically, the role of the challenger is to find inconsistencies in the reasoning of the defender and to try to disprove what the defender says, whereas the role of the defender is to parry arguments posed by the challenger and avoid adopting untenable logical positions. The debate is accompanied by a specific physical form, in which the challenger is standing, towering over the defender, who is sitting on the ground (Figure 1). Standing is said to enhance the speed and clarity of thinking. Moreover, remaining physically active allows the monks to maintain the debate over a longer period of time (Dreyfus, 2003). Appendix S3 provides more details about the debate format and Appendix S1 provides transcripts of two sample debates.

Debate is an integral component of Tibetan monastic training. Monastics undergo a program of up to 25 years of education and commonly practice debate for about 5 hours per day (see Appendix S2 for more details about the study program) to help cultivate cognitive and emotional skills. First, debate motivates participants to strongly develop their memorization skills. Monastics in our interviews report that they realize early on in their debate training that failing to memorize the text relevant to a particular debate results in an unfavorable outcome. Second, participating in debate may also cultivate one's reasoning ability, given the frequency and intensity of the practice. Monastic debate further has a strong social component, because knowledge is continually shared and tested inter-subjectively. It is therefore likely that monastics develop strong skills for assessing their partner's mental and emotional states, to allow them to probe their weak points. Moreover, debate likely involves the cultivation of emotion regulation skills, because monastics have told us that despite the debate's stressful situation that can sometimes include teasing and insults, it is critical to not lose composure or become angry, because that impairs the ability to think clearly.

To examine the process of debate in more detail, electroencephalography (EEG) investigations of this practice are needed that leverage what we know about the role of different brain oscillations in cognition as well as phenomenological descriptions by the monastic part of the team. Brain oscillations are useful measures because in contrast to event-related potentials, they are less strictly time-locked to particular events of interest, and thus reflect useful candidates for analyzing the real-world situation of monastic debate, in which there is a

lack of clarity on the temporal demarcation of events that occur. Brain oscillations have been associated with a wide range of cognitive functions (see Buzsáki, 2006, for a comprehensive overview). For example, mid-frontal 4—9Hz theta oscillations have been associated with attention, absorption, and cognitive control (e.g., Cavanagh, Frank, Klein, & Allen, 2010). Theta oscillations in predominantly parieto-temporal locations are associated with accumulating and comparing information (e.g., van Vugt, Simen, Nystrom, Holmes, & Cohen, 2012) as well as memory encoding and retrieval (e.g., Sederberg, Kahana, Howard, Donner, & Madsen, 2003). Alpha oscillations (10—14Hz) have been associated with idling and inhibition (Händel et al., 2010; Pfurtscheller et al., 1996). Beta oscillations (14—28Hz) have most frequently been associated with motor activity (Brovelli et al., 2004). Faster gamma oscillations (28—48Hz) have most reliably been associated with focused attention (Bauer et al., 2006; Hoogenboom et al., 2006).

Inspired by intense discussions between the monastics and scientists, two processes are of particular interest: the development of neural correlates of absorption over the course of the debate session, and the changes in inter-brain synchrony associated with accepting the same premises (agree) and holding different positions in relation to the topic (disagree). The voluntary sustaining of attention, in particular in the context of meditation, has frequently been associated with frontal midline theta oscillations (Ishii et al., 2014) that are thought to arise from medial prefrontal areas and anterior cingulate cortex (Ishii et al., 1999). For example, Aftanas and Golocheikine (2001) found that during internally-directed attention in meditation practice there was an increase in mid-frontal theta waves. This finding was recently replicated by Brandmeyer and Delorme (2018) in a sample of practitioners of Himalaya Yoga, a focused attention meditation practice focusing on a mantra. Some studies have additionally associated occipital alpha oscillations with sustained attention (Braboszcz & Delorme, 2011; Makeig & Jung, 1995), but this is likely reflecting passive fatigue-related reductions in attention rather than the process of actively sustaining attention (Clayton et al., 2015).

The degree of agreement between two debaters can be measured by a novel method for investigating inter-individual cognitive processes; the simultaneous recording of neuroelectric activity in the brain known as “EEG hyperscanning,” which has been utilized successfully to quantify neural synchronization with high temporal precision (Dumas et al., 2010; Lindenberger et al., 2009; Pfurtscheller & Lopes Da Silva, 1999). Synchronization between the brains of two different individuals has been observed in several contexts, brain areas, and frequency bands. For example, in a prisoner’s dilemma task, Babiloni et al. (2007)

demonstrated increased inter-brain synchronization in the alpha band when the players were cooperating rather than defecting. Inter-brain synchronization is also enhanced during diverse situations such as joint musical improvisation (Müller et al., 2013), successful therapy interventions (Koole & Tschacher, 2017) and in cooperating relative to working separately when pilots are orchestrating a flight take-off (Astolfi et al., 2011). In a classroom situation, Dikker et al. (2017) also found that when students paid more attention, their brains were more synchronized with one another than when they did not pay as much attention; and brains were more synchronized between students and teachers that liked each other.

In the present study, we examined several facets of monastic debate using a combination of live and videotaped coding as well continuous EEG recording of monastics as they engaged in debate. First, we sought to assess the degree of agreement by comparing inter-brain synchronization and predicted larger synchronization during periods of self-reported agreement as compared to periods of disagreement. We further hypothesized that their years of monastic experience would moderate the magnitude of absorption and inter-brain synchronization such that it would be more prominent with longer monastic training. Our second area of inquiry was absorption—the state of being immersed in the meditation practice with completely internally-focused attention—by tracking the level of mid-frontal theta power that monastics exhibited during the course of a debate. We predicted that mid-frontal theta would increase over the course of the debate (see also van Vugt et al., 2019).

Method

Participants

Participants were drawn from the population of over 1,800 monks at Sera Jey Monastery, Bylakuppe, India. Many monastic trainings proceed for 16 years post-high school, and monastics with between 0 to 4 years of training are generally regarded as beginners, monastics with 5 to 12 years of training are generally regarded as intermediate, while monastics with 13 to 16 years of training are generally regarded as experienced. A subset of monastics (~20%) continues their formal training in pursuit of advanced degrees, which can continue for an additional 6 to 10 years. Thus, experienced monastics may have as much as 25 years of formal monastic training. Age of entry can vary widely. Once a monk/nun joins the monastery/nunnery, they practice debate on average for 5 hours per day, at least 250 days per

year (i.e., ~1250 hours per year), which means that experienced monastics may have an accumulated 16,250 to 20,000 hours of experience with monastic debate.

We performed two studies. Given the study hypotheses, a decision was made to focus recruitment of monk volunteers among two cohorts: beginners versus experienced (approximately 13 in each group for Study 1, and 50 participants in each group for Study 2). In all debates, beginners only debated beginners, while experienced participants only debated experienced participants. The first study was more exploratory to assess the feasibility and refine the methodology of measuring facets of debate with EEG. The participants in this study had between 1 and 22 years of debate experience (mean debate experience for beginners 1 year; mean debate experience for experienced monastics 19.2 years). The participants in this study were between 18 and 44 years of age.

Based on the findings of the first study, we conducted a larger, more controlled second study to replicate these findings. To accrue this sample, an announcement was made by the disciplinarian of the monastery, a senior monk serving in an administrative role and tasked with ensuring that students attend classes and follow the monastic curriculum. The disciplinarian told the student body of the study and informed them that the debate topic was on *Bodhicitta*. “Bodhicitta” is a basic and well-known teaching in the Buddhist tradition and it focuses on altruism and compassion. He encouraged broad participation among the monastics and requested that all participants who volunteered for the study seriously engage with study tasks. A few additional participants were recruited by their science teacher. In hopes of constructing two groups that differed primarily in terms of monastic experience, we endeavored to select students who received top marks in their respective debate classes. For the beginner cohort, we selected participants who had completed their classroom instruction on the topic of Bodhicitta, which is emphasized in year 6 of the curriculum, but studied also before that time. While these are in fact already intermediate level, this level was necessary to allow them to debate about the same topic as the experienced monastics. The average years of experience in the beginners group was 5.3. For the experienced cohort, we selected participants with at least 14 years of debate training, with a mean of 16.1 years. The overall range of experience in this study was 5 to 17 years. The mean age of the beginners was 29.8, while the mean age of the experienced monastics was 31.8 (total range 19-45).

Procedure

We focused our investigation on the most common configuration for debate, which involves two monastics: a "challenger" whose role is to put forth a thesis related to canonical Buddhist principles and find contradictions in the logical argument of his opponent, known as the "defender," whose role is to try to interpret the thesis proposed by the challenger and to respond from the perspective of logic and consistency with the canonical texts from Buddhism. Within this configuration, debates can accommodate different formats. We chose to: (1) utilize a format called a "counting debate" which outlines the foundation of the debate topic and assesses the quality of the memorization of the text. In particular, the interlocutors are establishing the textual foundation of the debate as well as some ground rules for conducting the debate. This form of debate is quite cooperative. Counting debate is followed by (2) a "logic debate" in which the emphasis lies more strongly on exposing inconsistencies in reasoning. The counting debate is considered by many monks to be easier than the logic debate, and it often serves as a preparation for the logic debate. See Appendix S1 for a sample transcript of a logic and a counting debate.

Informed consent: Upon arrival at the testing location, prospective participants were first told about the procedure and we explained to them that participation in the study was entirely voluntary, and they could quit any time without any repercussions. The participants then gave oral informed consent, and the study was conducted in accordance with the declaration of Helsinki. The study protocol was approved by the CETO (Research Ethics Review Committee of the Faculty of Arts of the University of Groningen).

Instructions given to debaters: In Study 1, debater pairs were told they would debate in various configurations, with no specific topic. In Study 2, debater pairs were told that they would be asked to engage first in a 10-minute counting debate, followed by a 15-minute logic debate. The order of these debates was chosen because this order is customary in the monastery. The particular topic for the counting debate was "*The Definition of Bodhicitta*," which was selected given its familiarity to Beginner and Experienced monastics alike. Directly before the counting debate, monastics reviewed their textbook on Bodhicitta for 15 minutes to refresh their memory of the topic since experienced monks had studied it many years ago.

Conducting the Debates: After reviewing the textbook (only in Study 2), monastics provided their age, the year they entered the monastery, the year and level of monastic training they had achieved, and then were assigned an identification number that was used to anonymize

the data. At that point, monastics were wired with the EEG sensors, performed one counting debate, followed by a logic debate (see Figure 2 for an impression of the EEG setup). We reversed the roles of the challenger and defender and once again collected data in one counting and one logic debate (in the full study, only 2 counting and 4 logic debates were *not* reversed). Afterwards, participants were debriefed and a monastic observer completed a debate rating form (only Study 2; see Appendix S4). They were not paid for their participation but were served lunch or dinner following their participation in the study.

While the EEG data were recorded during the debate, a monastic member of the investigative team, fluent in Tibetan and well-versed in monastic debate, was observing the debate and pressed a trigger button whenever he noticed something of interest. In Study 1, he verbalized briefly why he pressed the button, which was noted down by another experimenter and later categorized. In Study 2, we used these verbal descriptions to develop a more complete classification system which is as follows: (1) Match/agree on same point/same opinion, (2) Difference of opinion, (3) Defender has difficulty, (4) Challenger has difficulty, (5) Challenger/defender finds it difficult to remember something, (6) Challenger/defender very focused, (7) Challenger/defender distracted, and (8) Anything else/Other. For this report we will focus on categories 1 (agreement) and 2 (disagreement). Agreement in the debate was operationally defined as a moment when both debaters accept the same theses and ideas. Disagreement in the debate was defined in two ways: when the defender starts to respond with "why?/disagree", "explain why this is the reason" or "it does not pervade", they enter a period of disagreement; or when the challenger does not accept the definition or explanation offered by the defender.

The rater was extensively briefed on the meaning of the categories. Moreover, the videos of study 2 were each re-rated by at least two raters using BORIS video observation software (Friard & Gamba, 2016). In contrast to the original ratings, where agreement and disagreement were coded as single moments in time, in BORIS we could indicate agreement and disagreements as periods with a beginning and end. On the basis of these periods, we divided the EEG signal into two-second periods, which were labeled as "agreement" when at least half of the raters considered them "agreement", and "disagreement" when at least half of the raters considered them "disagreement." All of the debates were re-rated by at least two raters (in 5 debates, it was rated by 3 raters), who collaborated to find consistent definitions of agreement and disagreement. The challenge with rating these moments of agreement and disagreement is that the rater has to guess what the debater is thinking. Different raters may have had different

interpretations. For example, some raters could have pressed the button when there was only a hint at disagreement, while another rater may have waited until they saw a stronger reason. More concretely, a debate proceeds in the following way. A challenger makes a statement, to which the defender can either agree or ask "why?" When the defender asks "why", this implies they doubt the challenger's assertion, but this is not yet enough to define it as a disagreement. After how much arguing one would define it as disagreement is what is a matter of subjective judgment.

Given this inherent subjectivity in judgments, we sought to measure the degree of consistency between the raters. Since the ratings involve the specification of time intervals, it is not possible to compute inter-rater reliabilities by means of the usual methods such as kappa. Instead, we developed some alternative metrics. Approximately 50% of the original ratings fell in an agreement/disagreement interval identified by at least one of the new raters, and approximately 20% of the original ratings fell in an interval identified by all new raters. There were rare cases where one rater thought of a time interval as reflecting agreement, while another rater judged it as being disagreement. This occurred in 7 out of the 54 debates of Study 2, and comprised 0.7% of the rated time periods. To adjust the analysis for the consistency between raters, we let the probability of including a particular time interval depend on the proportion of raters that felt it reflected agreement/disagreement. In other words: if two out of two raters felt it was agreement, the time interval was included; if only one of the two felt it was agreement, the time interval was included with a probability of 50%.

Measures

EEG recording. EEG data were recorded with a 32-channel EEG system (BrainProducts actiCAP) with BrainVision Recorder software, simultaneously for the two monks. The sampling rate was 500 Hz and the data were recorded with a 0.1-1000Hz bandpass filter. Individual channels were adjusted until impedances were below 25 kΩ.

EEG preprocessing. For preprocessing, which was performed in with Fieldtrip (Oostenveld et al., 2011), we had separate analysis flows for the examination of theta power over time and synchrony time-locked to specific events indicated by the observing monk (see previous section). Before segmentation, we first applied a 0.5-45Hz bandpass filter to remove high-frequency muscle activity, followed by an independent component analysis (separately for each of the two recorded participants). We removed any independent component analysis (ICA) component that looked suspicious (eye movements, blinks and muscle artifacts) before

transforming back to the original sensor space. For the continuous analysis, we divided the data into two-second segments, whereas for the time-locked analysis, we segmented the data into segments from five to one seconds prior to each button press. This window was used to account for the reaction time of the observing monastic when reporting an event of interest.

Data analyses

Most of the data analysis was carried out in Matlab by means of the Fieldtrip toolbox (Oostenveld et al., 2011). The EEG data were frequency-transformed by means of a convolution with a Hanning taper on a set of linearly-spaced frequencies with a four-cycle window length. Before averaging over the different frequencies within a frequency band, we log-transformed the oscillatory power. We identified the theta frequency as 4—9Hz, and the alpha frequency as 9—14Hz (van Vugt et al., 2007). Mid-frontal theta activity was examined in the usual Fz channel (Doppelmayr et al., 2008; Ishihara & Yoshii, 1972). For each individual and each debate, we then fitted a linear regression line to the change in oscillatory power over time to assess the degree of rise over the debate. The slopes of two participants in Study 1 were more than four standard deviations outside the distribution of slopes across participants, and therefore removed from the data analysis.

For the analysis of inter-brain synchrony, we also convolved the EEG with four-cycle Hanning tapers in the frequency band of interest (9—14Hz alpha). We then computed the phase at each moment in time and assessed the magnitude of the within-trial synchrony between the corresponding channels (Cohen, 2014). We compared this trial-averaged synchrony estimate between the different types of debates and different groups of participants by means of linear mixed effects models (Pinheiro & Bates, 2009). The advantage of using linear mixed effects models is that they are more robust to violations of independence between observations and different sample sizes for the different cells in the design (Baayen et al., 2008). Moreover, linear mixed effects models have larger statistical power and lead to fewer false discoveries than conventional ANOVA (Baayen et al., 2008; Bolker et al., 2009).

Because both inter-brain synchronization and frontal midline theta can be affected by aging (Cummins & Finnegan, 2007; Kardos et al., 2014; Tóth et al., 2014; van de Vijver et al., 2014), we regressed out age from inter-brain synchronization and frontal midline theta before running our linear mixed effects model of interest. Results do not change qualitatively between the statistical models that correct for age and those that do not.

In addition to reporting classical statistics, we also include Bayes Factors. The advantage of Bayes Factors is they do not just indicate the presence or absence of a significant effect, but also indicate how much evidence there is, both for or against the null hypothesis. In the results, Bayes Factors are always denoted as Bayes Factors in favor of the alternative hypothesis, against the null, and prefixed with "BF_{10}". Bayes Factors larger than three indicate substantial evidence in favor of the alternative hypothesis, while Bayes Factors larger than 10 indicate strong evidence in favor of the alternative hypothesis (Jeffreys, 1998; Wagenmakers et al., 2017). Bayes Factors smaller than 0.3 (1/3) indicate substantial evidence in favor of the null hypothesis (and against the alternative hypothesis), and Bayes Factors smaller than 0.1 indicate substantial evidence in favor of the null hypothesis. In the whole manuscript, we used the default prior. Because the datasets are not always completely balanced, we replaced the conventional ANOVAs and *t*-tests by linear mixed effects models (implemented in R's lme4 package, and the BayesFactor package for the Bayes Factors; Morey & Rouder, 2018).

Movement artifacts are a significant concern when performing EEG studies on moving participants. We addressed these problems in several ways. First, we used an active electrode system, which avoided artifacts arising from the dangling movement of the wires. Second, we used independent component analysis to remove components reflecting these movement artifacts, which have a time course very different from normal EEG (and are therefore well-captured by ICA). Third, we low-pass-filtered the data, since movement artifacts tend to show up predominantly at higher frequencies. Supplementary Figure S1 (Appendix S5) shows a sample EEG trace during the debate, which is representative of the average EEG quality (it is neither the most clean nor the most noisy). As a rough estimate of artifact activity, we also computed the average EEG amplitude and 110-140Hz activity (associated with movement) separately for the challenger (who is moving) and the defender (who is seated). Neither average EEG amplitude ($t(106)=0.17$, $BF_{10}=0.21$) nor 110-140Hz activity ($t(106)=1.43$, $BF_{10}=0.507$) were different between the challengers and defenders.

Results

Differences in inter-brain synchronization between agreement and disagreement periods

Our first hypothesis was that periods in which the debaters were observed to agree on a shared set of premises would be associated with higher inter-brain synchrony than when they express disagreement with one another. We surmised that when the monks agree on a shared set of premises, they are more likely to think similar thoughts, which would increase the chances that their brains are synchronized compared to when the monks have some disagreements. We also predicted that this difference would grow with debate experience.

We initially tested these hypotheses in our exploratory Study 1. As we predicted, we observed a statistically significant increase in frontal alpha interbrain synchronization for agreement relative to disagreement (linear mixed effects $\chi^2(1) = 3.94$, $p = 0.05$, $BF_{10} = 1.14$, Figure 3). When we look at electrodes that exhibit a significant main effect of experience in the linear mixed effects model (Figure 4), there was overall smaller inter-brain synchronization with more experience (linear mixed effects $\chi^2(1) = 7.58$, $p = 0.01$, $BF_{10} = 0.86$), and interestingly, for these electrodes that are sensitive to monastic experience in Study 1, inter-brain synchrony is higher for disagree compared to agree periods.

We then examined whether those effects replicated in the second study. In this study, we observed a main effect of agreement on alpha synchrony between the two debaters' brains ($\chi^2(1) = 33.62$, $p < 0.001$, $BF_{10} > 10.000$; see Figure 3). The topography was more widespread than observed in Study 1, but included also similar frontal electrodes. In contrast to Study 1, there was no effect of monastic experience on brain synchronization in the alpha band ($\chi^2(1) = 2.24$, $p = 0.13$, $BF_{10} = 0.08$; Figure 4). In Study 2 there were 27 (out of 32) electrodes that demonstrated a significant interaction between agreement and debate experience. The electrode with the strongest effect ($\chi^2(1) = 39.83$, $p < 0.001$, $BF_{10} = 5821.9$) reflected no difference between agreement and disagreement for beginner monks ($t(31.8) = -0.52$, $p = 0.604$; $BF_{10} = 0.214$); but a significant difference for experienced monks ($t(31.9) = 2.40$, $p = 0.022$, $BF_{10} = 2.23$).

Mid-frontal theta as a measure of absorption

Our second hypothesis was that monastics' attention becomes more strongly internally directed to the flow of arguments over the course of the debate, and that mid-frontal 4—9Hz theta power would increase from the start of the debate until its end as a consequence. Moreover, since this internally-directed attention cannot increase indefinitely, the theta power curve should flatten off towards the end of the debate. To test this hypothesis, we examined whether 4—9Hz theta power in electrode Fz increased over the course of the full debate.

In Study 1, in which we examined a set of 26 heterogeneous debates, we observed a significant increase in mid-frontal theta power over time ($t(51) = 4.06$, $p < 0.001$, $BF_{10} = 140$; Figure 5). Even though the top row of this figure seems to suggest that at the end of the debate, theta power drops again, this is an artifact of averaging debates of different lengths (see bottom row of Figure 5 for time course of theta power that is time-locked to the end of the debate; which does not demonstrate a drop). We used a linear mixed effects model to assess whether the magnitude of the mid-frontal theta slope was moderated by the role of the participant (challenger, defender), or their level of monastic experience (beginning, experienced) or the interaction of these two main effect factors. This linear mixed effects model was performed on the residuals of the theta slopes after age had been regressed out. There was no significant effect of role, that is, we could not tell whether there was a difference between challengers and defenders ($\chi^2(1) = 3.15$, $p = 0.07$, $BF_{10} = 0.81$) but there was there a main effect of experience ($\chi^2(1) = 4.67$, $p = 0.03$, $BF_{10} = 2.37$). The interaction of role and experience did not add to the prediction of mid-frontal theta power ($\chi^2(1) = 0.69$, $p = 0.40$, $BF_{10} = 2.29$).

In this first study consisting of heterogeneous debate dyads, we tried out many theoretically and hypothesis-driven configurations to assess the influence of different factors on the progression of the debate and associated brain activity. First, our monastic collaborators hypothesized that the presence of one's debate teacher would lead the participating monks to take the debate more seriously. Consequently, we predicted that the mid-frontal theta slope would be much steeper for the debate where the teacher was present as an observer, compared to where he was not present. This prediction turned out to be weakly supported by the data. Overall theta power was larger when the teacher was present (linear mixed effects intercept $M = 0.089$) than when he was not (intercept $M = 0.045$; trend towards a significant interaction between theta power and debate, linear mixed effects $\beta = -0.04$, $p = 0.098$, BF comparing models with and without teacher: 148). There was no significant difference in the slopes

between the debates with and without a teacher (linear mixed effects interaction β = -0.002, p = 0.46, BF_{10} = 0.1). A potential interpretation is that the teacher effect was already occurring due to the novelty of foreign researchers observing the debate with unfamiliar and potentially intimidating equipment.

Monastics usually debate people in their own class, who they know quite well. Monastics we interviewed indicated that when they debated a monastic from a different class, they tended feel the need to concentrate more so they would be better able to adapt to the unknown and unexpected strategies of their opponent. Consequently, we hypothesized that the slope of mid-frontal theta is larger when monastics are debating colleagues from a different class relative to their own class. We found a highly significant interaction between slope and class (β = -0.02, $p < 0.001$, BF_{10} = 121), indicating that the mid-frontal theta slope was larger when debating an interlocutor from different class (M = 0.0334) compared to debating an interlocutor from one's own class (M = 0.0128). Of course it should be kept in mind that these are only exploratory analyses on a small subset of the data, which need to be replicated before serious conclusions can be drawn.

In Study 2, we sought to replicate our prior findings while using a more controlled, internally reliable debate format. For instance, in this controlled setting, we elected to keep every debate to the same length and same topic (see Method). Increasing the number of recorded debates (N = 54) provided with more statistical power. Moreover, in this study, all monks did both a logic debate and a counting debate. The monastics hypothesized that the counting debate was much easier and would therefore be associated with less increase in mid-frontal theta activity. As before, we compared beginner to more experienced monastics.

As in Study 1, we observed a significant increase in mid-frontal theta over time (t(105) = 4.26, $p < 0.001$ BF_{10} = 382; Figure 5). We then asked whether this increase in mid-frontal theta was larger for more experienced monks than beginner monks, whether it depended on whether they were challenger or defender, and whether it differed between counting and logic debates. We observed a trend towards a significant effect of experience ($\chi^2(1) = 3.58$, $p = 0.058$, BF_{10} = 1.16), with a larger increase in theta power for more experienced monks compared to beginner monks (post-hoc t-test t = 2.58, p = 0.011). The data did not allow us to adjudicate whether there was a difference between counting and logic debates ($\chi^2(1) = 1.19$, p = 0.27, BF_{10} = 0.44). There was a weak but significant interaction between experience and the debate type ($\chi^2(1) = 4.13$, p = 0.04, BF_{10} = 1.94). The interaction indicated that for more experienced

monks there was an increase in theta over time for both counting and logic debates (post-hoc t-test comparing counting and logic debates, $t(50.8)= -0.22$, $p = 0.828$, $BF_{10} = 0.157$), but for beginner monks there was only an increasing theta slope for the logic debates, while the slope remained relatively flat during counting debates (post-hoc t-test comparing slopes of logic and counting debates, $t(49.2) = 2.01$, $p = 0.049$, $BF_{10} = 0.98$).

Because in this study our data were more reliable, we further explored whether the mid-frontal theta effect was possibly larger in other electrodes than Fz. Figure 7 indicates that the strongest theta slopes occurred slight to the right of Fz in channel F4 (the yellow color indicates t-values that are larger than 3.0, and thereby surpass a Bonferroni-corrected p-value threshold of 0.05). When we repeated the analysis in channel F4, we found that there was a main effect of experience ($\chi^2(1) = 6.83$, $p = 0.009$, $BF_{10} = 3.72$), and a significant interaction between experience and whether the debate was a counting or a logic debate ($\chi^2(1) = 6.99$, $p = 0.008$, $BF_{10} = 7.06$). As before, the interaction indicated that for more experienced monks there was an increasing theta slope for both counting and logic debates (post-hoc t-test indicates no difference; $t(47.2) = -0.89$, $p = 0.377$, $BF_{10} = 0.22$), but for beginner monks there was only a significant theta slope for the logic debates (post-hoc t-test shows higher slope for logic debates; $t(49.5) = 2.32$, $p = 0.024$, $BF_{10} = 1.75$). There was no main effect of logic vs. counting debates ($\chi^2(1) = 0.51$, $p = 0.48$, $BF_{10} = 0.30$).

Correlation between mid-frontal theta power and inter-brain synchronization

Finally, we asked whether, when a person has an overall steeper theta increase over the debate (potentially reflecting increased internally-directed attention), he is also more focused on the other person he is debating with. This can be operationalized as a correlation between the mid-frontal theta slope and the average inter-brain frontal alpha synchronization for a particular debate.

In Study 1 there was a significant positive correlation between overall debate theta and strength or interbrain synchrony ($r(51) = 0.34$, $p = 0.015$, $BF_{10} = 3.04$, Figure 8). The more a person's absorption increases over the course of the debate, the more his brain is also synchronized with other debater in frontal alpha oscillations.

We then examined whether the same relation would be observed in Study 2. We found that neither in logic debates ($r(54) = 0.016$, $p = 0.91$, $BF_{10} = 0.17$) nor in counting debates

($r(47) = -0.15$, $p = 0.32$, $BF_{10} = 0.29$) was there a significant correlation between these variables–in fact, the Bayes Factors indicate that there was some evidence for no correlation.

Discussion

This study represents an initial neuroscientific investigation of analytical meditation and monastic debate. The results showed that inter-brain synchronization during this non-solitary, interdependent meditation practice changes with the degree of agreement between the debaters. Inter-brain synchrony is a relevant measurement because the type of analytical meditation]described in this paper also has a strong social component. Recent work by Engert, Kok, Papassotiriou, Chrousos, & Singer (2017) has demonstrated that social/inter-dependent forms of meditation, which in their study trained perspective taking and involved dyadic practices reduced the stress response to a significant social stressor. In addition, dyadic meditation caused participants to feel more close to each other (Kok & Singer, 2017). This finding may indicate that engaging with another person in a meditative way can have benefits for emotional resilience in daily life situations. Monastic debate too involves the meditative interaction with another person. As such, future research could investigate whether monastic debate, which also fosters social bonding, albeit by way of a more vigorous and antagonistic approach, has similar effects on stress and feelings of closeness.

The presented work also furthers knowledge about the role of inter-brain synchrony in cognition more generally. At this point, there is no consensus yet about the exact role of inter-brain synchrony, and about whether synchrony in different brain areas and frequencies could have different functions. Some studies found increased inter-brain synchrony at predominantly alpha band frequencies during cooperation (Konvalinka et al., 2014; Toppi et al., 2016). Other studies have focused more on attentional engagement and found that when people are more engaged with the same stimuli and with each other, that their brain activity becomes synchronized (using slightly different metrics; Dikker et al., 2017; Ki, Kelly, & Parra, 2016). In those contexts, inter-brain synchrony may reflect more something akin to joint or shared attention (Lachat et al., 2012). The results reported here suggest a yet more subtle signature of inter-brain synchrony, which was larger when monastics were in agreement on a series of premises, compared to when they differed on the premises they accepted to be true. This suggests that inter-brain synchrony is not only sensitive to what happens at a particular

moment, but also information in working memory that participants collect over a longer period of time.

The data showed how across two studies, absorption, as indicated by mid-frontal theta power, increased over the course of the debates. This increase was stronger for more experienced monks as compared to beginner monks, and stronger for the more difficult logic debates than for the counting debates. These findings add to the literature on the neural correlates of meditation that has also shown increases in frontal midline theta during various meditative states (Aftanas & Golocheikine, 2001; Kubota et al., 2001). This increase in mid-frontal theta power correlates with meditation experience (Aftanas & Golocheikine, 2001; Cahn & Polich, 2006). Also putatively associated with concentration during focused attention meditation are reports of increased long-range temporal correlations in EEG activity (Irrmischer et al., 2018). The current findings are consistent with the idea that monastic debate can be classified as a form of meditation that trains attention, although further behavioral evidence is necessary to back up that claim.

Previous studies of other forms of meditation have not only demonstrated increased in mid-frontal theta, but other frequencies as well. For example, Lutz et al. (2004) observed increased gamma oscillatory power and synchrony compared to baseline during non-referential compassion, an open monitoring practice, and this increase was unique to highly experienced practitioners. Recent work has replicated this gamma increase, extending it by showing that gamma power was also higher in open monitoring meditation compared to focused attention meditation (Fucci et al., 2018). Increased gamma synchrony may be associated more with a sense of openness, broad awareness and breaking down of the barriers between self and others (Dahl et al., 2015; Josipovic, 2014; Lutz et al., 2015). Monastic debate is similar to this open monitoring practice in that one of its goals is also breaking down the barriers between self and other, albeit through methods that involve logic and reason instead of open awareness meditation (van Vugt et al., 2019). It may therefore be the case that the baseline state of accomplish debate practitioners have higher long-range gamma synchrony as well. Unfortunately, it was not possible to examine gamma power in this study, because the gamma band was filtered out in an effort to reduce movement artifacts.

Some studies show that alpha power increases during meditation, which has been interpreted as increases in relaxation (Cahn & Polich, 2006). Since its vigorous nature makes

it unlikely that monastic debate is associated with increases in relaxation, the presented analyses do not examine within-individual alpha power.

Limitations and Future Research Directions

Although the findings provide interesting new insights into the nature of monastic debate and the functional role of inter-brain synchrony, it is necessary to acknowledge several limitations. In the naturalistic setting in which EEG was applied, a worry may be the possibility of contamination of the EEG with movement artifacts. In contrast to classical EEG, which is done in a shielded laboratory in which participants sit very still, in this study EEG was recorded from moving and speaking participants in a Tibetan monastery in India without any shielding. To minimize this problem, active electrodes were used. Previous work has shown that active electrodes significantly reduce artifacts associated with power line interference and motion artifacts (Patki et al., 2012). Similarly, Nathan and Contreras-Vidal (2016) demonstrated that in a system very similar to the studies reported here, very few motion artifacts from walking could be detected. In addition, the comparisons made in this article are mostly within-dyad, which means that both of the processes being compared are similarly affected by artifacts. It remains possible that the increase in mid-frontal theta is driven by motion, because motion tended to increase over the course of the debate, but this is unlikely because motion is typically associated with activity in the beta and gamma bands (Ball et al., 2008). Furthermore, it remains possible that inter-brain synchrony is confounded with speech artifacts, but this is unlikely given that it is unlikely a difference in the amount of speech between the agreement and disagreement epochs.

Another challenge for the studies reported here is that they focus on neural measures without direct behavioral assessments. Consequently, it is not sure that, for example, mid-frontal theta reflects absorption, as it has been interpreted here. In fact, some have suggested that mid-frontal theta oscillations reflect fatigue rather than cognitive control and absorption (Kamzanova et al., 2011). However, the studies in which mid-frontal theta is seen as a consequence of fatigue describe stimulus-evoked theta. Wascher and colleagues (2014) showed that while stimulus-evoked theta increased with increasing fatigue over a 4-hour task, induced theta, which is more similar to the measure used here, decreased during the same period. Yet another interpretation of the mid-frontal theta effects is that they reflect larger effort engaged in by the experienced monastics. It is possible that rather than reflecting higher skill

of experienced monastics in focusing their attention, these findings could reflect a higher level of effort exerted in the debate (Smit et al., 2005). Such higher effort could either reflect more difficulty with debating, which is unlikely for more experienced monastics. Another possibility is that it reflects a voluntary choice to engage in a more complex debate on the topic, for example by making use of more different sources. Finally, a third possibility is that it reflects the depletion of attention (Schmeichel, 2007) as working memory load builds up during the debate. When asked, monastics never report such feelings of depletion after our 10-15 min. debates, and in regular debating sessions they typically continue debating for many hours. Nevertheless, future work could combine the EEG with innovative task-based measures to obtain higher certainty about the psychological correlates of the observed EEG states.

Another limitation of the current study is that many of the comparisons are based on experience—the effect of debate training was inferred from a comparison between more and less experienced monks. However, experience in monastic debate is also correlated with experience with monastic life. At this point it is not possible to say with certainty that any of the changes observed with experience are due to experience in debate, or that they instead reflect experience with monastic life in general. Most likely the social setting of the Tibetan monastery in itself also has strong effects on emotion regulation and cognitive processes, even when the monks do not debate. Future research should attempt to disentangle those factors.

A final concern is that a significant correlation between mid-frontal theta activity and inter-brain alpha synchrony was observed only in one of the studies—the study that was least controlled. One difference between the two studies is that Study 1 consisted only of logic debates, while Study 2 consisted of both logic and counting debates. However, even when considering the counting and logic debates separately, there was still no correlation between mid-frontal theta and inter-brain synchronization. This discrepancy across the two studies suggests that either there is a ceiling effect for mid-frontal theta in Study 2, or that the observed correlation in Study 1 is a chance fluctuation.

Given that this is an initial study examining the neural correlates of monastic debate, it is only a starting point. Since it is a cross-sectional study, it is not possible to know with certainty whether the difference in increase of mid-frontal theta with experience is a result of monastic debate practice, or whether instead this difference between beginner and experienced monastics reflects pre-existing differences between these groups of monastics. Future research should engage in a longitudinal study to verify whether the mid-frontal theta slope increases

over the course of debate training. Even if it were possible to show such an increase, one cannot easily conclude that the increase is directly due to debate or instead reflects general monastic experience. One possible way to disentangle these possibilities may be to compare monastic's debate to the debate of school children at Tibetan schools that have started to incorporate monastic debate in their curriculum (MacPherson, 2000). Yet, given the relatively limited experience that such children have, that can only elucidate the effects of the beginning years of learning debate. Another important direction for future work is to decompose the practice of debate into more detailed components and create theoretical models of this practice. For example, it is worthwhile investigating the role of memory in debating. Specifically, how does the ability to recall information affect the debate and its neural correlates? Finally, debate is not practiced for its own sake, but rather, to acquire a deep understanding of Buddhist philosophy and its implications in all aspects of life. It is therefore important to investigate how the neural correlates of debate that are reported in this work affect the quality of debate and the outcomes of the debate. A particularly interesting empirical question is whether self-reported new insights are associated with the neural signature of "aha" moments (Kounios & Beeman, 2009).

In conclusion, the data presented here demonstrate how the dyadic practice of analytical meditation is associated with increases in frontal alpha synchrony between two individuals when those individuals are agreeing on a set of tenets compared to when there is some disagreement. In addition, monastic debate is associated with increases in a neural index of mental absorption: mid-frontal theta activity. These findings are a good starting point for further investigating this form of analytical meditation and more clearly delineating where and when it differs from other forms of meditation. In addition, these findings expand on possible roles for inter-brain synchrony by extending it to a global state of being on the same page (metaphorically speaking). Future research should investigate how monastic debate may lead to mental transformations such as increases in the understanding and memory of the studied texts, or more globally to improvements in mental well-being.

Compliance with Ethical Standards:

Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical

standards. The study protocol was approved by the Research Ethics Committee of the Faculty of Arts of the University of Groningen (CETO), protocol number 70890721.

Informed consent: Oral informed consent was obtained from all individual participants included in the study. We chose to not use written informed consent because this would be very unfamiliar and anxiety-provoking in this culture that is mainly oral. It was emphasized that the participants could leave the study at any time if they desired to do so, without any adverse consequences to them.

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Conflict of interest: All authors declare no conflict of interest.

Data sharing:

Preprocessed EEG data can be downloaded here: https://unishare.nl/index.php/s/D3e6DMXzOLAldNO (Study 1) and here https://unishare.nl/index.php/s/1UYBgoG7tF2xfqG (Study 2).

Scripts used for data analysis can be downloaded here: https://unishare.nl/index.php/s/NbWJepzXM3aDLCX

References

Aftanas, L. I., & Golocheikine, S. A. (2001). Human anterior and frontal midline theta and lower alpha reflect emotionally positive state and internalized attention: High-resolution EEG investigation of meditation. *Neuroscience Letters*, *310*, 57–60.

Astolfi, L., Toppi, J., Borghini, G., Vecchiato, G., Isabella, R., Fallani, F. D. V., … Babiloni, F. (2011, August). *Study of the functional hyperconnectivity between couples of pilots during flight simulation: An EEG hyperscanning study*. 2338–2341. https://doi.org/10.1109/IEMBS.2011.6090654

Baayen, R. H., Davidson, D. J., & Bates, D. M. (2008). Mixed-effects modeling with crossed random effects for subjects and items. *Journal of Memory and Language*, *59*(4), 390–412. https://doi.org/10.1016/j.jml.2007.12.005

Babiloni, F., Astolfi, L., Cincotti, F., Mattia, D., Tocci, A., Tarantino, A., … Fallani, F. D. V. (2007, August). *Cortical Activity and Connectivity of Human Brain during the Prisoner's Dilemma: An EEG Hyperscanning Study*. 4953–4956. https://doi.org/10.1109/IEMBS.2007.4353452

Ball, T., Demandt, E., Mutschler, I., Neitzel, E., Mehring, C., Vogt, K., … Schulze-Bonhage, A. (2008). Movement related activity in the high gamma range of the human EEG. *NeuroImage*, *41*(2), 302–310. https://doi.org/10.1016/j.neuroimage.2008.02.032

Bauer, M., Oostenveld, R., Peeters, M., & Fries, P. (2006). Tactile Spatial Attention Enhances Gamma-Band Activity in Somatosensory Cortex and Reduces Low-Frequency Activity in Parieto-Occipital Areas. *Journal of Neuroscience*, *26*(2), 490–501.

Bolker, B. M., Brooks, M. E., Clark, C. J., Geange, S. W., Poulsen, J. R., Stevens, M. H. H., & White, J.-S. S. (2009). Generalized linear mixed models: A practical guide for

ecology and evolution. *Trends in Ecology & Evolution*, *24*(3), 127–135. https://doi.org/10.1016/j.tree.2008.10.008

Braboszcz, C., & Delorme, A. (2011). Lost in thoughts: Neural markers of low alertness during mind wandering. *NeuroImage*, *54*(4), 3040–3047. https://doi.org/10.1016/j.neuroimage.2010.10.008

Brandmeyer, T., & Delorme, A. (2018). Reduced mind wandering in experienced meditators and associated EEG correlates. *Experimental Brain Research*, *236*(9), 2519–2528. https://doi.org/10.1007/s00221-016-4811-5

Brovelli, A., Ding, M., Ledberg, A., Chen, Y., Nakamura, R., & Bressler, S. (2004). Beta oscillations in a large-scale sensorimotor cortical network: Directional influences revealed by Granger causality. *Proceedings of the National Academy of Sciences, (USA)*, *101*(26), 9849–9854.

Buzsáki, G. (2006). *Rhythms of the Brain*. New York: Oxford University Press.

Cahn, B. R., & Polich, J. (2006). Meditation states and traits: EEG, ERP, and neuroimaging studies. *Psychological Bulletin*, *132*(2), 180–211. https://doi.org/10.1037/0033-2909.132.2.180

Cavanagh, J., Frank, M. J., Klein, T. J., & Allen, J. J. B. (2010). Frontal theta links prediction errors to behavioral adaptation in reinforcement learning. *NeuroImage*, *49*, 3198–3209.

Clayton, M. S., Yeung, N., & Cohen Kadosh, R. (2015). The roles of cortical oscillations in sustained attention. *Trends in Cognitive Sciences*, *19*(4), 188–195. https://doi.org/10.1016/j.tics.2015.02.004

Cohen, M. X. (2014). *Analyzing Neural Time Series Data: Theory and Practice*. MIT Press.

Cummins, T., & Finnegan, S. (2007). Theta power is reduced in healthy cognitive aging. *International Journal of Psychophysiology*, *66*, 10–17.

Dahl, C. J., Lutz, A., & Davidson, R. J. (2015). Reconstructing and deconstructing the self: Cognitive mechanisms in meditation practice. *Trends in Cognitive Sciences*, *19*(9), 515–523. https://doi.org/10.1016/j.tics.2015.07.001

Desbordes, G., Negi, L. T., Pace, T. W. W., Wallace, B. A., Raison, C. L., & Schwartz, E. L. (2012). Effects of mindful-attention and compassion meditation training on amygdala response to emotional stimuli in an ordinary, non-meditative state. *Frontiers in Human Neuroscience*, *6*. https://doi.org/10.3389/fnhum.2012.00292

Dikker, S., Wan, L., Davidesco, I., Kaggen, L., Oostrik, M., McClintock, J., … Poeppel, D. (2017). Brain-to-Brain Synchrony Tracks Real-World Dynamic Group Interactions in the Classroom. *Current Biology*, *27*, 1–6. http://dx.doi.org/10.1016/j.cub.2017.04.002

Doppelmayr, M., Finkenzeller, T., & Sauseng, P. (2008). Frontal midline theta in the pre-shot phase of rifle shooting: Differences between experts and novices. *Neuropsychologia*, *46*(5), 1463–1467. https://doi.org/10.1016/j.neuropsychologia.2007.12.026

Dreyfus, G. (2003). *The Sound of Two Hands Clapping: The Education of a Tibetan Buddhist Monk*. University of California Press.

Dumas, G., Nadel, J., Soussignan, R., Martinerie, J., & Garnero, L. (2010). Inter-Brain Synchronization during Social Interaction. *PLoS ONE*, *5*(8), e12166. https://doi.org/10.1371/journal.pone.0012166

Engert, V., Kok, B. E., Papassotiriou, I., Chrousos, G. P., & Singer, T. (2017). Specific reduction in cortisol stress reactivity after social but not attention-based mental training. *Science Advances*, *3*(10), e1700495. https://doi.org/10.1126/sciadv.1700495

Friard, O., & Gamba, M. (2016). BORIS: A free, versatile open-source event-logging software for video/audio coding and live observations. *Methods in Ecology and Evolution*, *7*(11), 1325–1330. https://doi.org/10.1111/2041-210X.12584

Fucci, E., Abdoun, O., Caclin, A., Francis, A., Dunne, J. D., Ricard, M., … Lutz, A. (2018). Differential effects of non-dual and focused attention meditations on the formation of automatic perceptual habits in expert practitioners. *Neuropsychologia*, *119*, 92–100. https://doi.org/10.1016/j.neuropsychologia.2018.07.025

Händel, B. F., Haarmeier, T., & Jensen, O. (2010). Alpha Oscillations Correlate with the Successful Inhibition of Unattended Stimuli. *Journal of Cognitive Neuroscience*, *23*(9), 2494–2502. https://doi.org/10.1162/jocn.2010.21557

Hoogenboom, N., Schoffelen, J. M., Oostenveld, R., Parkes, L. M., & Fries, P. (2006). Localizing human visual gamma-band activity in frequency, time and space. *NeuroImage*, *29*(3), 764–773.

Irrmischer, M., Houtman, S. J., Mansvelder, H. D., Tremmel, M., Ott, U., & Linkenkaer-Hansen, K. (2018). Controlling the Temporal Structure of Brain Oscillations by Focused Attention Meditation. *Human Brain Mapping*, *39*(4), 1825–1838. https://doi.org/10.1002/hbm.23971

Ishihara, T., & Yoshii, N. (1972). Multivariate analytic study of EEG and mental activity in juvenile delinquents. *Electroencephalography Clinical Neurophysiology*, *33*, 71–80.

Ishii, R., Canuet, L., Ishihara, T., Aoki, Y., Ikeda, S., Hata, M., … Takeda, M. (2014). Frontal midline theta rhythm and gamma power changes during focused attention on mental calculation: An MEG beamformer analysis. *Frontiers in Human Neuroscience*, *8*, 406. https://doi.org/10.3389/fnhum.2014.00406

Ishii, R., Shinosaki, K., Ukai, S., Inouye, T., Ishihara, T., Yoshimine, T., … Takeda, M. (1999). Medial prefrontal cortex generates frontal midline theta rhythm. *NeuroReport*, *10*(4), 675–679. https://doi.org/10.1097/00001756-199903170-00003

Jeffreys, H. (1998). *The Theory of Probability*. Oxford University Press: Oxford, U. K.

Josipovic, Z. (2014). Neural correlates of nondual awareness in meditation. *Annals of the New York Academy of Sciences*, *1307*(1), 9–18. https://doi.org/10.1111/nyas.12261

Kabat-Zinn, J. (2003). Mindfulness-based interventions in context: Past, present and future. *Clinical Psychology: Science and Practice*, *10*(2), 144–156.

Kamzanova, A. T., Matthews, G., Kustubayeva, A. M., & Jakupov, S. M. (2011). EEG indices to time-on-task effects and to a workload manipulation (Cueing). *World Academy of Science, Engineering and Technology*, *80*, 19–22. Retrieved from Scopus.

Kardos, Z., Tóth, B., Boha, R., File, B., & Molnár, M. (2014). Age-related changes of frontal-midline theta is predictive of efficient memory maintenance. *Neuroscience*, *273*, 152–162. https://doi.org/10.1016/j.neuroscience.2014.04.071

Ki, J. J., Kelly, S. P., & Parra, L. C. (2016). Attention Strongly Modulates Reliability of Neural Responses to Naturalistic Narrative Stimuli. *Journal of Neuroscience*, *36*(10), 3092–3101. https://doi.org/10.1523/JNEUROSCI.2942-15.2016

Kok, B. E., & Singer, T. (2017). Effects of Contemplative Dyads on Engagement and Perceived Social Connectedness Over 9 Months of Mental Training: A Randomized Clinical Trial. *JAMA Psychiatry*, *74*(2), 126–134. https://doi.org/10.1001/jamapsychiatry.2016.3360

Konvalinka, I., Bauer, M., Stahlhut, C., Hansen, L. K., Roepstorff, A., & Frith, C. D. (2014). Frontal alpha oscillations distinguish leaders from followers: Multivariate decoding of mutually interacting brains. *NeuroImage*, *94*, 79–88. https://doi.org/10.1016/j.neuroimage.2014.03.003

Koole, S. L., & Tschacher, W. (2017). Synchrony in Psychotherapy: A Review and an Integrative Framework for the Therapeutic alliance. *Frontiers in Psychology*, (7), 862. https://doi.org/10.3389/fpsyg.2016.00862

Kounios, J., & Beeman, M. (2009). The Aha! Moment: The cognitive neuroscience of insight. *Current Directions in Psychological Science*, *18*(4), 210–216.

Kubota, Y., Sato, W., Toichi, M., Murai, T., Okada, T., Hayashi, A., & Sengoku, A. (2001). Frontal midline theta rhythm is correlated with cardiac autonomic activities during the performance of an attention demanding meditation procedure. *Cognitive Brain Research*, *11*, 281–287.

Kuyken, W., Hayes, R., Barrett, B., Byng, R., Dalgleish, T., Kessler, D., … Byford, S. (2015). Effectiveness and cost-effectiveness of mindfulness-based cognitive therapy compared with maintenance antidepressant treatment in the prevention of depressive relapse or recurrence (PREVENT): A randomised controlled trial. *The Lancet*, *386*(9988), 63–73. https://doi.org/10.1016/S0140-6736(14)62222-4

Lachat, F., Hugeville, L., Lemarechal, J.-D., Conty, L., & George, N. (2012). Oscillatory Brain Correlates of Live Joint Attention: A Dual-EEG Study. *Frontiers in Human Neuroscience*, *6, 156*. https://doi.org/10.3389/fnhum.2012.00156

Liberman, K. (2007). *Dialectical Practice in Tibetan Philosophical Culture: An Ethnomethodological Inquiry into Formal Reasoning*. Rowman & Littlefield Publishers.

Liberman, K. (2015). The logic is made to dance. Rhythm in Tibetan debating. *Etnografia e Ricerca Qualitativa*, 3. https://doi.org/10.3240/81722

Lindenberger, U., Li, S.-C., Gruber, W., & Müller, V. (2009). Brains swinging in concert: Cortical phase synchronization while playing guitar. *BMC Neuroscience*, *10*, 22. https://doi.org/10.1186/1471-2202-10-22

Lutz, A., Greischar, L. L., Perlman, D. M., & Davidson, R. J. (2009). BOLD signal in insula is differentially related to cardiac function during compassion meditation in experts

vs. Novices. *NeuroImage*, *47*(3), 1038–1046. https://doi.org/10.1016/j.neuroimage.2009.04.081

Lutz, A., Greischar, L. L., Rawlings, N. B., Ricard, M., & Davidson, R. J. (2004). Long-term meditators self-induce high-amplitude gamma synchrony during mental practice. *Proceedings of the National Academy of Sciences, (USA), 101*(46), 16369–16373.

Lutz, A., Jha, A. P., Dunne, J. D., & Saron, C. D. (2015). Investigating the Phenomenological Matrix of Mindfulness-related Practices from a Neurocognitive Perspective. *The American Psychologist*, *70*(7), 632–658. https://doi.org/10.1037/a0039585

Lutz, A., Slagter, H. A., Dunne, J. D., & Davidson, R. J. (2008). Attention regulation and monitoring in meditation. *Trends in Cognitive Sciences*, *12*(4), 163–169.

MacPherson, S. (2000). *A path of learning: Indo-Tibetan Buddhism as education* (University of British Columbia). https://doi.org/10.14288/1.0055009

Makeig, S., & Jung, T. P. (1995). Changes in alertness are a principal component of variance in the EEG spectrum. *NeuroReport*, *7*(1), 213–216.

Morey, R. D., & Rouder, J. N. (2018). *BayesFactor: Computation of Bayes Factors for Common Designs*. Retrieved from https://CRAN.R-project.org/package=BayesFactor

Müller, V., Sänger, J., & Lindenberger, U. (2013). Intra- and Inter-Brain Synchronization during Musical Improvisation on the Guitar. *PLoS ONE*, *8*(9), e73852. https://doi.org/10.1371/journal.pone.0073852

Nathan, K., & Contreras-Vidal, J. L. (2016). Negligible Motion Artifacts in Scalp Electroencephalography (EEG) During Treadmill Walking. *Frontiers in Human Neuroscience*, *9, 708*. https://doi.org/10.3389/fnhum.2015.00708

Oostenveld, R., Fries, P., Maris, E., & Schoffelen, J. M. (2011). FieldTrip: Open Source Software for Advanced Analysis of MEG, EEG, and Invasive Electrophysiological

Data. *Computational Intelligence and Neuroscience*, *2011*, 156869. https://doi.org/10.1155/2011/156869

Pace, T. W. W., Negi, L. T., Dodson-Lavelle, B., Ozawa-de Silva, B., Reddy, S. D., Cole, S. P., … Raison, C. L. (2013). Engagement with Cognitively-Based Compassion Training is associated with reduced salivary C-reactive protein from before to after training in foster care program adolescents. *Psychoneuroendocrinology*, *38*(2), 294–299. https://doi.org/10.1016/j.psyneuen.2012.05.019

Patki, S., Grundlehner, B., Verwegen, A., Mitra, S., Xu, J., Matsumoto, A., … Penders, J. (2012). Wireless EEG system with real time impedance monitoring and active electrodes. *Biomedical Circuits and Systems Conference (BioCAS), 2012 IEEE*, 108–111. IEEE.

Perdue, D. (1992). *Debate in Tibetan Buddhism*. Snow Lion Publications.

Perdue, D. (2014). *The Course in Buddhist Reasoning and Debate: An Asian Approach to Analytical Thinking Drawn from Indian and Tibetan Sources*. Boston; London: Snow Lion.

Pfurtscheller, G., & Lopes Da Silva, F. H. (1999). Event-related EEG/MEG synchronization and desynchronization: Basic principles. *Clinical Neurophysiology*, *110*(11), 1842–1857. https://doi.org/10.1016/S1388-2457(99)00141-8

Pfurtscheller, G., Stancák, A., & Neuper, Ch. (1996). Event-related synchronization (ERS) in the alpha band — an electrophysiological correlate of cortical idling: A review. *International Journal of Psychophysiology*, *24*(1), 39–46. https://doi.org/10.1016/S0167-8760(96)00066-9

Pinheiro, J., & Bates, D. (2009). *Mixed-effects models in S and S-PLUS*. Springer.

Schmeichel, B. J. (2007). Attention control, memory updating, and emotion regulation temporarily reduce the capacity for executive control. *Journal of Experimental Psychology. General*, *136*(2), 241–255. https://doi.org/10.1037/0096-3445.136.2.241

Sederberg, P. B., Kahana, M. J., Howard, M. W., Donner, E. J., & Madsen, J. R. (2003). Theta and gamma oscillations during encoding predict subsequent recall. *Journal of Neuroscience*, *23*(34), 10809–10814.

Smit, A. S., Eling, P. A. T. M., Hopman, M. T., & Coenen, A. M. L. (2005). Mental and physical effort affect vigilance differently. *International Journal of Psychophysiology*, *57*(3), 211–217. https://doi.org/10.1016/j.ijpsycho.2005.02.001

Toppi, J., Borghini, G., Petti, M., He, E. J., Giusti, V. D., He, B., … Babiloni, F. (2016). Investigating Cooperative Behavior in Ecological Settings: An EEG Hyperscanning Study. *PLOS ONE*, *11*(4), e0154236. https://doi.org/10.1371/journal.pone.0154236

Tóth, B., Kardos, Z., File, B., Boha, R., Stam, C. J., & Molnár, M. (2014). Frontal midline theta connectivity is related to efficiency of WM maintenance and is affected by aging. *Neurobiology of Learning and Memory*, *114*, 58–69. https://doi.org/10.1016/j.nlm.2014.04.009

van de Vijver, I., Cohen, M. X., & Ridderinkhof, K. R. (2014). Aging affects medial but not anterior frontal learning-related theta oscillations. *Neurobiology of Aging*, *35*(3), 692–704. https://doi.org/10.1016/j.neurobiolaging.2013.09.006

van Vugt, M. K., Moye, A., Pollock, J., Johnson, B., Bonn-Miller, M., Gyatso, K., … Fresco, D. M. (2019). Tibetan Buddhist monastic debate: Psychological and neuroscientific analysis of a reasoning-based analytical meditation practice. *Progress in Brain Research, Vol.*, *422*, 233–253. https://doi.org/bs.pbr.2018.10.018

van Vugt, M. K., Sederberg, P. B., & Kahana, M. J. (2007). Comparison of spectral analysis methods for characterizing brain oscillations. *Journal of Neuroscience Methods*, *162*(1–2), 49–63.

van Vugt, M. K., Simen, P., Nystrom, L., Holmes, P., & Cohen, J. D. (2012). EEG oscillations reveal neural correlates of evidence accumulation. *Frontiers in Human Neuroscience*, *6*, 106.

Wagenmakers, E.-J., Love, J., Marsman, M., Jamil, T., Ly, A., Verhagen, J., … Morey, R. D. (2017). Bayesian inference for psychology. Part II: Example applications with JASP. *Psychonomic Bulletin & Review, 25, 58–76*. https://doi.org/10.3758/s13423-017-1323-7

Wascher, E., Rasch, B., Sänger, J., Hoffmann, S., Schneider, D., Rinkenauer, G., … Gutberlet, I. (2014). Frontal theta activity reflects distinct aspects of mental fatigue. *Biological Psychology*, *96*, 57–65. https://doi.org/10.1016/j.biopsycho.2013.11.010

Figure 1

Typical monastic debate at Sera Jey monastery in India. Debate is a dyadic interaction between a challenger (standing) and a defender (seated) in which the two debaters try to clarify their reasoning.

Figure 2

Example of the EEG setup. One challenger (standing) and one defender (seated) are both wired with an EEG cap. Another monastic is seated behind a computer and presses trigger buttons to create events in the EEG data. Video is also collected of each debate, which was subsequently analyzed with behavioral coding software.

Figure 3

Effects of *agreement* on inter-brain synchrony. Top row: inter-brain synchronization in the alpha band as a function of agreement/disagreement and experience for the channel showing the largest difference between *agreement and disagreement*. More experience is indicated with blue-green bars, while less experience is denoted by red bars. Error bars reflect standard error of the mean. Bottom row: significance of the effect of experience for all channels in terms of p-value.

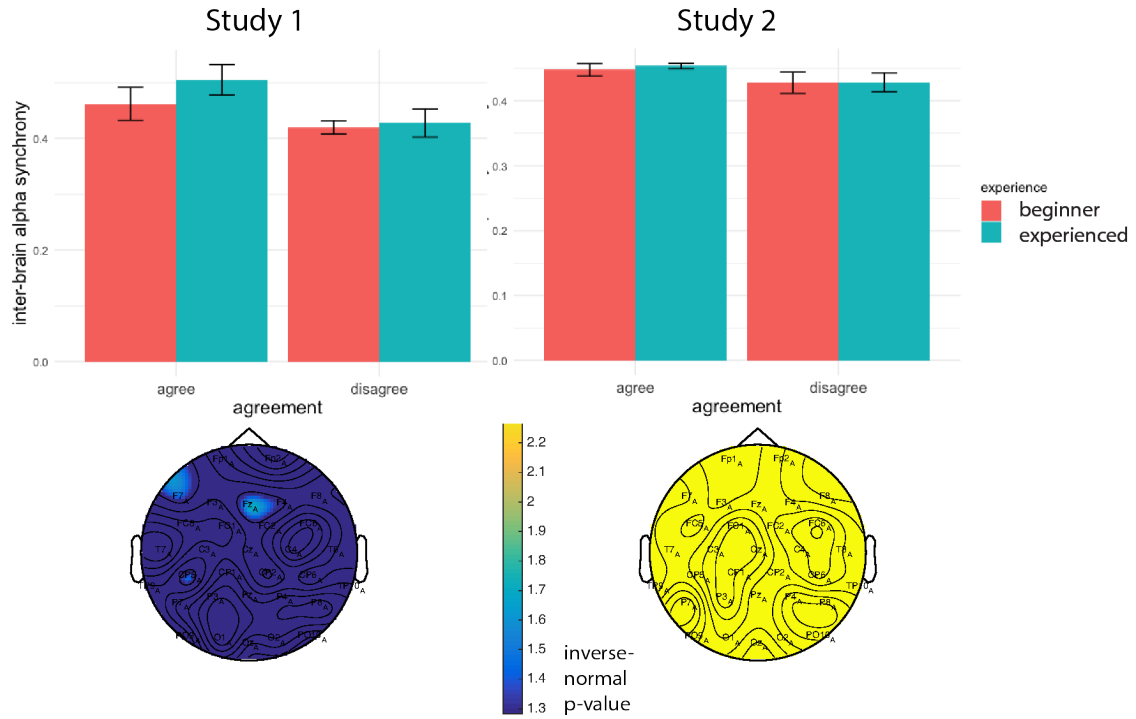


Figure 4

Effects of *experience* on inter-brain synchrony. Top row: inter-brain synchronization in the alpha band as a function of agreement/disagreement and experience for the channel that showed the largest difference between *more and less experience.* More experience is indicated with blue-green bars, while less experience is denoted by red bars. Error bars reflect standard error of the mean. Bottom row: significance of the effect of experience as a function of channel, indicated by the p-value where yellow color indicates significance.

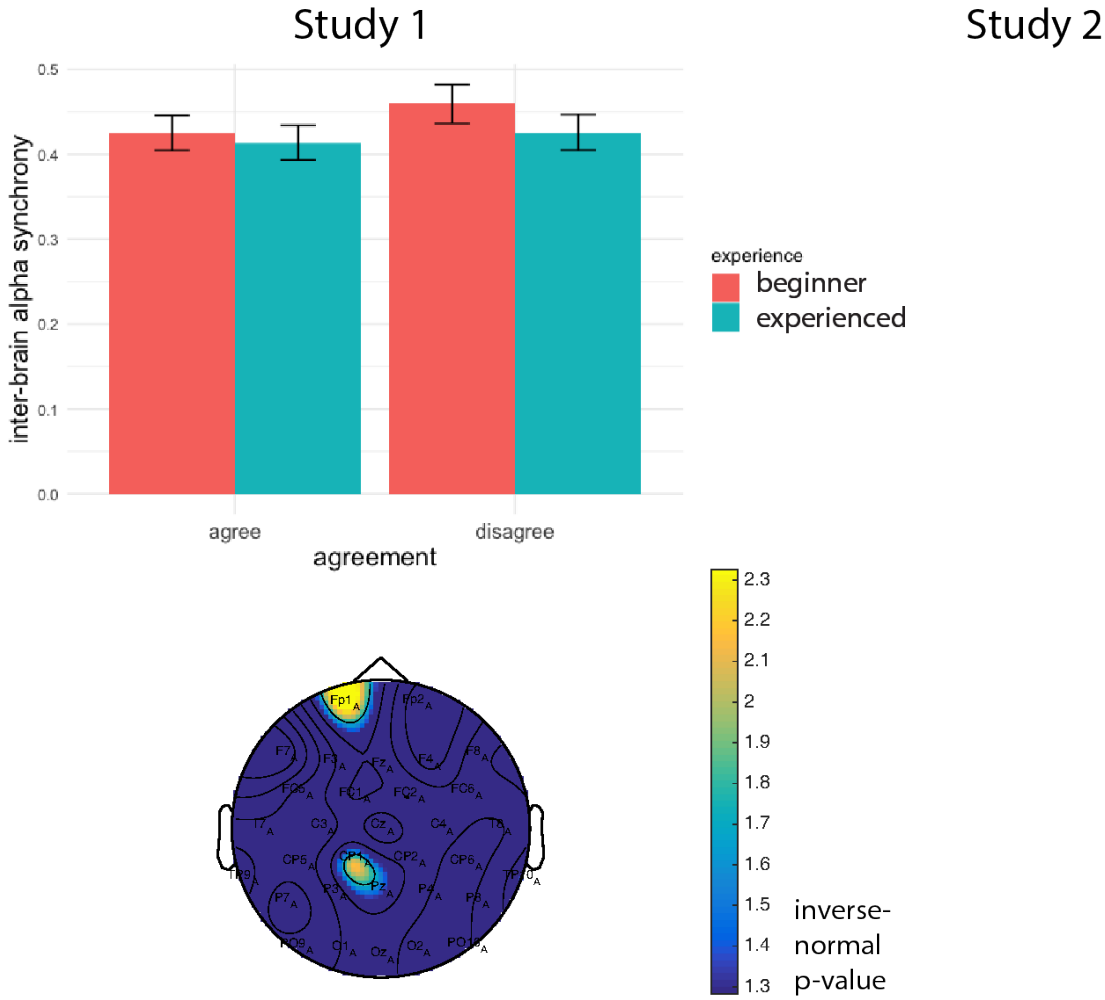


Figure 5
4-9Hz theta oscillatory power increases significantly over the duration of the debate in Study 1. Shown here is average z-scored theta power over time, time-locked to the beginning of the debate (top) and to the end of the debate (bottom). Time zero indicates the beginning of the debate, while the ending time is flexible. If the debate persisted for more than 15 minutes, the remaining time is cut off from the graph. Grey shading represents a 95% confidence interval estimated with a loess curve.

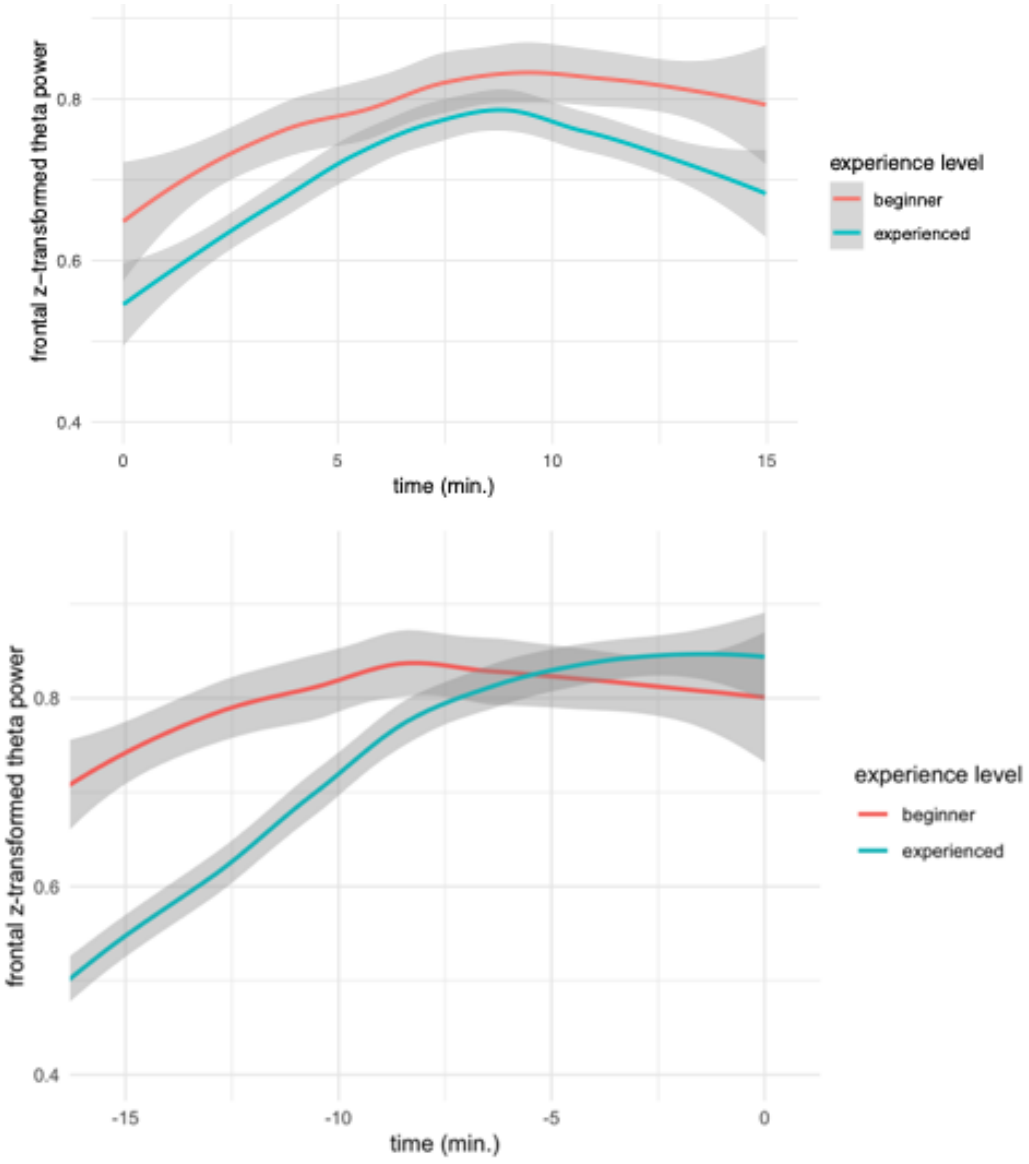


Figure 6

4-9 Hz theta oscillations increase significantly over the duration of the debate in Study 2, separately for beginners and experienced monks in logic debates (right). Left column shows that for counting debates, the increase is only visible for experienced monks. Shown here is average z-scored theta power over time, where time zero indicates the start of the debate. Logic debates have a 15-minute duration, while counting debates have a 10-minute duration. Grey shading indicates the 95% confidence interval.

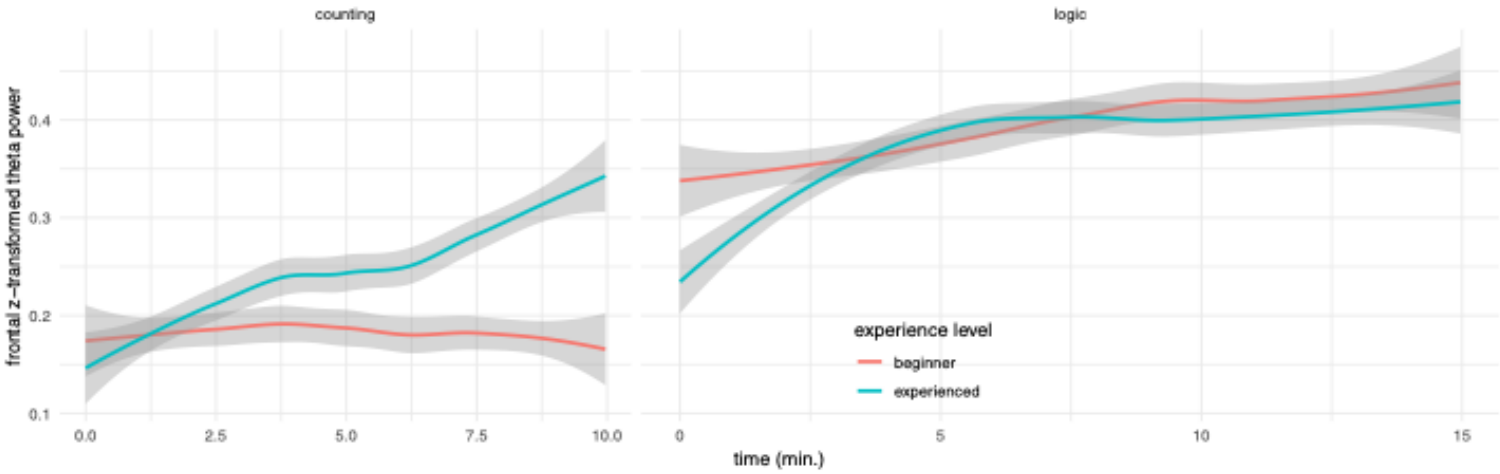


Figure 7

Topographical plot of theta slope for all channels, separately for the counting and the logic debates. More yellow colors indicate a more positive slope (color indicates the value of the t-statistic on the slopes). A t-value of 1.66 corresponds to a p-value of 0.05; a t-value of 3.0 corresponds to a p-value of 0.001, which is equivalent to a p-value threshold of 0.05 that is Bonferroni-corrected across the number of channels.

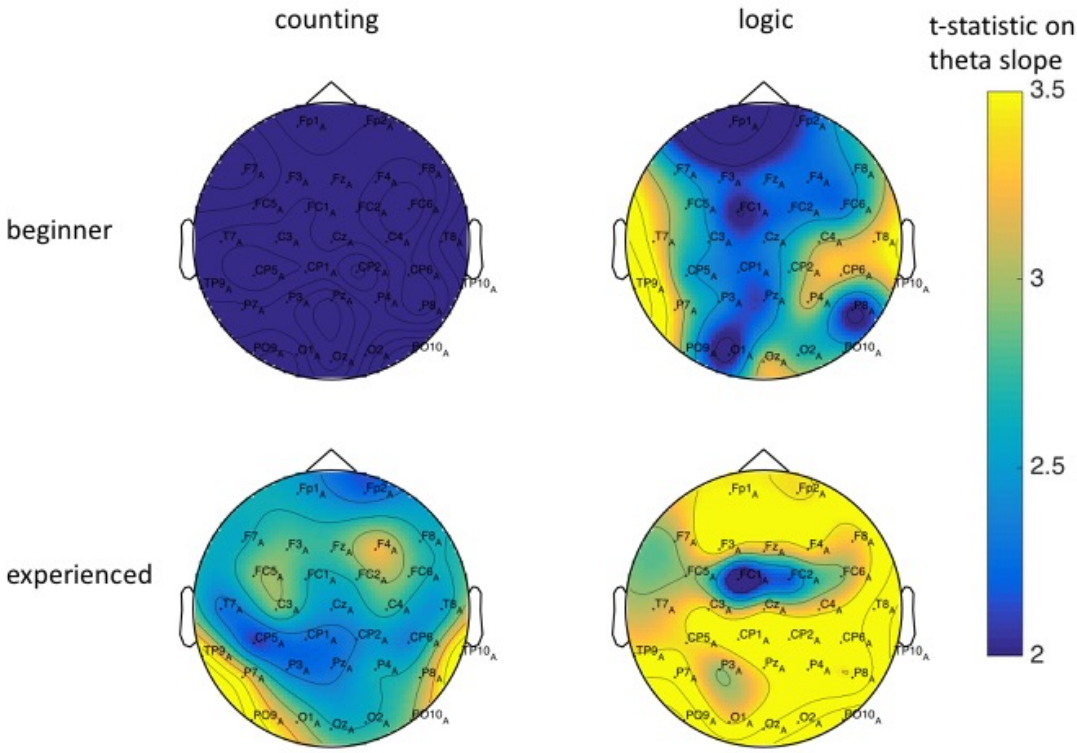
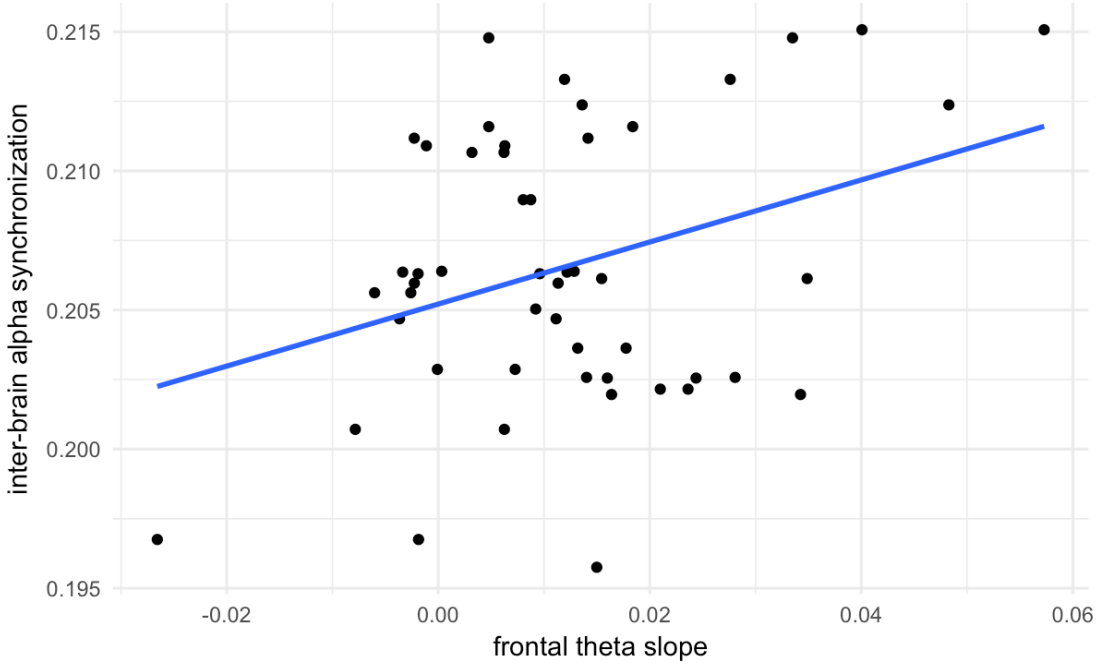


Figure 8

Correlation between mid-frontal theta slope and inter-brain frontal alpha synchronization in Study 1. Each dot reflects an individual in a debate.



Tibetan Buddhist monastic debate: psychological and neuroscientific analysis of a reasoning-based analytical meditation practice

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Abstract

Analytical meditation and monastic debate are contemplative practices engaged in by Tibetan Buddhist monastics that have up to now been largely unexplored in Western contemplative science. The highly physical form of contemplative debating plays an important role in the monastic curriculum. Based on discussions and recorded interviews Tibetan monastic teachers and senior students at Sera Jey Monastic University and preliminary experiments, we outline an initial theory that elucidates the psychological mechanisms underlying this practice. We then make predictions about the potential effects of this form of debating on cognition and emotion. On the basis of initial observations, we propose that successful debating requires skills that include reasoning and critical thinking, attentional focus, working memory, emotion regulation, confidence in your own reasoning skills, and social connectedness. It is therefore likely that the many cumulative hours of debate practice over 20+ years of monastic training helps to cultivate these very skills. Scientific research is needed to examine these hypotheses and determine the role that monastic debate may play in terms of both psychological wellbeing and educational achievement.

Keywords: monastic debate, meditation, contemplative practice, emotion regulation

Introduction

Although the literature on contemplative practices is burgeoning, the extant literature is almost exclusively restricted to the study of mindfulness and other concentration and awareness meditation practices (Dahl, Lutz, & Davidson, 2015; Van Dam et al., 2018). Such practices represent only a small morsel of the palette in the contemplative tradition that further includes many practices focusing on self-enquiry (Dahl et al., 2015). Two practices that focus on self-enquiry and are common to Tibetan monastic traditions (especially the Gelug school) are analytical meditation and monastic debate. These practices involve a process of deep contemplation on the nature of mind and reality, which are said

to result in shifts of consciousness that give the feeling of an elucidation of something that was unknown before (Kounios & Beeman, 2009). Both analytical meditation and debate rely on critical reasoning as opposed to authority or scripture. Given their centrality to monastic training in Tibetan Buddhism as a means of cultivating critical reasoning and wisdom, analytical meditation and monastic debate may have beneficial effects on cognition and emotion. For this reason, it is worth exploring in more detail whether those practices could provide suggestions for the improvement of Western psychological and educational practices. Moreover, these practices may provide benefits for physical and mental health even in old age. In this chapter, we first describe debate in general. This section is based on a review of the literature on monastic debate complemented by a series of interviews with approximately 30 monastics acquired over the course of two years. The interviewees include both novice and advanced monastics, as well as senior teachers and experts in monastic debate. We then outline a biobehavioral model of monastic debate, followed by some initial quantitative measures of its phenomenology. We also place monastic debate in the phenomenological matrix that has recently been proposed to categorize contemplative practices. Finally, we use the descriptions of analytical meditation and debate to speculate about how these practices may be of use in modern society in domains such as education.


Figure 1: Impression from a monastic debate at Sera Jey monastic University.

General introduction of debate as a form of analytical meditation

What is monastic debate?

Monastic debate is a highly social practice in which the understanding of the memorized and contemplated material is deepened by means of constant questioning. "It is a creative activity that depends upon continually placing the thinking of participants at risk." Unlike Western-style debate, in which the objective is to convince the opponent, this form of debate is more dialectic and serves to "carry the participants to logical conclusions they may not have otherwise realized." (Liberman, 1992). The main question that drives the debate is "what is the consequence of that?" (Tillemans, 2008).

Monastic debate is also unique in its physical manifestation with clapping movements, stomping on the ground and other specific gestures (see Figure 1 for an impression) that make the debate more engaging and urgent. Importantly, monastics we interviewed explained that these gestures are symbolic reminders that the goal of each question posed is to remove ignorance and to compassionately alleviate misconceptions about reality. Debating can also involve humor, teasing, and even shoving matches between the various challengers to get the opportunity pose a question or make a statement (G. B. Dreyfus, 2008). The

physical dimension of the practice may help the interlocutors to convert knowledge from mere intellectual knowledge to embodied knowledge.

Debates follow strict argumentation rules, intended to guide the debaters towards insights into the logical consequences of the defender's statements. These insights are important, because it gives the interlocuters a deeper understanding of the different theories in Buddhist philosophy and how they compare to each other. Moreover, it allows the debaters to examine what it would mean to really apply these philosophical insights in the context of other scriptures or everyday life. The structure of debates, with its emphasis on dissecting definitions and categories, ensures that both debaters are very clear on what they are talking about (Liberman, 1992).

In its simplest form, debate consists of an interaction between a defender, who is sitting down, literally defending their ground and being held to consistency of the assertions he or she[1] agrees to, and the challenger, who is standing and challenges the statements of the defender without being held to consistency for their statements (G. B. Dreyfus, 2008). Challenger and defender take turns in the debate. The challenger is making statements, often in the form of syllogisms, and sometimes accompanied by quite active movements and strongly expressed emotions. Monastics we interviewed explained that the goal of the challenger is to demonstrate an inconsistency in the defender's argumentation, and when one is detected, s/he emphasizes that by a loud utterance of "tsa!" In contrast, defenders can only choose from one of four response options to each of the challenger's statements: (1) I agree, (2) please state a reason why, (3) the reason is not established or (4) no pervasion (i.e., the statement does not apply to this class/these beings; Dalai Lama, 2018; Sera Jey Science Centre, 2015).

In general, being the defender is considered to be the more challenging role in the debate, because the defender has no agency about the topic of the debate and direction in which it flows. Not surprisingly, therefore, the final examination in the Gelug monastic tradition requires the candidate to make a monastery tour

[1] Traditionally, much debate was done by male monastics, but recently also female monastics have started to engage in debate and obtain higher degrees in Buddhist studies. For a more extensive description of debate practices by female monastics see MacPherson (2000).

and serve as a defender in all the major Gelug monasteries (Sera, Drepung, Gaden)—thereby requiring the candidate to face many unfamiliar challengers.

Another important characteristic of debate is that long pauses with silence are considered a weakness—and when they occur, either debater can be ridiculed by the onlookers or be the victim of a counterattack (Liberman, 1992, 2008). Hence, debaters must develop the ability to think quickly. Frequently, sessions begins with debate being practiced with just one defender and one challenger. In the second part of a typical debate session, group debates are conducted that consist of multiple challengers and/or multiple defenders. We have observed that the groups are fairly fluid with one to four challengers and one to four defenders, and the rest of the class of up to 30 people observing. These observers may sometimes jump in when a debate is really engaging, wanting to help the challenger or defender, or to respond to outrageous statements of one of the debaters.

Debate has a theatrical quality, in which debaters show dramatic movements and sounds (MacPherson, 2000). This staging contributes to the joyful and captivating quality of debate (Liberman, 2015). The dramatic show is also used to impress both observing senior monks tasked with assessing the debate sessions, and wider audiences, for example during the debate exams (Liberman, 1992). The function of the observing mentors is to ensure that debaters follow the rules and to provide guidance, especially to younger monastics that are still getting familiar with logical reasoning found in Buddhist philosophy.

Types of monastic debate

Monastics we interviewed report that two important classes of debate are counting debates and logic debates. Counting debates focus on having the debaters jointly trying to recall a text, its outlines, enumerations, and definitions. By contrast, logic debates focus on trying to find out what conclusions are consistent and what conclusions are inconsistent with premises contained within the text (Dalai Lama, 2018). For this reason, a counting debate tends to precede a logic debate. Nevertheless, a real-life debate may meander in and out of counting debate when it is needed. Monastics told us that debates typically begin with a focus on reproduction of definitions of terms, which is then followed by a

dissection of these definitions in terms of their logical consequences and consistencies/inconsistencies with other sources. Whereas the recitation of a definition would be part of the counting debate, the dissection of its consequences would be part of the logic debate. Debates also meander between periods in which the structure of debate is rigidly applied, and periods in which the discussion flows more freely (Liberman, 1992).

How is debate taught?

Debate is a crucial component of Tibetan monastics' philosophical training. First, monastics listen to and read the material to be studied, then they memorize and contemplate the text, and finally they test and deepen their understanding through the practice of debating (G. Dreyfus, 2003). Monastics report that debating is a critical part of their training because their own logic and reasoning becomes the final authority, as opposed to relying completely on scripture.

Debate is found playing differing roles in each of the four major schools or traditions of Tibetan Buddhism. At the major monastic universities of the Gelug tradition, such as Sera Jey Monastery, monastic debate is first taught when monks are approximately 14 years old. To learn the rules of logic and argumentation on abstract topics such as colors, students first memorize scripted debates and simply read them out like play (G. Dreyfus, 2003). They gradually shift towards actual debating, but still following the scripts fairly strictly as they continue to learn the rules of logic and argumentation on abstract topics such as colors. After approximately two years, the focus has shifted from learning the skill of debate to using debate as a tool to acquire knowledge about the studied texts. Debating continues for a total of about twenty years, until monks obtain their Geshe degree (the endpoint of education, roughly equivalent to a PhD). Not all monks finish this whole curriculum. Some specialize in other topics such as ritual, others obtain jobs as administrators, and some leave the monastery. During the academic session (approximately ten months per year), debate is practiced for approximately five hours per day, at least six days a week in monasteries in the Gelug tradition of Tibetan Buddhism. A monk that graduates with a Geshe degree will have spent more than 25,000 hours in debate practice. Once a year, debates take place between the different classes. Monastics report that these inter-class debates are

an extra challenge because the debaters must now face opponents with unfamiliar knowledge and strategies. Other traditions rely less on debate; for example, Namdroling monastery, which is part of the Nyingma tradition, debate is practiced for only one to two hours a day, for typically eight years, and this allows these monastics to take more classes (Lempert, 2012).

Debate and analytical meditation

In monastic training, debate (*riglam*) is complemented by seated, individual analytic meditation (*ché gom*). In fact, debate may best be regarded as an embodied and social form of analytical meditation. In fact, monastics have referred to analytical meditation as "self-debate". During individual analytical meditation, the practitioner contemplates a passage of text or an idea in their minds. This reasoning-based form of sitting meditation is sometimes alternated with resting meditation without any particular object of focus (*jok gom*), which is thought to allow new insights to consolidate and become embodied (Desbordes & Negi, 2013; Kongtrul, 2003).

A biobehavioral model of monastic debate

On the basis of the phenomenology described above, we can start to develop a biobehavioral model of monastic debate, which can result in testable predictions for future studies. When debating, the two interlocuters start with a relatively empty slate; especially the defender will entertain a low cognitive load and a neutral emotional state. This situation arises because the defender has no idea what will happen, while the challenger can already prepare in their working memory a mental representation of the line of argument they want to pursue. Then, as each statement in the debate is made, the debater's cognitive load increases, since they have to keep track of each statement that is made in order to prevent agreeing to contradictory statements (defender) or detect contradictions (challenger). The increase in cognitive load is accompanied by a filling of working memory with the statements the debaters have track. This filling of working memory likely reduces distraction by external phenomena, because so much attention is needed for the inward focus (Taatgen, van Vugt, Daamen, Katidioti, & Borst, submitted). On a neural level, we expect that as the debate progresses, there

is increased engagement of the fronto-parietal attention network. Specifically, the need to keep more and more information in working memory may be associated with increased engagement of the dorsolateral prefrontal cortex (Eriksson, Vogel, Lansner, Bergström, & Nyberg, 2015), while the continuous need for monitoring for logical contradictions may be associated with activation of the anterior cingulate cortex, similar to what has been observed in other meditation practices (Posner & Petersen, 1990; Tang, Hölzel, & Posner, 2015). The strong internally directed attention required for the practice may in electroencephalography (EEG) measurements manifest itself as increases in mid-frontal 4-9Hz theta oscillations, which have also been observed in other meditation practices (Cahn & Polich, 2006).

However, attention and working memory are not the only critical cognitive functions involved in the practice of debate. Debating also requires very fast cognitive processing, as quick replies are required—there is little time to think. In other words, debate is likely to press on the speed of processing. Speed of processing has been related to brain health in general, but not to specific brain regions (Penke et al., 2010).

Similarly, mental flexibility is key: being able to look at a set of propositions from many different angles to be able to out-maneuver the opponent. In the brain, cognitive flexibility is associated with activation in a wide range of areas such as the anterior cingulate cortex and prefrontal cortex (Leber, Turk-Browne, & Chun, 2008).

Given the strong memory requirements of the practice, debate may also be associated with activation of the hippocampus and the medial temporal lobe, especially during counting debates. The logical reasoning that is continually needed during debate practice should result in increased activation in the left prefrontal cortex and left parietal areas (Goel, 2007).

As the debate proceeds, not only more working memory skills are needed, but also increased emotion regulation. Challengers often employ tactics to distract their opponent, e.g., by making fun of them or displaying anger. If the defender gives in to these emotions, this is likely to impair their reasoning and ability to maintain their line of argumentation. Consequently, successful debating likely requires strong emotion regulation skills. While the defenders are the ones that

most frequently face challenges in debate because they are not able to choose the topic of the debate and are subject to the emotional challenges of the challenger, also the challenger her- or himself can face difficulties. For example, the challenger can realize they do not remember a certain part of the text that is being debated and thereby be unable to corner the defender. Also bystanders, the debate observers, can create feelings of frustration in the challenger with their comments about the debate. As debaters learn to manage their emotional arousal better in the face of these challenges, we suggest that this could be associated with increased dorsolateral prefrontal cortex and decreased amygdala activation (e.g., Desbordes et al., 2012), together with increased activity in the caudate, an area crucial for emotion regulation (Kirk, Downar, & Montague, 2011).

Continued practice of debate may result in the improvement of the ability to handle high cognitive load situations as well as emotional challenges. In addition, and more speculatively, the practice is thought to result in new insights into the nature of reality. Such insights may be similar to "aha" moments that have been described in the literature on problem solving. Such "aha" moments are typically associated with increases in parietal gamma oscillations in EEG, and in fMRI activity in the right superior temporal gyrus.

Some of the insights cultivated in debate are thoughts to reduce the attachment to the importance of the self (Sahdra, Shaver, & Warren Brown, 2010), as well as lead to reduced self-related elaboration. This reduced sense of self-related elaboration may psychologically manifest as an increase in decentering (Bernstein et al., 2015; Fresco et al., 2007) and neurally as decreased activation of the default mode network (Christoff, Gordon, Smallwood, Smith, & Schooler, 2009) including especially the posterior cingulate cortex (Garrison et al., 2013). On a behavioral level, a decreased sense of self-importance may be associated with increases in altruistic behavior.

In summary, monastic debate is likely associated with strong activation of the brain's memory and cognitive control systems, which increases as the debate continues of time. In addition, debate requires significant emotion regulation skills. Over time, debate may have important impacts on the nature of self-related processing. Different forms of debate have different cognitive demands. While counting debates tends to be more collaborative and are often considered to be

easier, logic debates are thought to be more challenging and require more attentional resources. In the next section, we will begin to assess some of these claims by quantitatively assaying the events that occur during debating.

Quantifying the phenomenology of monastic debates

The performative nature of monastic debates lends it to quantitative assessments of its phenomenology. In this section we will present analyses as well as a differentiation between logic and counting debates on the basis of mental states predicted by our bio-behavioral model.

Methods

A method to assess debate phenomenology is by means of second-person judgments obtained during simultaneous measurement with dyadic EEG (reported in van Vugt et al., 2018). These second-person judgments were derived from rating video segments of debates from the EEG study on a set of predefined events of interest. In particular, the events of interest were defined on the basis of discussions with the monastic collaborators about the kinds of events that occur during debating. The monastic authors on this paper nominated periods of agreement and disagreement as important events identifiable in debate. Agreement refers to an exchange where both debaters subscribe to the same set of statements, while disagreement refers to an exchange where the set of statements that the two debaters agree to differ from one another. Perdue (2014) gives the following example of an exchange that could occur during a debate in his Chapter 25:

> "Challenger: How do these two compare—direct perceivers and valid cognizers? [..]
>
> Defender: They are mutually inclusive. [..]
>
> Challenger: It follows that they are not mutually inclusive.[2] Give a reason justifying that they are mutually inclusive. [..]

[2] The seemingly illogical assertion here is a trick by the challenger. This is where the disagreement starts: the defender adopts the position that the two are mutually inclusive, while the challenger thinks they are not mutually inclusive. More precisely, according to Buddhist philosophy, all direct perceivers are valid cognizers, but valid cognizers are not necessarily direct perceivers, because valid cognition can also come about through valid inference (http://www.rigpawiki.org/index.php?title=Pramana).

Defender: Because they are different, whatever is a direct perceiver is necessarily a valid cognizer, and whatever is a valid cognizer is necessarily a direct perceiver."

We have used this classification system most intensively in a series of 54 debates that were part of the parent EEG study, wherein we classified the occurrence of expected events of interest from video recordings. Approximately half of these debates were 10-minute counting debates, and half were 15-minute logic debates. Since counting debates involve the simple reproduction of the material that is debated, those tend to be shorter. The debates were scored by at least two raters, and here we take the average judgments of these raters.

We compared the ratings by means of repeated measures anova performed in the R statistical language (R Core Team, 2013).

In addition, we used Bayes Factors. as they are helpful to indicate the relative amount of support for the hypotheses under consideration instead of just providing a probability of rejecting the null hypothesis. For example, the BF_{10}, which is the statistic we report here, indicates how much more evidence there is for the alternative (H_1) than for the null hypothesis (H_0). A BF_{10} of three indicates that given the data, the alternative hypothesis is three times as likely as the null hypothesis. Conversely, a BF_{10} of 0.1 indicates that there is ten times (1/0.1) as much support for the null hypothesis than for the alternative hypothesis. This conveniently demonstrates another advantage of Bayes Factors: they can not only quantify support for the alternative hypothesis, but also for the null hypothesis.

Analysis of debate events

In Figure 2 we show the proportion of time during the debate that debaters were classified as expressing agreement versus disagreement, separately for the counting and the logic debates. As we predicted, the amount of agreement is higher during the counting debates than during the logic debates, while the amount of disagreement is higher during the logic debates. Indeed, while there is no significant main effect of debate type on the ratings (logic vs. counting; $F(1,52) = 1.40$, $p = 0.24$, $BF_{10} = 0.274$), there is a significant main effect of agreement ($F(1,52) = 20.4$, $p = 3.65*10^{-5}$, $\eta_g^2 = 0.22$, $BF_{10} = 1.05*10^5$) and a significant interaction between agreement and debate type ($F(1,52) = 13.4$, $p = 5.8*10^{-4}$, $\eta_g^2 = 0.16$, $BF_{10} = 3.05*10^3$).

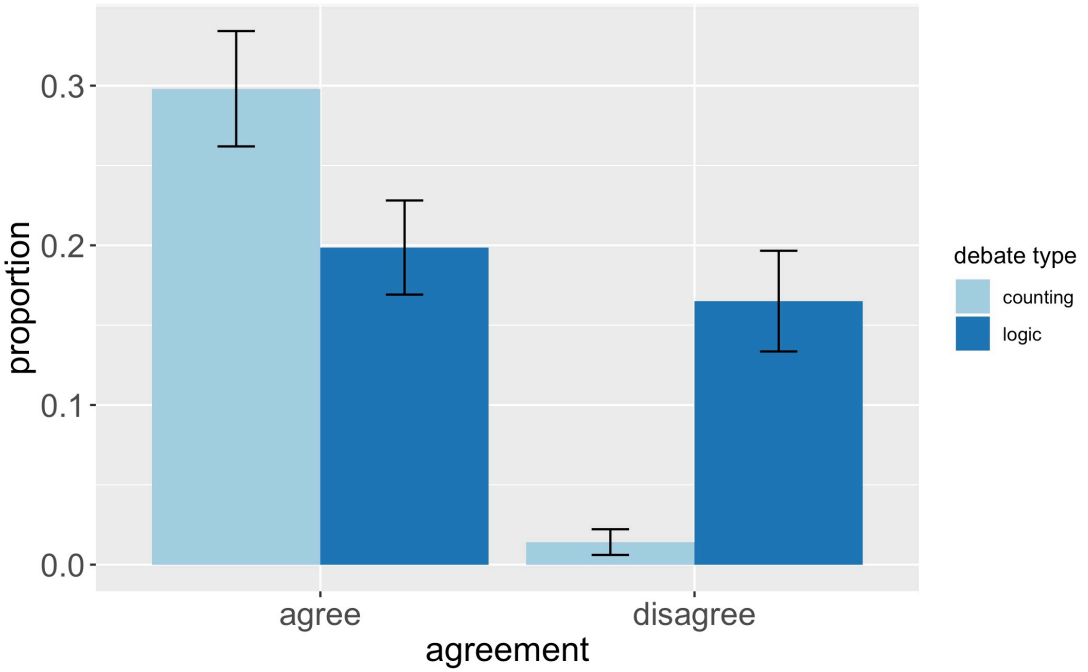

Figure 2: Fraction of the time the debate during which debaters agree or disagree. Any moment in the debate could be classified as "agreement", "disagreement", or "undefined." Error bars reflect standard error of the mean.

The monastics we interviewed said that another important common occurrence during debate is when one of the debaters is in a place in the argument where their only next option is to contradict themselves, or when they are led into a topic area they have not properly memorized, and therefore cannot effectively debate. The defender is relatively more likely to get into this kind of difficulty because given the rules of debate, s/he has no control over the topic that is being discussed, and therefore cannot steer the debate towards topics for which s/he feels more confident. Figure 3 indicates how often a debater is bested over the course of the 15-minute debate. Indeed, the defender gets into difficulty more often than the challenger ($F(1,52) = 41.6, p = 3.76*10^{-8}, \eta_g^2 = 0.24$; $BF_{10} = 2.77*10^6$

Debaters overall find themselves more often in challenging situations (for example, when the next move is likely to lead to a contradiction) during logic debates than during counting debates ($F(1,52) = 6.8$, $p = 1.21*10^{-2}$, $\eta_g^2 = 0.07$; $BF_{10} = 4.07$). This is not surprising given the more confrontational nature of logic debates compared to counting debates. It is not clear whether there is an interaction between these two variables because the classical statistics are not

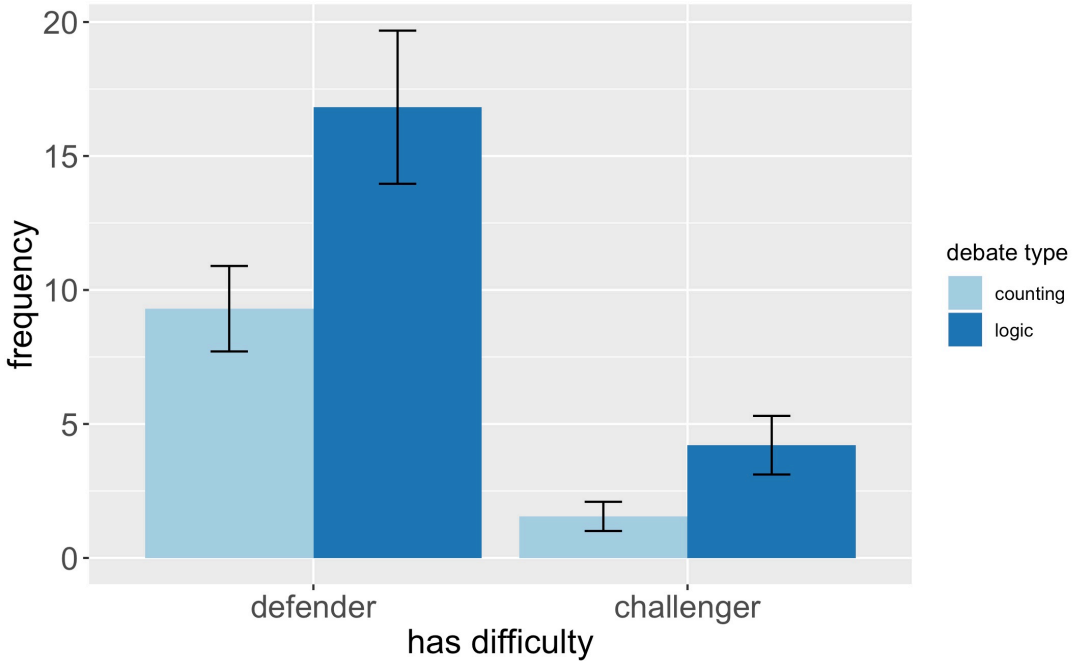

Figure 3: Frequency with which the defender and challenger are in difficulty as a function of debate type. Error bars reflect standard error of the mean.

significant and the Bayes Factors do not give strong evidence either way ($F(1,52) = 2.32$, $p = 0.13$; $BF_{10} = 2.67$).

Finally, we examined how often monks were judged to be attentive or distracted by the debate observers during the different types of debates, and how frequently they were judged to have difficulty remembering something. In our biobehavioral model, we predicted that logic debates were more challenging than counting debates. In contrast, counting debates require more memory retrievals. Indeed, the data plotted in Figure 4 support these hypotheses; the frequencies of both focus and distraction are larger during logic debates than during counting debates. This is confirmed by a main effect of mental state in a repeated measures ANOVA ($F(2,104) = 5.9$, $p = 3.7*10^{-3}$, $\eta_g^2 = 0.07$, $BF_{10} = 8.61$). It is not clear whether there is a main effect of logic versus counting debates ($F(1,52) = 3.1$, $p = 0.082$, $BF_{10}=0.45$). Less surprisingly, we can see that having difficulty remembering

something is particularly common during counting debates, which are centered around recalling the study texts. This prediction is confirmed by a significant interaction between mental state and debate type ($F(2,104) = 11.6$, $p = 2.86*10^{-5}$, $\eta_g^2 = 0.13$, $BF_{10} = 4.00$).

In short, we found that in logic debates the proportion of time disagreeing is almost the same as the proportion of time agreeing, while during counting debates the majority of time is spent in agreement. We also found that the defender got more into trouble than the challenger, especially during logic debates. Finally, we found that there is more distraction but also more strong focus during logic debates than counting debates, while there is more difficulty in remembering during counting compared to logic debates.

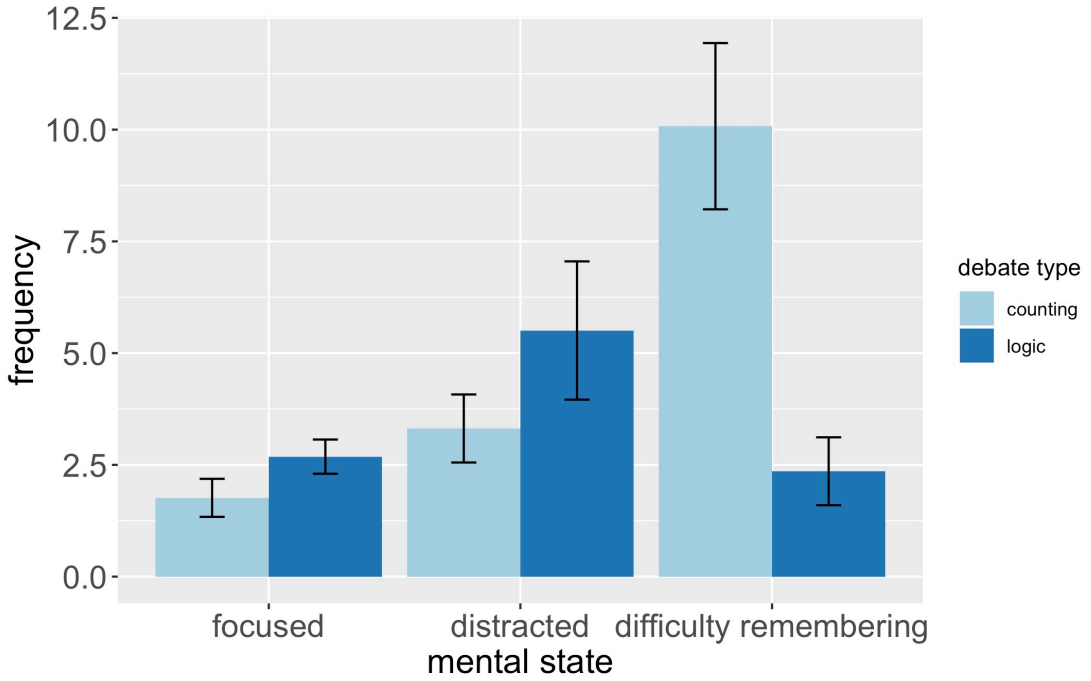

Figure 4: Self-reported levels of concentration and distraction during different types of debates. Error bars reflect standard error of the mean.

Comparing debate to other meditation practices

Recently, a phenomenological matrix has been offered as a means to classify and compare contemplative practices (Lutz, Jha, Dunne, & Saron, 2015). Here we will attempt to fit monastic debate into this matrix. The

phenomenological matrix initially emphasized two main practices: open monitoring and focused attention meditation, as variants of these are two meditation practices are the most commonly practiced in the West (Lutz, Slagter, Dunne, & Davidson, 2008). Whereas focused attention meditation practices involve paying attention to a single object of focus such as the breath, open monitoring meditation has no specific focus and involves a simple non-judgmental monitoring of whatever occurs in the mind. The exercise of placing debate into the phenomenological matrix may help us to understand where it is similar, and where it is different, from meditation practices more frequently described in the literature. It may also reveal where the phenomenological matrix is not able to capture crucial aspects of the practice at all.

In the phenomenological matrix, contemplative practices are initially classified along a series of functional dimensions. The first functional dimension is object orientation, referring to whether the practice entails the utilization of a particular object to retain focus. Whereas focused attention meditation is strongly focused on an object (e.g., the breath), open monitoring meditation has little object focus. Using these criteria, monastic debate perhaps does not fit well into either category. The object that is kept in focus is the text that is being discussed and the utterances that have preceded. Such an object is considerably more complex than meditation objects such as the breath or a visual image, that are common in focused attention meditation.

The second functional dimension is referred to as 'dereification', which as "the degree to which thoughts, feelings, and perceptions are phenomenally interpreted as mental processes rather than as accurate depictions of reality" (Lutz et al., 2015). Dereification in the mindfulness literature is more commonly referred to as decentering (e.g., Bernstein et al., 2015). In debate, a decentered perspective may be cultivated, for example, by systematically using reasoning to investigate where thoughts come from, how they arise from circumstances, how they are impermanent. Hence, this systematic investigation can generate a meta-cognitive perspective on one's thoughts. In addition, the investigation can lead to a deep, reasoned and intellectual understanding of concepts such as impermanence. The monastics report that because this understanding is based on reason, it will not disappear as quickly as an understanding of the decentered

perspective that arises on the basis of feelings that occur during mindfulness meditation. Reasoned understanding of the decentered perspective can take substantial time to develop, in contrast to the fleeting experience of decentering that arises even during practice of beginning mindfulness meditators (Hoge et al., 2015). This leads to the testable hypothesis that the amount of decentering during debate is initially less than during mindfulness, but with increasing experience, the amount of decentering during debate increases.

The third functional dimension is meta-awareness, which is defined as a state in which attention is directed to noting the current contents of consciousness (Lutz et al., 2015). As discussed in the biobehavioral model, meta-awareness is also crucial for monastic debate, in which the interlocutors have to continually monitor the train of thoughts for contradictions.

Contemplative practices are further classified according to a set of qualitative dimensions. These qualitative dimensions are mostly relevant for sitting meditation practices that focus on sensory objects and do not apply well to monastic debate. The first qualitative dimension is 'aperture'—the width of the meditator's attentional focus. The monastics have indicated that during debate, the attention is not focused so much on sensory objects, but instead on the progression of the dialogue and the text that is being debated. The second qualitative dimension is vividness, a subjective sense of clarity of the meditation object. Since monastic debates do not focus on sensory objects, vividness does not seem to be such a relevant dimension. The third qualitative dimension is stability. For experienced debaters, the debate state can be so stable that they forget time completely, and find themselves debating until the next morning (Liberman, 1992). Finally, meditation practices differ along the qualitative dimension of effort. Monastics indicate that subjectively experienced effort decreases in debates as the practitioners become more accomplished.

Potential applications of debate in societal domains

Having described the practices of analytical meditation and monastic debate, it is important to think about how it can be of most benefit for modern society. This first requires an analysis of its potential cognitive and affective mechanisms, followed by the societal applications.

What are the cognitive mechanisms of analytical meditation and monastic debate?

A worthy question to ask is what cognitive and affective mechanisms may be impacted by practicing these forms of meditation. Monastics we interviewed told us that the main reason for engaging in debate is to try to understand the true nature of phenomena so they can uproot their negative emotions and move closer towards enlightenment. On a more mundane level, monastic debate may also enhance memory and understanding of the texts that are being studied.

From a Western perspective, practicing debate could develop a wide array cognitive and emotional skills. One skill that is likely to be cultivated in the study and practice of monastic debate is logical reasoning. To be a successful debater, one needs to develop solid skills in logical argumentation. Dreyfus (2008) writes that "Tibetan debates aim at maximizing the rationality of the discourse of its participants." The whole debate is centered around using reasoning to find logical consequences of assertions and inconsistencies between them. In fact, according to Geshe Lhakdor, head of the Library of Tibetan Works and Archive, debate is also used to develop "an inquisitive mind, capable of asking and answering questions by using logic and consistency" (Byłów-Antkowiak, 2017). Hence, the first years of debate training consist of learning to use the rules of logic by reasoning about simple objects such as colors (G. Dreyfus, 2003; Perdue, 1992). Our phenomenological analysis demonstrates that logical reasoning is trained more during logic than during counting debates (Figure 2). Logic is not necessarily trained in individual analytical meditation, in which reasoning is confined to the individual, and therefore logical fallacies cannot be exposed by another person. Together, this suggests that debating can help reduce the likelihood of logical fallacies and thereby improve the quality of reasoning.

Another skill that is necessary for being a successful debater—and therefore likely to be cultivated by this practice—is focused attention, the ability to block out all external and internal distractions. Debaters commonly report that they do not perceive anything around them while they debate. Their attention is purely focused on their mental model of the debate and on their opponent(s). Monastics told us that this ability to block out everything else is considered to be a quality of a proficient debater, which also allows them to study effectively during the preparation of the debate (i.e., engage in analytical meditation). Consistent

with these reported subjective experiences, we have collected EEG data that support the idea that focused attention is cultivated by debate practice (van Vugt et al., 2018). In addition, our quantitative analysis showed that more focused attention is required during logic than during counting debates (Figure 4).

Monastics have also told us that debaters steadily cultivate an ability to plan debating moves, much like chess-players, so that they can corner their opponent more effectively into adopting a contradictory position. In addition to planning ahead, a successful debater needs to keep track of the previous utterances of both interlocutors to protect against uttering inconsistencies while noting the opponent's inconsistencies. Thus, debate likely relies strongly on working memory, where working memory is defined as a limited-capacity system that temporarily maintains, manipulates, and stores information (Baddeley, 2003). Such planning abilities of proficient debaters are not only trained *during* the practice of debate, but also afterwards, when good debaters replay the debate in their minds and review what went well and strategize about what other strategies could have worked better. The replay of past debates and the development of new debate strategies can also become the focus of subsequent more formal analytic meditation practice.

Another potential by-product of analytical meditation and debate is the development of emotional awareness and adaptive emotion regulation strategies. For instance, during monastic debate, one observes periods of what appears to be disgust and loud aggressive vocalizations that are quickly followed by bursts of laughter or joy, and/or periods of relative soft-spoken calmness. In addition, monastics report that early on in one's training, debate is highly intimidating, and can provoke genuine fear, frustration, and anger. However, they also report that as they continue to practice debate, and experience that humiliation or undergoing the other's seemingly harsh interrogation is not as bad as anticipated, they develop a sense of humor with their emotions that creates resilience (see also the first-person account of this process by Dreyfus, 2003). Debaters report that although strong emotions may still arise as before, they no longer have as much impact. They are more able to respond in a controlled manner to the situational arising of their emotions.

Notably, monastic debate is a highly social practice, which is significant because it has recently been demonstrated that contemplative practices that are social in nature are particularly powerful for reducing stress (Engert, Kok, Papassotiriou, Chrousos, & Singer, 2017). As years progress, monastics report they develop a strong sense of social connectedness cultivated by the highly social nature of the debate. Although a strong foundation of social connectedness is supported by the communal living in the monasteries and nunneries, debating appears to amplify the ability of monastics to empathize with one another, and to predict the other's responses. Monastics are likely to acquire a strong sense of how to play with the opponent's emotions, an sensitivity to how to regulate ones' own emotions.

Social connectedness may well be measurable by modern neuroscience methods (Dumas, Nadel, Soussignan, Martinerie, & Garnero, 2010). For instance, EEG hyperscanning has been demonstrated to pick up neural patterns related to empathy in Western samples (Astolfi et al., 2015)—suggesting that changes in the inter-person communication during the debate may well be measurable with this method. Somewhat in-line with this idea, we found that there are differences in frontal alpha inter-brain synchrony between different states in the debate, although we observed only little change in inter-brain synchrony with experience (van Vugt et al., 2018).

Monastic debate appears to be a means to develop a sense of confidence in one's ability to reason independently (Perdue, 2014), since debaters learn to defend their reasoning against attacks from their interlocutors (Figure 3). As monastics gain experience in winning another over through their arguments, they acquire confidence in their own ideas, instead of having to merely rely on outer sources of authority. Such confidence is beneficial for the development of independent and critical thinking (Facione, Sánchez, Facione, & Gainen, 1995). Moreover, the monastics say that debate gives them confidence in their knowledge of Buddhist philosophy and in the Buddhist philosophy itself.

Finally, given the highly physical nature of debate, this practice offers an outlet for the monastics' physical energy while also making the elaboration and integration of nuanced philosophical arguments more lively, playful and motivating. Monastic debate can be thought of as a particular form of

contemplative exercise, which suggests it is relevant to compare monastic debate to other forms of contemplative exercise such as tai chi and yoga (Kerr, Sacchet, Lazar, Moore, & Jones, 2013). However, tai chi and yoga are typically practiced quite slowly and have a much lower cardio-vascular intensity than debate, during which heart rates going up to 180 bpm have been observed[3].

Potential uses for monastic debate in Western education

Some of the major challenges facing education are teaching critical thinking (Holmes, Wieman, & Bonn, 2015) and increasing student motivation (Pintrich, 2003). Thus, if appropriately adapted outside of monastic context, debate could potentially become a pedagogical tool to help develop those skills (see MacPherson, 2000, for a description of how debate is used in Tibetan schools in India). For instance, debaters practice continually seeing things from many different perspectives, so that they can philosophically maneuver in response to their opponent. In addition, they train in identifying the consequences of different lines of argumentation so that they can catch the inconsistencies in the opponent's reasoning. These capacities are crucial for critical thinking. Anecdotally, some of the monastics we interviewed mentioned that debate often afforded new insights when their opponents questioned assertions that they never thought about.

Debate also turns out to be highly motivating, bringing excitement to highly abstract and challenging study material by means of its competitive nature and its active physical and theatrical form (MacPherson, 2000). As Dreyfus (2008) writes "rhetorical and performative elements are not just disruptions of a smooth system of logical connections, but give life to a practice that would otherwise be too boring to keep the attention of a large number of participants." Further supporting this idea, we once watched a particularly vigorous debate which turned out to only be about a technical grammatical issue. In his book, Dreyfus also mentions that debate serves to gather the intellectual qualities of both debaters and the audience to help elucidate the fine technical details in even the most abstract of topics.

The prospect of enlivening educational material has led secular Tibetan secondary schools to utilize the monastic style and rules of debate as a pedagogical

[3] These heart rates were observed during an in-class demonstration of the Emory-Tibet science initiative taking place at Drepung monastery in June 2018.

tool (Byłów-Antkowiak, 2017). More concretely, Byłów-Antkowiak (2017) gives the example of how a math lesson in such a school may involve debating about the definition of prime numbers, and a student challenger may ask a student defender questions such as: is five a prime number? Is eight a prime number? And just like debate in the monastery, asking these questions is punctuated by claps. Similarly, analytical meditation could have a place in Western education, allowing students to test their knowledge thoroughly in a fun and physically active way. The relatively recent field of contemplative education (Barbezat & Bush, 2013) makes some efforts to integrate the method of analytical meditation, but has not yet considered monastic debate.

In addition to potential functions in education, analytical meditation could potentially also play a role in the enhancement of psychological well-being. For example, critical deficiencies underlying major depressive disorder are associated with an inability to decenter (Bernstein et al., 2015; Fresco et al., 2007) and impairments in working memory and emotion regulation (e.g., Disner, Beevers, Haigh, & Beck, 2011; Koster, De Lissnyder, Derakshan, & De Raedt, 2011). If debate practice can enhance the capacities of decentering, working memory, and emotion regulation, as we have suggested above, then this should also help to create resilience against relapses of depression. More specifically, monastics we interviewed gave examples of how debate practice helps them have a wider perspective on their thoughts, as well as an increased capacity to observe their thoughts from another person's perspective. Since negative self-referential thinking is a crucial hallmark of depression (Disner et al., 2011; Marchetti, Koster, Klinger, & Alloy, 2016), an ability to step outside of this self-referential thinking could be beneficial to depressed patients.

Challenges and future directions

Although we believe it is important to study monastic debate, this form of contemplative practice remains a difficult endeavor to investigate with rigor and contemporary scientific methodology. Moreover, studying debate requires a tremendous amount of cultural sensitivity to establish trust and good communication. Having a research team that involves Tibetan monastics is crucial for at least two important reasons. First, because of being embedded Tibetan

monastic tradition, monastics' experience with analytical meditation and debate offer key insights on how best to frame the scientific questions to pose. Second, in a very pragmatic sense, scientists not fluent in formal Tibetan must rely on monastics who have learnt Western languages to instruct their fellow monastics in the tasks of the study, as well as to translate the findings. An important case of where this trust and their multi-lingual knowledge allowed this collaboration to advance occurs from the moment to moment assessments during debate with measures such as EEG. As discussed above, those investigations rely crucially on temporal markers of events of interest. Such events can only be generated with the help of people familiar with debate, and who are able to recognize the identified moments (e.g., agreements, disagreements, etc.) when they occur (van Vugt et al., 2018). Moreover, this inclusion of the emic perspective in the scientific investigation helps to realize a richer understanding of the phenomenon under a study that is not restricted to the categories and theories of Western psychology and neuroscience.

Another important challenge in the study of monastic debate lies in the choice of outcome measures. Both self-report (e.g., questionnaires that tap emotion regulation) and behavioral measures (e.g., a logical reasoning task) that are routinely used for Western undergraduates may not even be appropriate for people from other traditions and social and cultural backgrounds (Davidson & Harrington, 2001; Henrich, Heine, & Norenzayan, 2010) and may lead to misunderstanding or unexpected results. To make those measures usable with other populations, intensive discussion and piloting with intelligent multi-lingual collaborators from within the communities themselves are required (Davidson & Harrington, 2001). Moreover, a proper study of monastic debate may require the development of novel measures that are more geared towards the mental habits and cognitive experiences that monastics build up in their career, which may be quite different from the mental habits of Western college students, who are usually the participants in scientific studies. For example, instead of measuring memory with a task such as free recall—in which participants are shown lists of meaningless words to remember on a screen, after which they are asked to recall this list in any order—we may develop a cognitive task in which monastics are

requested to memorize a philosophical argument and recall it in order. This task is closer to the tasks Tibetan monastics experience on a daily basis.

To build a productive collaboration with monastics, it is important to have a cadre of monks who are trained in scientific methods. Fortunately there have been efforts in recent times to improve the science training of Tibetan monastics (e.g., Desbordes & Negi, 2013; Hasenkamp & White, 2017; Sager, 2013). Herein lies an opportunity for collaborative cross-cultural research, in which monastics who have undergone science training themselves are involved in the scientific study of debate. Those monastics can help conduct the scientific studies of monastic debate, while at the same time learning about how science is conducted in real life. In this way there is a synergy between teaching science and conducting science at the same time. We believe that only in this way we can begin to understand the treasure chest that is monastic debate, and bring benefits to modern society in both the East and in the West.

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References

Astolfi, L., Toppi, J., Casper, C., Freitag, C., Mattia, D., Babiloni, F., … Siniatchkin, M. (2015). Investigating the neural basis of empathy by EEG hyperscanning during a Third Party Punishment. In *2015 37th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)* (pp. 5384–5387). https://doi.org/10.1109/EMBC.2015.7319608

Baddeley, A. (2003). Working memory: looking back and forward. *Nature Reviews Neuroscience*, *4*(10), 829–839.

Barbezat, D. P., & Bush, M. (2013). *Contemplative Practices in Higher Education: Powerful Methods to Transform Teaching and Learning*. John Wiley & Sons.

Bernstein, A., Hadash, Y., Lichtash, Y., Tanay, G., Shepherd, K., & Fresco, D. M. (2015). Decentering and Related Constructs: A Critical Review and Metacognitive Processes Model. *Perspectives on Psychological Science*, *10*(5), 599–617. https://doi.org/10.1177/1745691615594577

Byłów-Antkowiak, K. (2017). *"Others before self" : Tibetan pedagogy and childrearing in a Tibetan children's village in the Indian Himalaya* (PhD). University of St Andrews, St. Andrews. Retrieved from http://hdl.handle.net/10023/11352

Cahn, B. R., & Polich, J. (2006). Meditation states and traits: EEG, ERP, and neuroimaging studies. *Psychological Bulletin*, *132*(2), 180–211. https://doi.org/10.1037/0033-2909.132.2.180

Christoff, K., Gordon, A. M., Smallwood, J., Smith, R., & Schooler, J. W. (2009). Experience sampling during fMRI reveals default network and executive system contributions to mind wandering. *Proc. Nat. Acad. Sci., USA*, *106*, 8719–8724.

Dahl, C. J., Lutz, A., & Davidson, R. J. (2015). Reconstructing and deconstructing the self: cognitive mechanisms in meditation practice. *Trends in Cognitive Sciences*, *19*(9), 515–523. https://doi.org/10.1016/j.tics.2015.07.001

Davidson, R. J., & Harrington, A. (2001). *Visions of Compassion: Western Scientists and Tibetan Buddhists Examine Human Nature*. Oxford University Press.

Desbordes, G., & Negi, L. T. (2013). A new era for mind studies: training investigators in both scientific and contemplative methods of inquiry.

Frontiers in Human Neuroscience, *7*, 741. https://doi.org/10.3389/fnhum.2013.00741

Desbordes, G., Negi, L. T., Pace, T. W. W., Wallace, B. A., Raison, C. L., & Schwartz, E. L. (2012). Effects of mindful-attention and compassion meditation training on amygdala response to emotional stimuli in an ordinary, non-meditative state. *Frontiers in Human Neuroscience*, *6*. https://doi.org/10.3389/fnhum.2012.00292

Disner, S. G., Beevers, C. G., Haigh, E. A. P., & Beck, A. T. (2011). Neural mechanisms of the cognitive model of depression. *Nature Reviews Neuroscience*, *12*(8), 467–477. https://doi.org/10.1038/nrn3027

Dreyfus, G. (2003). *The Sound of Two Hands Clapping: The Education of a Tibetan Buddhist Monk*. University of California Press.

Dreyfus, G. B. (2008). What is Debate for? The Rationality of Tibetan Debates and the Role of Humor. *Argumentation*, *22*(1), 43–58. https://doi.org/10.1007/s10503-007-9079-2

Dumas, G., Nadel, J., Soussignan, R., Martinerie, J., & Garnero, L. (2010). Inter-Brain Synchronization during Social Interaction. *PLoS ONE*, *5*(8), e12166. https://doi.org/10.1371/journal.pone.0012166

Engert, V., Kok, B. E., Papassotiriou, I., Chrousos, G. P., & Singer, T. (2017). Specific reduction in cortisol stress reactivity after social but not attention-based mental training. *Science Advances*, *3*(10), e1700495. https://doi.org/10.1126/sciadv.1700495

Eriksson, J., Vogel, E. K., Lansner, A., Bergström, F., & Nyberg, L. (2015). Neurocognitive architecture of working memory. *Neuron*, *88*(1), 33–46.

Facione, P. A., Sánchez, C. A., Facione, N. C., & Gainen, J. (1995). The disposition toward critical thinking. *The Journal of General Education*, *44*(1), 1–25.

Fresco, D. M., Moore, M. T., van Dulmen, M. H. M., Segal, Z. V., Ma, S. H., Teasdale, J. D., & Williams, J. M. G. (2007). Initial Psychometric Properties of the Experiences Questionnaire: Validation of a Self-Report Measure of Decentering. *Behavior Therapy*, *38*(3), 234–246. https://doi.org/10.1016/j.beth.2006.08.003

Garrison, K. A., Scheinost, D., Worhunsky, P. D., Elwafi, H. M., Thornhill IV, T. A., Thompson, E., … Brewer, J. A. (2013). Real-time fMRI links subjective experience with brain activity during focused attention. *NeuroImage*, *81*, 110–118. https://doi.org/10.1016/j.neuroimage.2013.05.030

Goel, V. (2007). Anatomy of deductive reasoning. *Trends in Cognitive Sciences*, *11*(10), 435–441.

Hasenkamp, W., & White, J. R. (2017). *The Monastery and the Microscope: Conversations with the Dalai Lama on Mind, Mindfulness, and the Nature of Reality*. Yale University Press.

Henrich, J., Heine, S. J., & Norenzayan, A. (2010). Most people are not WEIRD. *Nature*, *466*(7302), 29–29. https://doi.org/10.1038/466029a

Hoge, E. A., Bui, E., Goetter, E., Robinaugh, D. J., Ojserkis, R. A., Fresco, D. M., & Simon, N. M. (2015). Change in Decentering Mediates Improvement in Anxiety in Mindfulness-Based Stress Reduction for Generalized Anxiety Disorder. *Cognitive Therapy and Research*, *39*(2), 228–235. https://doi.org/10.1007/s10608-014-9646-4

Holmes, N. G., Wieman, C. E., & Bonn, D. A. (2015). Teaching critical thinking. *Proceedings of the National Academy of Sciences*, *112*(36), 11199–11204. https://doi.org/10.1073/pnas.1505329112

Kerr, C. E., Sacchet, M. D., Lazar, S. W., Moore, C. I., & Jones, S. R. (2013). Mindfulness starts with the body: somatosensory attention and top-down modulation of cortical alpha rhythms in mindfulness meditation. *Frontiers in Human Neuroscience*, *7*, 12. https://doi.org/10.3389/fnhum.2013.00012

Kirk, U., Downar, J., & Montague, P. R. (2011). Interoception drives increased rational decision-making in meditators playing the ultimatum game. *Frontiers in Neuroscience*, *5*, 49. https://doi.org/10.3389/fnins.2011.00049

Kongtrul, D. (2003). *Chidon an Introduction to Madhyamika*. Rigpa. Retrieved from https://www.scribd.com/document/128062649/89248114-Chidon-an-Introduction-to-Madhyamika-by-Dzigar-Kongtrul

Koster, E. H. W., De Lissnyder, E., Derakshan, N., & De Raedt, R. (2011). Understanding depressive rumination from a cognitive science perspective: The impaired disengagement hypothesis. *Clinical Psychology Review*, *31*(1), 138–145. https://doi.org/10.1016/j.cpr.2010.08.005

Kounios, J., & Beeman, M. (2009). The Aha! moment: The cognitive neuroscience of insight. *Current Directions in Psychological Science*, *18*(4), 210–216.

Lama, D. (2018). *Science and Philosophy in the Indian Buddhist Classics: The Physical World*. Simon and Schuster.

Leber, A. B., Turk-Browne, N. B., & Chun, M. M. (2008). Neural predictors of moment-to-moment fluctuations in cognitive flexibility. *Proceedings of the National Academy of Sciences*, *105*(36), 13592–13597.

Lempert, M. (2012). Interaction Rescaled: How Monastic Debate Became a Diasporic Pedagogy. *Anthropology & Education Quarterly*, *43*(2), 138–156. https://doi.org/10.1111/j.1548-1492.2012.01166.x

Liberman, K. (1992). Philosophical Debate in the Tibetan Academy. *The Tibet Journal*, *17*(1), 36–67.

Liberman, K. (2008). Sophistry In and As Its Course. *Argumentation*, *22*(1), 59–70. https://doi.org/10.1007/s10503-007-9070-y

Liberman, K. (2015). The logic is made to dance. Rhythm in Tibetan debating. *Etnografia e Ricerca Qualitativa*, (3/2015). https://doi.org/10.3240/81722

Lutz, A., Jha, A. P., Dunne, J. D., & Saron, C. D. (2015). Investigating the Phenomenological Matrix of Mindfulness-related Practices from a Neurocognitive Perspective. *The American Psychologist*, *70*(7), 632–658. https://doi.org/10.1037/a0039585

Lutz, A., Slagter, H. A., Dunne, J. D., & Davidson, R. J. (2008). Attention regulation and monitoring in meditation. *Trends in Cognitive Sciences*, *12*(4), 163–169.

MacPherson, S. (2000). *A path of learning : Indo-Tibetan Buddhism as education*. University of British Columbia. https://doi.org/10.14288/1.0055009

Marchetti, I., Koster, E. H. W., Klinger, E., & Alloy, L. B. (2016). Spontaneous Thought and Vulnerability to Mood Disorders: The Dark Side of the

Wandering Mind. *Clinical Psychological Science*, *4*(5), 835–857. https://doi.org/10.1177/2167702615622383

Penke, L., Maniega, S. M., Murray, C., Gow, A. J., Hernández, M. C. V., Clayden, J. D., … Deary, I. J. (2010). A general factor of brain white matter integrity predicts information processing speed in healthy older people. *Journal of Neuroscience*, *30*(22), 7569–7574.

Perdue, D. (1992). *Debate in Tibetan Buddhism*. Snow Lion Publications.

Perdue, D. (2014). *The Course in Buddhist Reasoning and Debate: An Asian Approach to Analytical Thinking Drawn from Indian and Tibetan Sources*. Boston ; London: Snow Lion.

Pintrich, P. R. (2003). A motivational science perspective on the role of student motivation in learning and teaching contexts. *Journal of Educational Psychology*, *95*(4), 667.

Posner, M. I., & Petersen, S. E. (1990). The attention system of the human brain. *Annual Review of Neuroscience*, *13*, 25–42. https://doi.org/10.1146/annurev.ne.13.030190.000325

R Core Team. (2013). *R: A Language and Environment for Statistical Computing*. Vienna, Austria: R Foundation for Statistical Computing. Retrieved from http://www.R-project.org/

Sager, B. (2013). *Beyond the Robe: Science for Monks and All it Reveals about Tibetan Monks and Nuns*. PowerHouse Books.

Sahdra, B. K., Shaver, P. R., & Warren Brown, K. (2010). A Scale to Measure Non-Attachment: A Buddhist Complement to Western Research on Attachment and Adaptive Functioning. *Journal of Personality Assessment*, *92*(2), 116–127.

Sera Jey Science Centre. (2015). *Science - Brief introduction to science debate 2015*. Bylakuppe: Sera Jay Monastic University.

Taatgen, N. A., van Vugt, M. K., Daamen, J., Katidioti, I., & Borst, J. P. (submitted). The resource-availability theory of distraction and mind-wandering.

Tang, Y.-Y., Hölzel, B. K., & Posner, M. I. (2015). The neuroscience of mindfulness meditation. *Nature Reviews Neuroscience*, *16*(4), 213–225. https://doi.org/10.1038/nrn3916

Tillemans, T. (2008). Introduction: Buddhist Argumentation. *Argumentation*, *22*, 1–14. https://doi.org/10.1007/s10503-007-9072-9

Van Dam, N. T., van Vugt, M. K., Vago, D. R., Schmalzl, L., Saron, C. D., Olendzki, A., … Meyer, D. E. (2018). Mind the Hype: A Critical Evaluation and Prescriptive Agenda for Research on Mindfulness and Meditation. *Perspectives on Psychological Science*, *13*(1), 36–61. https://doi.org/10.1177/1745691617709589

van Vugt, M. K., Pollock, J., Johnson, B., Gyatso, K., Norbu, N., Lodroe, T., … Fresco, D. M. (2018). Inter-brain synchronization in the practice of Tibetan monastic debate. *MindRxiv*. https://doi.org/10.31231/osf.io/f2ept

The Limits of Abstraction: Diversifying Cognitive Research Beyond WEIRD Populations through the Study and Inclusion of Tibetan Monks

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Abstract

In this article, we present examples and discuss potential pitfalls of conducting research with Tibetan monks in south India, in order advance the discussion about the limitations of cognitive science based on our experiences with this very specialized population. Given that an overwhelming majority of research is based on samples of undergraduate students from Western, educated, industrialized, rich, and democratic (WEIRD) societies, it is crucial to expand the scope of research with control conditions such as the Tibetan monastic culture as it is a highly literate and nevertheless a distinctly non-western culture that has developed a highly advanced and intricate system of information processing and knowledge (i.e., logical reasoning, philosophy and psychology). In particular, we focus on a central aspect of monastic training: the analytical meditative tradition of monastic debate.

We report the results from a study in which experienced and inexperienced Tibetan monks were compared with western participants in tasks assessing association memory, logic, and spatial complex working memory. Contrary to our expectations, the experienced monks performed less well or similarly well on the tasks than the inexperienced monks. Counter our hypothesis, the western participants outperformed both groups of monks in all tasks. We argue that cultural differences such as values, education, and cognitive styles may have been underestimated. The reliance on abstraction as a means for reducing cultural bias in the tasks is discussed as a potential cultural artifact in itself.

Keywords: cross-cultural research, WEIRD societies, non-western populations, cultural differences, cultural context, task design, cultural bias, abstraction, human universals, cultural variation, cognitive styles, research methodology, cognitive science, analytical meditation, monastic debate, Tibetan monastic culture, association memory, deductive logic, spatial complex working memory.

Public significance statement

This research highlights the importance of including diverse and underrepresented non-western populations in cognitive science studies to better understand human universals and variations. By studying Tibetan monks and comparing their performance to western participants in various cognitive tasks, the study reveals potential cultural biases in task design and emphasizes the need to consider cultural context when conducting cross-cultural research. A specific recommendation is to rethink the role of abstraction as a means of reducing cultural bias, as it may be a cultural artifact in itself. The findings underscore the value of actively engaging with (e.g., by including members of the local community into the research process) and understanding the cultural context to ensure more accurate and inclusive results in cognitive science research, ultimately improving the accuracy and applicability of cognitive science findings to a broader range of populations.

It is widely acknowledged in fields such as cognitive science and psychology that research participants from diverse cultural backgrounds are crucial for advancing scientific knowledge and developing theories that are applicable to a broader population (Henrich et al., 2010b; Nielsen et al., 2017). However, the question of whether cognitive tasks designed for western populations can be generalizable to such research with non-western populations remains a topic of debate (Grossmann & Na, 2014; Medin & Bang, 2014; Norenzayan & Heine, 2005). In this paper we present examples and reflections from multi-study research conducted with Tibetan monks in South India, in which unexpected data was obtained, which – as we will argue in depth – may be due to unanticipated cultural differences and biases in the tasks and paradigms in which they were developed.

Our ongoing research project began in 2015 and is aimed at better understanding an integral aspect of Tibetan monastic training: analytical meditation and its possible application to other contexts, as well as facilitating collaboration with the Tibetan monastic community. Analytical meditation is a form of dialectical reasoning that has been developed and practiced for centuries in Tibetan Buddhist monasteries. One of our main interests is focused on the potential outcomes of being well-trained in analytical meditation. Monks who have engaged in debate for 20 years or more report to have developed notable social and emotional and cognitive qualities. This anecdotal evidence suggests that there may be significant benefits to engaging in monastic debate, which could have wider implications for society as a whole. Similar effects and implications apply to focused attention meditation, a practice that has been extensively studied and shown to produce positive outcomes such as increased focus, reduced stress, and improved emotional well-being (Goyal et al., 2014; Khoury et al., 2013; Lutz et al., 2008; Sedlmeier et al., 2012; Tang et al., 2015). Our research project aims to explore the unique effects of monastic debate in comparison to focused attention meditation and to shed light on the potential advantages of this lesser-known practice. While analytical meditation involves and is often accompanied by single-pointed meditation, we believe it is essential to differentiate the two and highlight their distinct benefits.

By understanding the specific capacities and skills developed through engaging in debate, we can better appreciate why this practice is so highly valued within the Tibetan Buddhist tradition and what new insights it may offer to the broader scientific community. To further emphasize the importance of studying monastic debate, we can consider the analogy of training to become a doctor. Just as a medical professional gains various skills and capacities after 10 or 20 years of education and practice, so too do Tibetan monks who engage in rigorous debate training. Breaking down the key capacities ostensibly developed through debate, as derived from our conversations with such experts in the monastic community, we can identify a number of highlights that make this practice particularly exciting and worthy of further exploration:

- A deeper understanding of one's own beliefs, values, and motivations, promoting personal growth and self-awareness.
- Improved communication and persuasion abilities, fostering more productive and open dialogues between individuals with differing viewpoints.
- Enhanced critical thinking and logical reasoning skills, allowing individuals to analyze complex issues more effectively.
- Heightened empathy and compassion, which can lead to more understanding and supportive interpersonal relationships.
- Greater mental resilience and adaptability, equipping individuals to better cope with challenges and setbacks they may encounter in life.

In order to test the validity of these claims and further investigate the potential benefits of monastic debate, we conducted a series of empirical studies and cross-cultural comparisons. Taking into consideration the sophistication of the monastic curriculum and the emphasis on cognitive skills

such as concentration, logic and memory, one might assume that the experienced monks would perform comparably to western participants with a university background, which seems to be the typical participants in psychology research. However, as we began collecting data, we noticed unexpected interactions between our research tasks, the monks' cultural background and our underlying assumptions. Although it could not be ruled out that the monastic training was simply ineffective, the patterns of the cross-cultural differences (e.g., inverted effects of negative vs. positive images on reaction time in an emotional decentering task) indicated a more complex interplay of factors at work. Given that such confusing patterns did not emerge when physiological measures of monks debating were assessed, we decided to further investigate the potential role of cultural differences and task-specific biases in shaping our findings.

In the following sections, we will illustrate this by presenting a subset of the cognitive tasks that were administered to the participants. The purpose of presenting these tasks in this paper is not – as initially planned – to gain more insight into the outcomes related to monastic debate, but rather to provide a concrete illustration of the issues of generalizability and cultural bias.

WEIRD Population Bias

Cognitive science literature is often presented as if findings on cognitive skills such as perception, attention, memory and decision making are culture-independent. Yet, it is well known that not all tasks and tests are valid across different cultures (Greenfield, 1997; Nisbett et al., 2001). A prominent example of this is the debate around IQ and related intelligence assessments. It appears to be exceedingly difficult to construct a test that is truly "culture-free" or "culture-fair". Researchers have therefore argued that constructs such as intelligence must be understood within and relative to the context of the particular culture (Sternberg, 2004). Moreover, the cultural context may even influence more fundamental functions such as elementary perception. For instance, when comparing individuals from different cultures in their response to optical illusions, there seem to be culture distinctive biases (Day, 1989; Jahoda & Stacey, 1970; Segall et al., 1963). Segall et al. (1963) found that participants from non-Western populations were less susceptible to certain optical illusions (the Müller-Lyer figure and the Sander Parallelogram), while other illusions (two forms of the Horizontal-vertical figure) indicated differences among non-Western cultures and also relative to Western cultures themselves. Some of these may be explained by differences in urbanization and lifestyle, which lead to different priors in the visual processing. Yet, other theories suggest that this may be due to culture-dependent cognitive styles such as holistic vs. analytic thinking, which also affect a wider spectrum of perceptual, mental and emotional processes. Research has shown that culturally dependent traits such as cognitive styles are among the most influential factors in shaping how individuals from different cultures perceive and interpret the world around them (Nisbett et al., 2001; Nisbett & Masuda, 2003). Holistic thinking, which is more prevalent in East Asian cultures, involves a focus on context, relationships, and the overall pattern of a situation, whereas analytic thinking, more common in Western cultures, emphasizes individual components, rules, and linear causality.

When considering such cultural differences, it becomes clear that it is problematic when a huge majority of samples in psychological research consist of people from Western, educated, industrialized, rich and democratic societies (WEIRD; Henrich et al., 2010b). The WEIRD acronym, which is increasingly being used in the field of cross-cultural research, alludes to the fact that most findings about supposed human universals (e.g., cognitive processes, emotional responses, and social behaviors) are based on a very narrow and unrepresentative sample of the world's population:

Western psychology undergraduates[1]. The fact that even in this article focusing on non-Western populations most sources (that are not explicitly about cross-cultural research) also suffer from this WEIRD bias, further highlights the need to diversify and expand the scope of psychological research. More than a decade after the publication of Henrich et al. (2010a), Thalmayer, Toscanelli and Arnett (2021) showed that an estimated 89% of the world's population are still neglected in cognitive science publications and that given such stark distortions in representation, claims about human universals need to be revisited critically (e.g., by replicating and researching in underrepresented populations).

Tibetan monastic culture

Collaborative research with and on Tibetan monks provides a unique opportunity to address this issue and contribute to a more inclusive and representative understanding of human cognition and behavior. This population presents an especially rare instance for cultural comparisons and supplementations for two reasons. First, Tibetan culture has been comparatively sheltered from other surrounding ones for centuries due to its inaccessible location in the Himalayas and is therefore still relatively unaffected by western culture. Second, while there have been interesting comparisons in psychological functions between western and non-western cultures, many of the salient findings compare western populations with non-literate or semi-literate populations (Cole, 1971; Ross & Millsom, 1970; Segall et al., 1963). Furthermore, such populations do not seem to prioritize many typical western values such as highly-developed information systems (e.g., the scientific method, mathematics, abstraction, logical reasoning, etc.). It can therefore not be ruled out (and one may indeed be suspicious) that these differences are reducible to a western focus on literacy and academic education. Thus, Tibetan monastic culture provides a valuable control condition as it is a highly literate and nevertheless a distinctly non-western culture that has developed a highly advanced and intricate system of information processing and knowledge (i.e., logical reasoning, philosophy and psychology).

As has been alluded, analytical meditation, is a dyadic practice, usually involving two participants: a "challenger" and a "defender". In their collaborative interaction, the defender must maintain a coherent intellectual position, while the challenger guides the defender to see different angles of the argument and think more clearly. The task of the challenger is to dissect the defender's reasoning, seeking out any logical inconsistencies, while the defender's role is to counter the challenger's propositions and steer clear of indefensible logical standpoints. Deductive logic can provide an explanation for certain aspects of debating; however, the result of the debate is not predetermined and can consequently not be reduced to a solely logical process. In classical monastic training, this is preceded by memorization of relevant philosophical texts that provide the material for contemplation and the topic for monastic debate (Dreyfus, 2003; van Vugt et al., 2019).

Assumptions and research questions

In order to further advance the understanding of Tibetan monastic training, we had more and less experienced monks complete various measures, tests and tasks assessing mental skills. Given that monks are encouraged to debate counterfactual scenarios and even defend philosophical positions they may not personally find plausible, we assumed proficiency in extrapolation and

[1] Such an expansion might even already benefit from comparatively small changes: by including more students from different faculties (e.g., art, philosophy, etc.) within Western universities, as well as incorporating participants from more rural areas within WEIRD societies (e.g., farmers, artisans, and indigenous communities), as this would likely already lead to ostensibly established human universals being reconsidered and refined.

divergent thinking. Hence, we surmised that they would have an easy time applying their strategies to a multitude of contexts. We concluded that it would be reasonable to implement tasks that use abstracted stimuli, in particular because it reduced the need to rely on stimulus translation with its associated challenges (Anderson, 1967).

We assumed that the older and more experienced monks would have improved strategies for maintaining and manipulating multiple threads of information in working memory, as this is a crucial skill for ongoing debates that can last for up to two hours. Consequently, we chose an existing task for assessing working memory, which relied partially on spatial information and featured a special distractor. Apart from a translation of the stimuli, the task was not adapted in order to make it as comparable as possible. When we encountered unexpected results, we decided to choose a more customized approach, selecting tasks to better align with the monks' unique training and experiences. Our next task focused on long-term memory, which we hypothesized would be highly developed in the monks due to their extensive memorization of texts and scriptures. However, this test (the association memory task) was abstract in the sense that the word pairs were randomly created and thus arbitrary (e.g., remembering the word pair "rabbit-teabag" has no real-life relevance). We still expected the task abstraction to be in and of itself useful to test the monks' ability to flexibly apply their skills to new tasks. The abstraction seemed furthermore advantageous in the comparison between inexperienced and experienced monks (as both groups are equally unfamiliar with the tasks) and in the comparison with Western populations (as it was thought to reduce cultural biases in familiarity with the content of the stimuli). When these results also proved to be unexpected, we had monks participate in a task that more closely resembles their daily activities and training: a logic test. Yet, the logic tasks also contained randomly picked and therefore mostly implausible subjects (e.g., all gardeners are surgeons and some astronauts are not surgeons), which still allowed for a certain degree of abstraction and generalizability.

Specifically, we hypothesized that experienced Tibetan monks would perform better than novice monks on tasks assessing working memory, association memory and logic, and that their performance would be comparable to that of their Western counterparts, as this would be an indication of the skills being cultivated over the years of monastic training.

Material and methods

Transparency and openness

All data, analysis code, and research materials are available at https://osf.io/zqx5j/?view_only=8d063e1272e3404eb818d686c1213faa. Data were analyzed using R, version 4.2.0 (R Core Team, 2022) and included utilization of mainly the following packages:

- tidyverse (Wickham, 2017)
- ggplot2 (Wickham et al., 2016)
- lme4 (Bates et al., 2015)
- jmv (Gallucci, 2019)

This study's design and its analysis were not pre-registered.

Participants

Our sample consisted of selected monks from the Sera Jey Monastery in Bylakuppe, India, which houses over 1800 monks. The 16-year rigorous training program can roughly be divided into three stages: novice (0-4 years), intermediate (5-12 years), and proficiency (13-16 years). About 20%

of the monks pursue advanced degrees for an extra 6-10 years, potentially acquiring up to 25 years of monastic education. Each monk dedicates an average of five hours daily to debate practice, implying that experienced monks may accumulate between 16,250 and 20,000 hours of debate experience. Demographic details, such as sample size, age, and years of experience, are thoroughly depicted in Table 1.

Table 1
Demographic information

	Complex working memory task			Association memory task			Logic task		
	n	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*
Novice monks	36			25			137		
Age		22.31	4.37		28.40	6.19		24.50	5.89
Experience		10.47	4.76		11.84	4.44		10.95	4.62
Experienced monks	39			15			115		
Age		36.54	2.47		35.80	3.17		35.90	4.67
Experience		21.69	3.82		23.47	4.44		21.54	4.74
Western students	29			20			244		
Age		NA	NA		26.00	~ 6.00[a]		21.67	3.11
Experience		NA	NA		NA	NA		NA	NA

Note. The age was not available for the students in the CWM task. Since Western control samples are not enrolled in the monastic system, their experience is encoded as NA. [a] The standard deviation for the AM task was not available. However, the range was given (18 to 40 years) and the assumption of a uniform distribution implies a standard deviation of approximately 6.

Tasks

The subset of cognitive tasks presented for this paper contains the complex working memory (CWM; Huijser et al., 2018) task, a logic questionnaire and an associative recognition memory (AM) task.

Complex working memory task. In the CWM task, participants had to remember a sequence of locations of a target in a 4 by 4 grid, while responding with "yes" and "no" to distractor stimuli in between presentations of the targets. There were two conditions of distractors: self-related words (e.g., small, lazy) and objects (e.g., pen, boat). In the self-related condition, participants were instructed to judge whether the presented words described them accurately or not. In the object condition, they had to decide whether the objects would fit into a shoebox or not. The targets were furthermore presented in two conditions: remembering a span of either 3 or 4 locations.

Associative recognition memory task. In the associative recognition memory task (Borst et al., 2013), participants had to correctly recognize 46 randomly created word pairs that had been learned in an earlier phase of the task. These word pairs were presented among 46 foils (that consisted of the same words but in pairs that had not been learned in the first phase).

Logic task. In the logic task, which was adapted from a questionnaire by Ragni et al. (2019), participants had to respond to 24 multiple choice questions about three different domains:

- Conditional statements (e.g., "If someone is a sweeper, then he is not a civil servant. Karma is not a civil servant. this means that…")
- Syllogistic logic (e.g., "Some doctors are actors. All doctors are pilots. this means that…")

- Relational statements (e.g., "Dolma stands north of Thinley. Dolma stands south of Tsering. this means that…").

The first two cohorts of participants completed the logic task on tablets. When the intracultural difference was smaller than expected we had the next two cohorts fill it out on paper to remove assumed barriers.

Flanker task. We controlled for familiarity with digital devices by accounting for reaction time in a task all monks completed prior to the experiment. Given that this exceedingly simple task was administered on tablets, we hypothesized that any potential differences in reaction time could be attributed to varying levels of experience with digital technology. This was done because the older monks had limited exposure to technology and we wanted to ensure that their performance was not affected by this factor. The flanker task consists of a series of visual stimuli, where the participant is required to respond as quickly as possible to a centrally presented letter (e.g., "K") but not another (e.g., "H"), while ignoring the surrounding arrows.

Statistical methods

To test these hypotheses, we conducted a series of linear mixed models with task performance as the dependent variable, group (novice monks, experienced monks, and Western students) as the fixed effect, and participants as the random effect. Depending on the task other effects such as distractor reaction time, flanker reaction time and target span, were also included in the models to account for potential moderators and confounding factors. All analyses were modeled at a trial-by-trial level, except one. This method enabled a more thorough examination of the data (e.g., controlling for reaction times on a trial-by-trial level), without requiring any assumptions about combining data across trials. The process of model selection consisted of adding all the control variables as either main or random effects (depending on their scaling and nature) and adding the main predictors of interest with all possible interaction terms among them. The next step involved stepwise removal of non-significant interaction terms and control variables, while monitoring the model fit indices (Bayesian Information Criterion) to ensure the best-fitting model was retained. When appropriate and feasible, Bayes factors were used to compare evidence for the null hypothesis versus the alternative. Bayes factors provide a continuous measure of evidence that can be interpreted in a straightforward way: values greater than 1 indicate evidence for the alternative hypothesis, while values less than 1 indicate evidence for the null hypothesis. The common benchmark for 'moderate' evidence in favor of the alternative hypothesis is a Bayes factor of 3 or more, while 'moderate' evidence for the null hypothesis is typically considered a Bayes factor of less than 1/3.

Complex working memory model. The performance in the complex working memory task was modeled with a mixed effects logistic regression, predicting the correct responses on a trial-by-trial level, while correcting for the reaction time in the flanker task, the reaction time in the distractor task as well as the average accuracy in the distractor task. The reason for including only the average accuracy and not the trial-by-trial accuracy of the distractor task is that the accuracy can only be computed for the shoebox trials but not the self-related trials. The main effects of interest were experience, span (3 vs 4), and condition as well as all two-way and three-way interaction terms. The trial-by-trial analysis also allowed for including a random intercept for every subject to reflect the repeated measures design.

Association Memory model. The performance in the association memory task was modeled with a mixed effects logistic regression, predicting the correct responses on a trial-by-trial level, while correcting for the reaction time in the flanker task. The fixed effects were thus, experience, pair type (target vs foil), reaction time, as well as all two-way and three-way interaction

terms. The trial-by-trial analysis also allowed for including a random effect for the stimulus, taking the overall difficulty per word pair into account as well as a random intercept for every subject to reflect the repeated measures design.

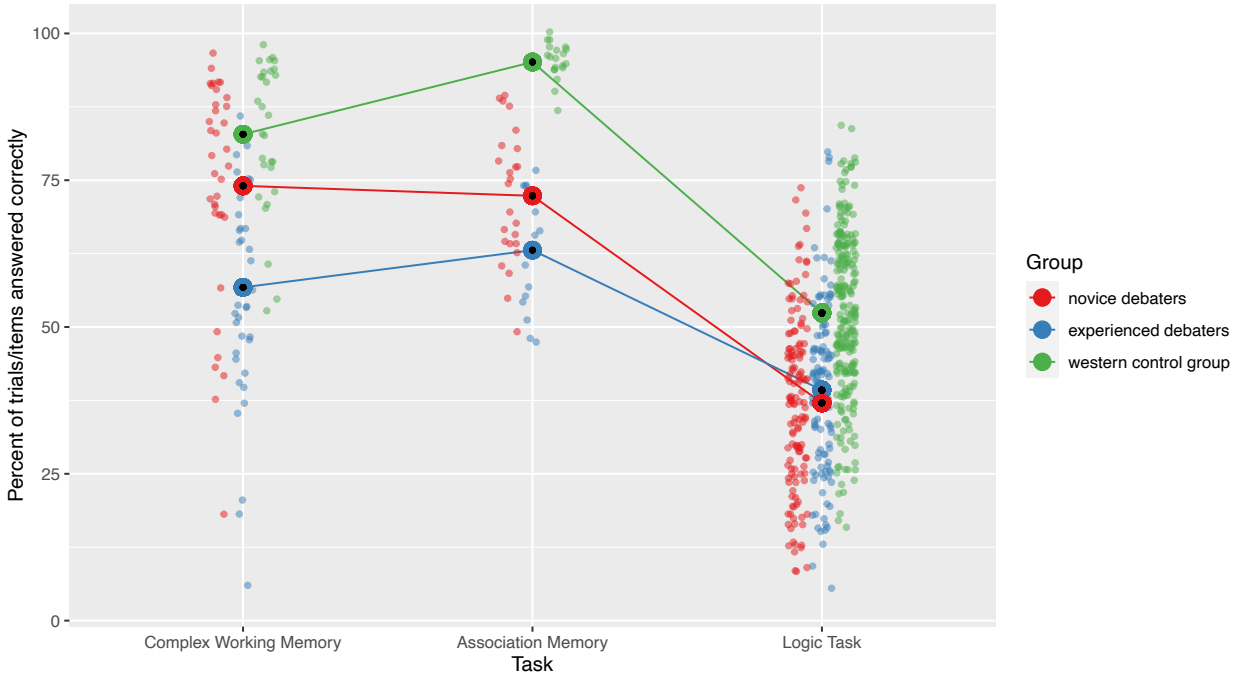
Logic task model. The performance in the logic task was analyzed using a similar mixed effects logistic regression model as the complex working memory task and the association memory task. However, as the Western data set consisted of items that were almost identical could not be matched exactly to the items used in the Tibetan data set (due to adaptations into the Tibetan format), the analyses reported in this section will be based on subject averaged performance scores instead of trial-by-trial data. The results of this model in the intracultural comparison were comparable to the more fine-grained trial-by-trial model (which was also available for the intracultural comparison). The model included the main effects of experience, domain (relational, conditional and syllogistic logic) and the medium (tablet vs. paper), as well as the interaction term between experience and medium (as this was of specific interest). Furthermore, a random intercept for every subject was added to account for the repeated measures design. No further control variables were included in this analysis, as the logic task was completed both on the tablet and on paper, eliminating the need to control for tablet acuity for the pooled data.

Results

Overview

Figure 1

Overview of the data across tasks and groups



Note. The data points are jittered vertically to avoid overlap and to allow clearer visualization of the data distribution.

We expected experienced Tibetan monks to outperform novice monks (intracultural comparison) in tasks assessing working memory, logic, and long-term memory, and to perform

comparably to or better than Western students (cross-cultural comparison). Overall, the results were contrary to our initial hypotheses. Experienced Tibetan monks did not outperform novice monks (average performance across tasks: experienced monks M = 45.4, SD = 17.8; novice monks M = 48.2, SD = 22.6; $t(651) = -4.02$, $p < .001$), and their performance was not comparable or better than that of Western students (average performance across tasks: Western students M = 58.3, SD = 18.9; $t(651) = -11.34$, $p < .001$). Among the three tasks the logic task stand out in that the intracultural found across all three tasks is reversed here (difference = 2.19, *beta* = 0.106, $t(651) = 1.20$, p = 0.230). The cross-cultural difference in the logic task points in the same direction, but is the smallest one among the tasks (difference = -13.13, *beta* = 0.637, $t(651) = -8.05$, $p < 0.001$).

In the following sections we report the comparison from experienced monks to both novices as well as western students in detail. In order to control for culture and age to some degree we also compared the younger novice monks to the western students, who were of an approximately similar age (age of novice monks: M =22.3, SD = 4.37; age of Western students: M = 22.0, SD = 3.33). The results of this comparison are not reported in detail as they were not the primary focus of our study. However, it is worth mentioning that as can be seen in figure 1 the novice monks also consistently performed lower than the Western students in all tasks (average performance across tasks: $t(651) = -8.03$, $p < .001$). In the CWM and AM task the cross-cultural difference was of a smaller extent than the experienced monks'. The differences between novices and the western students were significant in all tasks, (p's < 0.005; see appendix for detailed tables).

Intracultural comparison

Complex working memory

Table 2
Complex working memory logistic regression: Fixed Effects Parameter Estimates

Effect	*B*	*SE*	exp(*B*)	Lower *CI*	Upper *CI*	*z*	*p*
Intercept	0.759	0.098	2.136	1.763	2.587	7.747	0.000
Average distractor accuracy	0.156	0.102	1.169	0.958	1.427	1.537	0.124
Distractor reaction time	-0.219	0.034	0.803	0.751	0.859	-6.387	0.000
Flanker reaction Time	-0.401	0.111	0.670	0.539	0.832	-3.620	0.000
Experience	-0.545	0.222	0.580	0.375	0.896	-2.456	0.014
Span	-0.133	0.044	0.875	0.803	0.954	-3.026	0.002
condition (shoebox – self)	-0.024	0.044	0.976	0.895	1.064	-0.545	0.586
Experience * span	0.013	0.088	1.013	0.853	1.203	0.148	0.882
Experience * condition	0.094	0.087	1.099	0.927	1.303	1.088	0.277
Span * condition	0.044	0.088	1.045	0.880	1.242	0.502	0.616
Experience * span * condition	0.015	0.175	1.015	0.720	1.432	0.087	0.930

Table 3
Complex working memory logistic regression: Random Components

Groups	Name	*SD*	Variance	*ICC*
Subject	Intercept	0.820	0.672	0.170
Residuals		1.000	1.000	.

The conditional R^2 for the model was found to be 0.252 and the BIC value was 13135.329, indicating a moderate amount of variance explained. Of the independent variables experience (B = -0.545, z = -2.456, p = 0.014) and span (B = -0.133, z = -3.026, p = 0.002) were significant, but not condition and none of the interaction terms (all z's < 1.088, all p's> 0.277). Of the control variables flanker reaction time (B = -0.401, z = -3.620, p < 0.001) and distractor reaction time (B = -0.219, z = -6.387, p < 0.001) were also found to be significant predictors of performance in the complex working memory task but not the average distractor task accuracy (B = 0.156, z = 1.537, p = 0.124). Contrary to our hypothesis, the negative main effect of experience on the task performance suggests that more experienced monks had a lower probability of correctly responding to the presented stimuli (novice debater accuracy: M = 74.040, SD = 29.698; experienced debater accuracy: M = 56.785, SD = 31.623). The significant effect of span is in line with our expectations, as it is unsurprising that individuals with a higher span would perform worse (span-3 accuracy: M = 66.966, SD = 33.441; span-4 accuracy: M = 64.368, SD = 30.109). Taken together, these results suggests that individuals with more experience and a higher span performed worse in the complex working memory task, irrespective of the condition they were in and even after controlling for acuity with tablets. The lack of significance for the average distractor task accuracy indicates that it might not be a crucial factor in determining the performance in the complex working memory task or that the variance explained by this variable is already captured by other predictors in the model (e.g., distractor reaction time with which it correlates strongly). The inclusion of this predictor nevertheless rules out the possibility that the difference between experienced and novice monks are solely or even mainly due to differences in their ability to handle to the distractor task or their motivation to pay attention to it.

Association memory

Table 4
Association memory logistic regression: Fixed Effects

Effect	*B*	*SE*	exp(B)	Lower *CI*	Upper *CI*	*z*	*p*
Intercept	0.954	0.106	2.595	2.107	3.196	8.972	0.000
Experience	-0.398	0.173	0.672	0.479	0.942	-2.306	0.021
Target vs. Foil	0.360	0.150	1.433	1.067	1.924	2.392	0.017
Flanker reaction time	-1.392	0.423	0.249	0.108	0.569	-3.293	0.001
Experience * Target vs. Foil	0.397	0.162	1.488	1.083	2.044	2.451	0.014
Experience* Flanker reaction time	0.713	0.892	2.041	0.355	11.717	0.800	0.424
Target vs. Foil * Reaction Time	-2.348	0.387	0.096	0.045	0.204	-6.072	0.000
Experience * Target vs. Foil * Flanker reaction Time	-2.914	0.817	0.054	0.011	0.269	-3.566	0.000

Table 5
Association memory logistic regression: Random Components

Groups	Name	*SD*	Variance	*ICC*
Test words	Intercept	0.471	0.222	0.0633
	Target vs. Foil	0.953	0.907	

Subject	Intercept	0.448	0.201	0.0576
Residuals		1	1	

The conditional R^2 for the model was found to be 0.195 and the BIC value was 4443.287, indicating a moderate amount of variance explained. All main effects and interaction terms were significant (all $|z|$'s > 2.306, all p's < 0.021), except for the experience * flanker reaction time interaction (B = 0.713, z = 0.800, p = 0.424), indicating that the association memory task performance was influenced by various factors. Contrary to our hypothesis, the negative main effect of experience (B = -0.398, z = -2.306, p = 0.021) on the task performance suggests that more experienced monks had a lower probability of correctly responding to the presented stimuli (novice debaters accuracy: M = 72.363, SD = 44.730; experienced debater accuracy: M = 62.914, SD = 48.320). This pattern remains when looking at the effect in the context of the higher order interactions. An analysis of the simple effects (see appendix) shows that significant differences between novices and experienced monks appear only for the target stimuli at average and below average flanker reaction times (i.e., the word pairs that they had indeed seen during training; $|z|$'s > 3.214, p < 0.001), and not for the foil stimuli (i.e., the word pairs that were not seen during training; $|z|$'s < 1.323, p's > 0.186). This suggests that the negative effect of experience on association memory performance is specific to the target stimuli as well as those with average or faster reaction times in the flanker task. Both novices and experienced monks were relatively good at recognizing foils as new stimuli.

Logic

Table 6
Logic task mixed effect model: Fixed Effects Parameter Estimates

Effect	*B*	*SE*	Lower *CI*	Upper *CI*	*df*	*t*	*p*
(Intercept)	0.375	0.009	0.357	0.393	248	40.724	0.000
Experience	0.027	0.018	-0.009	0.063	248	1.448	0.149
Domain (relational – conditional)	0.044	0.013	0.019	0.070	500	3.423	0.001
Domain (syllogistic – conditional)	0.040	0.013	0.015	0.065	500	3.106	0.002
tablet - paper	-0.066	0.018	-0.102	-0.030	248	-3.578	0.000
Experience * (tablet – paper)	0.046	0.037	-0.026	0.118	248	1.244	0.215
(relational – conditional) * (tablet – paper)	-0.054	0.026	-0.105	-0.003	500	-2.095	0.037
(syllogistic – conditional) * (tablet – paper)	-0.073	0.026	-0.124	-0.022	500	-2.821	0.005

Table 7
Logic task mixed effect model: Random Components

Groups	Name	*SD*	Variance	*ICC*
Subject	Intercept	0.117	0.014	0.404
Residual		0.143	0.020	

The conditional R^2 for the model was found to be 0.438 and the BIC value was -414.466, indicating a moderate amount of variance explained. The main effect of domain was found to be significant (omnibus test: $F(2, 500) = 7.153$, p < 0.001), indicating that performance varied

depending on the type of logic task (relational accuracy: $M = 39.694$, $SD = 48.938$; syllogistic accuracy: $M = 39.518$, $SD = 48.901$; conditional accuracy: $M = 34.813$, $SD = 47.649$). The control variable of medium also showed a significant effect ($B = -0.0659$, $t(248) = -3.578$, $p < 0.001$), with participants generally performing better on paper ($M = 40.798$, $SD = 19.385$) than on tablet ($M = 34.028$, $SD = 17.406$). The significant effects also produced a significant interaction between domain and medium (omnibus test: $F(2, 500) = 4.290$, $p = 0.014$), which was further explored through simple effects analysis. The positive effect of paper versus tablet was greatest for the syllogistic domain ($B = -0.097$, $t(560.26) = -4.070$, $p < 0.001$), followed by the relational domain ($B = -0.078$, $t(560.26) = -3.278$, $p = 0.001$), and was not significant for the conditional domain ($B = -0.024$, $t(560.26) = -0.995$, $p = 0.320$). Given that the conditional domain was also the domain that monks had the hardest time with overall, there may have been a floor effect that masked any potential differences between the two mediums.

Contrary to our hypothesis, experience itself ($B = 0.027$, $t(248) = 1.448$, $p = 0.149$) and also its interaction with the medium ($B = 0.046$, $t(248) = 1.244$, $p = 0.215$) were not found to be significant predictors, suggesting that there were no differences in performance between novice and experienced monks even when accounting for the medium used (tablet or paper). The interaction with domain, which was not included in this model for reasons of fit and parsimony, was even less likely to reveal any significant relationships. This lack of significance for the experience factor might indicate that the skills and knowledge acquired during monastic training do not have a direct impact on performance in the logic tasks or that the effect of experience is too small to be detected in this analysis. The direction of the non-significant effect of experience, was positive, indicating a potential trend for experienced monks to perform slightly better than novice monks (novice debaters accuracy: $M = 37.036$, $SD = 48.297$; experienced debaters accuracy: $M = 39.192$, $SD = 48.827$). Furthermore, a simple effects analysis of the non-significant interaction of experience and medium revealed a surprising tendency: the difference in performance between novice and experienced monks was slightly larger for tablets (difference = 4.960, $t(248) = 1.745$, $p = 0.082$) than for paper (difference = 0.375, $t(248) = 0.160$, $p = 0.873$), although neither of these differences reached statistical significance. When taking the clear main effect of the medium into account, it seems that the paper version may have created a ceiling effect for both novice and experienced monks, making it difficult to detect any effect of experience on their performance. However, given that the sample size was quite large (137 novices and 115 experienced), it is unlikely that a lack of statistical power is the sole explanation for the non-significance of this effect. A Bayes Factor post-hoc test indicated moderate evidence for the null hypothesis ($BF_{10} = 0.279$) of the experience factor, further supporting the notion that experience does not have a substantial impact on performance in the logic tasks. More likely, the group difference, if there is indeed one, is small and might only become apparent with even larger sample sizes or under specific conditions not tested in the current study.

Cross-cultural comparison

Complex working memory

Table 8
Complex working memory logistic regression: Fixed Effects Parameter Estimates

Effect	*B*	*SE*	exp(*B*)	Lower *CI*	Upper *CI*	z	*p*
Intercept	1.076	0.108	2.934	2.376	3.623	10.008	0.000
Standardised distractor RT	-0.199	0.036	0.819	0.763	0.880	-5.499	0.000
Standardised average distractor accuracy	0.241	0.217	1.272	0.832	1.944	1.112	0.266
Culture (Tibetan-Dutch)	-1.569	0.215	0.208	0.137	0.317	-7.296	0.000
Condition (shoebox – self)	0.155	0.042	1.167	1.076	1.267	3.706	0.000
Culture (Dutch) * span	-0.354	0.058	0.702	0.626	0.787	-6.070	0.000
Culture (Tibetan) * span	-0.126	0.058	0.882	0.786	0.989	-2.155	0.031
Culture * condition	-0.251	0.083	0.778	0.661	0.916	-3.016	0.003
Culture (Dutch) * condition * span	0.033	0.117	1.034	0.822	1.299	0.283	0.777
Culture (Tibetan) * condition * span	0.054	0.117	1.055	0.840	1.327	0.462	0.644

Table 9

Complex working memory logistic regression: Random Components

Groups	Name	*SD*	Variance	*ICC*
Subject	Intercept	0.855	0.731	0.182
Residuals		1	1	.

The comparison between experienced monks and Dutch students was modeled with a mixed effects logistic regression, while controlling for the reaction time in the distractor task and the average accuracy in the distractor task. The conditional R^2 of the overall model was found to be 0.293 and the BIC was 15215.942, indicating a moderate explanatory power. The control variables were centered per group in order to avoid multicollinearity issues, as the Dutch students were much faster and more accurate in the distractor task. In this analysis, the main effects of interest were group (experienced monks vs. Dutch students), span (3 vs 4), and condition, as well as all two-way and three-way interaction terms of the independent variables. All predictors except the average distractor task accuracy and the three-way interaction term were found to be significant in this analysis (all $|z|$'s> 2.155, all p's < 0.031). This indicates that there were differences in performance between experienced monks and Dutch students, with the latter group generally performing better in the complex working memory task (experienced debater accuracy: M = 56.785, SD = 31.623; Dutch student accuracy: M = 82.824, SD = 27.741; B = -1.569, z = -7.296, p < 0.001). The significant two-way interaction terms indicate that the cultural difference in performance is not uniform across all levels of span and condition. Specifically, the performance gap between the two groups was more pronounced for the span-3 trials (z = -7.629, p < 0.001) compared to the span-4 trials (z = -6.694, p < 0.001), and also varied depending on the specific condition (self condition simple effect: z = -6.601, p < 0.001; shoebox condition simple effect: z = -7.722, p < 0.001). The smaller gap in the span-4 trials may be due to a floor effect, as both groups found these trials more challenging (experienced debater accuracy: M = 55.414, SD = 29.400; Dutch student accuracy: M = 80.567, SD = 28.635), while the reason for the interaction between condition and group is less clear and warrants further investigation. The fact that the three-way interaction term was non-significant and explained virtually no variance (delta R^2 < 0.001), suggests that the effect of span and condition on the performance gap between the two groups was at most minimally dependent on each other.

Association memory

Table 10
Association memory logistic regression: Fixed effects

Effect	*B*	*SE*	exp(*B*)	Lower *CI*	Upper *CI*	z	*p*
Intercept	1.842	0.097	6.312	5.220	7.632	19.015	0.000
Culture (Tibetan-Dutch)	-2.565	0.193	0.077	0.053	0.112	-13.268	0.000
Target vs. Foil	0.194	0.066	1.214	1.066	1.382	2.921	0.003
Culture * Target vs. Foil	0.140	0.133	1.150	0.887	1.491	1.054	0.292

Table 11
Association memory logistic regression: Random Components

Groups	Name	*SD*	Variance	*ICC*
Subject	Intercept	0.529	0.280	0.078
Residuals		1	1	.

The conditional R^2 for the model was found to be 0.190 and the BIC value was 8208.115, indicating a moderate amount of variance explained. The comparison between experienced monks and Dutch students included only fixed effects for the pair type (target vs foil), group (Tibetan vs Dutch) and the two-way interaction. Both main effects were highly significant (all $|z|$'s > 2.921, all p's < 0.003) , but not the interaction (B = 0.140, z = 1.054, p = 0.292), indicating that the differences in performance between the two groups were consistent across both target and foil stimuli. Specifically, the Dutch students outperformed the experienced monks in the association memory task (experienced debater accuracy: M = 62.871, SD = 48.332; Dutch student accuracy: M = 95.126, SD = 21.533; B = -2.565, z = -13.268, p < 0.001), irrespective of the stimulus type.

Logic task

Table 12
Logic task mixed effect model: Fixed Effects Parameter Estimates

Effect	*B*	*SE*	Lower *CI*	Upper *CI*	*df*	*t*	*p*
Intercept	0.458	0.008	0.442	0.474	357	57.300	0.000
Domain (relational – conditional)	0.018	0.012	-0.005	0.041	714	1.552	0.121
Domain (syllogistic – conditional)	-0.031	0.012	-0.054	-0.008	714	-2.645	0.008
Culture	0.131	0.016	0.100	0.162	357	8.202	0.000
relational - conditional * culture	-0.070	0.024	-0.117	-0.024	714	-2.979	0.003
syllogistic - conditional * culture	-0.159	0.024	-0.205	-0.112	714	-6.719	0.000

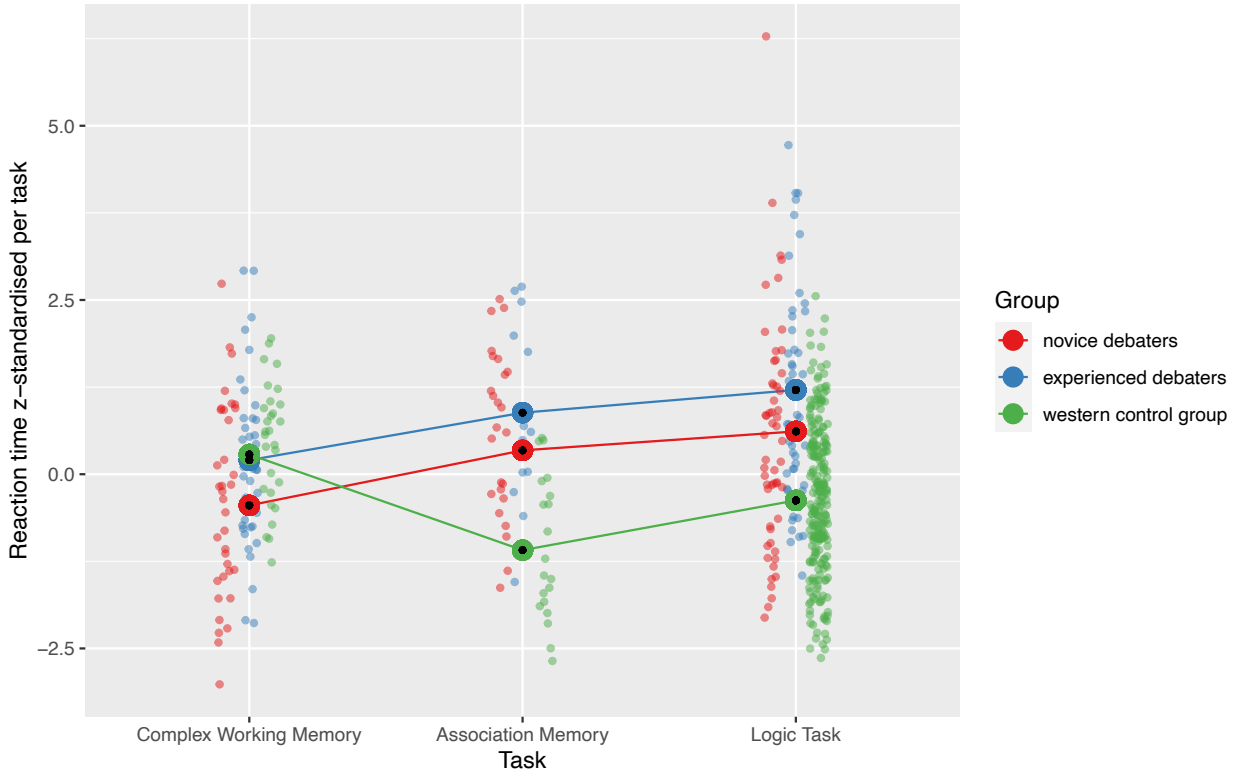
Table 13
Logic task mixed effect model: Random Components

Groups	Name	*SD*	Variance	*ICC*
Subject	Intercept	0.113	0.013	0.369
Residual		0.148	0.022	

The conditional R^2 for the model was found to be 0.456 and the BIC value was -611.394, indicating a moderate amount of variance explained. All effects and the interaction term were found to be significant in this analysis. The main effect of domain was found to be significant (omnibus test: $F(2, 714) = 9.008$, $p < 0.001$), indicating that performance varied depending on the type of logic task (relational accuracy: $M = 50.526$, $SD = 18.867$; syllogistic accuracy: $M = 43.987$, $SD = 19.040$; conditional accuracy: $M = 49.958$, $SD = 21.296$). The main effect of culture was also found to be significant ($B = 0.131$, $t(357) = 8.202$, $p < 0.001$), suggesting that Western students generally performed better than experienced monks in the logic task (Western student accuracy: $M = 52.357$, $SD = 19.307$; experienced monk accuracy: $M = 39.245$, $SD = 18.379$). Furthermore, the significant interaction between domain and culture ($B = -0.159$, $t(714) = -6.719$, $p < 0.001$) indicated that the performance gap was more pronounced in certain domains. A simple effects analysis revealed that Western students outperformed experienced monks in all three domains, with the largest difference observed in the conditional domain (difference = 20.741, $t(842.036) = 9.874$, $p < 0.001$), followed by the relational domain (difference = 13.710, $t(842.036) = 6.526$, $p < 0.001$), and the smallest difference in the syllogistic domain (difference = 4.883, $t(842.036) = 2.325$, $p = 0.020$). What is more, among Western students, the conditional was the easiest domain ($M = 56.602$, $SD = 20.249$), followed by the relational ($M = 54.918$, $SD = 17.327$), and the syllogistic ($M = 45.551$, $SD = 18.437$). In contrast, among experienced monks, the relational domain ($M = 41.208$, $SD = 18.681$) and the syllogistic ($M = 40.668$, $SD = 19.937$) were roughly equally easy, while the conditional domain, which was the most successful for the Western students ($M = 35.860$, $SD = 15.978$) was the most difficult for the monks. It would therefore seem that the cultural differences were not only quantitative (differences in overall performance), but also qualitative (differences in the pattern of performance across different domains).

Reaction time data

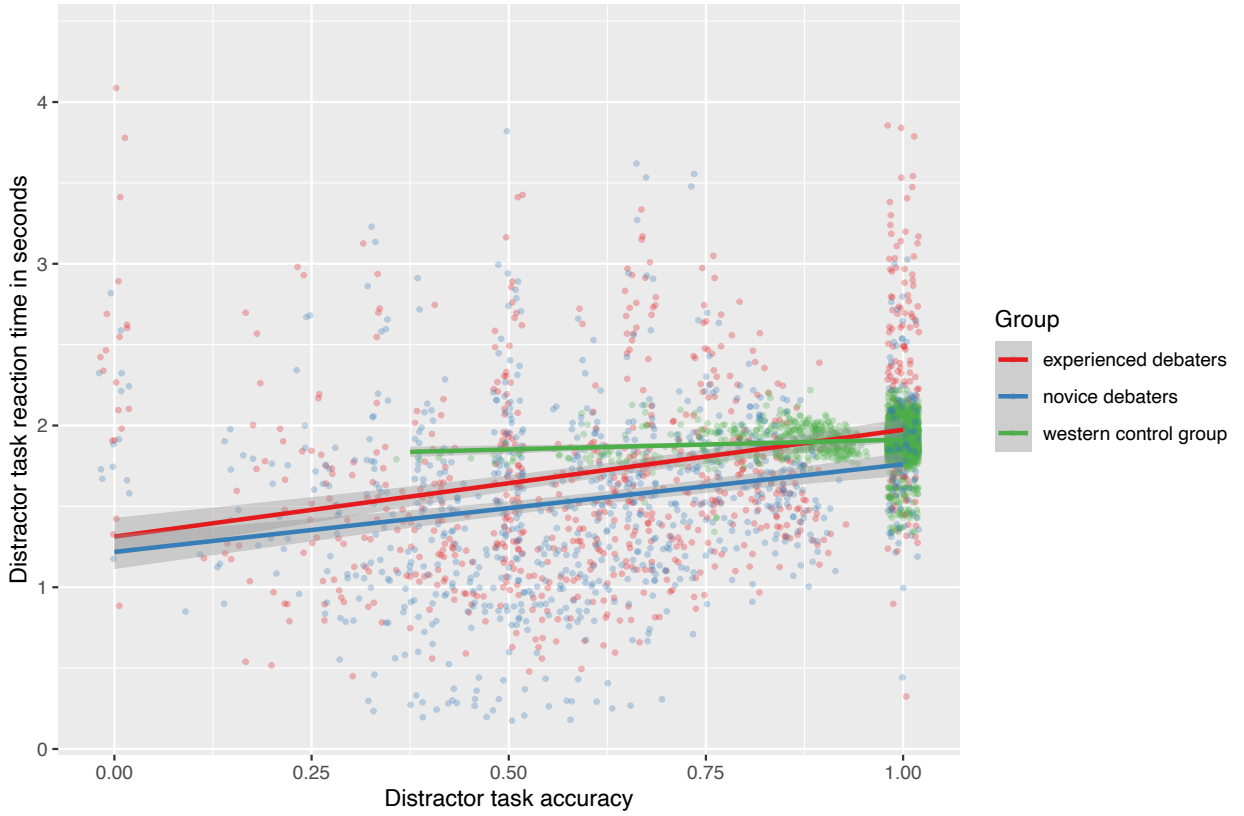
Figure 2
Overview of the response times across tasks and groups



Note. The data points are jittered vertically to avoid overlap and to allow clearer visualization of the data distribution.

Figure 3

Response times and accuracy of the distractor task in the complex working memory task per group



Note. The data points are jittered horizontally to avoid overlap and to allow clearer visualization of the data distribution.

In order to investigate whether the differences in performance were related to speed-accuracy trade-offs, we analyzed response time data for each task (specifically for the response to the distractor task in the complex working memory task and for the choice regarding the right answer in the association memory and logic tasks). Only the distractor in the complex working memory task explicitly required participants to respond quickly and accurately, but reaction times were recorded for all tasks to assess any potential strategy differences (in the logic task the response time data was only available for the participants who filled out the digital version). We moreover expected Tibetan monks to be slower in all tasks due to their relative unfamiliarity with digital devices and the testing environment. Apart from the complex working memory task, both the association memory task (novice debaters response time: M = 2.763, SD = 0.551; experienced debaters response time: M = 3.320, SD = 0.981; western control group response time: M = 1.287, SD = 0.249) and the logic task (novice debaters response time: M = 27.101, SD = 12.333; experienced debaters response time: M = 33.272, SD = 12.860; western control group response time: M = 16.826, SD = 5.672) showed significant differences in response times between the groups (F's > 52.936, p's < 0.001). In the complex working memory task experienced debaters (M = 1.873, SD = 0.530) showed slower response times than novice debaters (M = 1.583, SD = 0.457), as was expected but surprisingly both Tibetan monk groups were faster than the Western group (M = 1.909, SD = 0.100; see figure 2). This different was significant for novices (Welch's t(39.104) = -4.154, p < 0.001, BF10 = 71.015) but not for experienced monks (Welch's t(41.590) = -0.415, p = 0.680, BF10 = 0.266), for whom there is

actually evidence for no difference. However, when taking the accuracy into account something resembling a speed-accuracy trade-off was revealed (see figure 3). The Western students were more accurate in responding to the distractor task (M = 0.972, SD = 0.036) compared to both the novice debaters (M = 0.622, SD = 0.131; Welch's $t(41.356) = -15.374$, $p < 0.001$, BF10 = 4.897×10^17) and the experienced debaters (M = 0.660, SD = 0.134; Welch's $t(45.014) = -13.824$, $p < 0.001$, BF10 = 1.786×10^15), suggesting that the Western students were slower because they took more care to ensure their responses were correct. Even when looking at the Tibetan participants separately from the Western students, a similar pattern emerged. Response time and accuracy were correlated for both novice debaters (spearman's rho = 0.489, $p = 0.013$) and experienced debaters (spearman's rho = 0.640, $p < 0.001$), indicating that within each group, higher and thus slower response times were associated with higher accuracy. The relationship between accuracy and response time suggests that the observed differences in response time between the groups in the complex working memory task cannot be solely attributed to differences in digital familiarity and testing situations, but include – and this case are likely overshadowed by – different strategies employed by the participants. This conclusion is corroborated by the large cross-cultural difference in the variance in both response time and accuracy (Levene's test for equality of variances for response time: $F(2, 101) = 24.765$, $p < 0.001$; for accuracy: $F(2, 101) = 27.948$, $p < 0.001$). The larger variances in response time and accuracy for the Tibetan groups compared to the Western students could indicate both a culturally mediated preference for different strategies as well as varying levels of familiarity with the testing environment and digital devices. This could have gone so far, that a subset of the monks simply gave up on the distractor task (e.g., due to the required speed) and answered randomly.

Discussion

The results of our analyses revealed significant differences in performance in the intracultural as well as cross-cultural comparisons of association memory, complex working memory and logic tasks. However, all results concerning culture and experience were contrary to our expectations. Specifically, Western students significantly outperformed both experienced monks and novice monks in all three tasks, while novices significantly outperformed experienced monks in the complex working memory task and association memory task but not in the logic task, where there was a slight non-significant advantage for experienced monks. Furthermore, the performance gap between the respective groups for a given task often varied across different levels of variables such as span, flanker reaction time, condition, medium and domain indicating that the group differences are not uniform across all aspects.

General factors and limitations affecting performance outcomes

There are multiple factors that could be responsible for these unexpected results. One glaring conclusion is that monastic training may simply not be as effective in improving mental and affective capacities as the nature of the training would lead one to assume. This cannot be ruled out, but seems unlikely, as our neurophysiological data clearly show, that the experienced monks improved on various parameters regarding performance in debate (e.g., deeper neural correlates of concentration; van Vugt et al., 2020).

Another possible explanation for the observed discrepancies in performance could be related to the limitations of our experimental design. In particular, we were not able to control for crucial variables such as age, as the field research conditions made it difficult to recruit participants for control groups (in this case lay Tibetans of similar ages and educational backgrounds). We attempted to control for proxies such as acuity with digital devices, but these are likely to be imperfect indicators. Nevertheless, the fact that the younger novice monks also performed significantly worse than their Western counterparts suggests that the difference between experienced monks and Western students likely does involve a substantial number of cultural factors (e.g., differences in

educational background, familiarity with the testing environment, values, cognitive styles), rather than solely being a product of age difference.

Cultural factors and cognitive Styles

Both based on these data and our conversations with the monks who participated in our studies as well as our collaborators who helped to conduct them, we started to suspect that the skills assessed in the Western tasks were not as related to the skills that are important in the Tibetan monastic training as we initially believed. What is more, we repeatedly had the impression that the project itself was puzzling to the monks. For example, quite a few participants did not understand what the point of their participation was and how such experiments could possibly contribute to anything worthwhile. Little by little, we revised false assumptions on our part about the nature of the skills the monks use and the emphasis that is respectively valued in the Tibetan monastic culture. As Cole and his colleagues (1971, p. XI) put it in a nutshell: "people will be good at doing the things that are important to them, and that they have occasion to do often". The fact that monks had trouble with the tasks, may therefore also have something to do with the narrow focus and single-minded dedication of monks for whom the practice of analytical meditation and contemplation are a full-time occupation (van Vugt et al., 2019). In retrospect it became more obvious that although counterfactuals and theoretical positions are an important part of monastic training, they are always a means to an end. The scenarios that are debated, even when theoretical, always retain strong relevance to plausible realities (in contrast to most western academic philosophy). Unlike Western education, which places emphasis on improving general mental (and to a lesser degree affective) abilities as ends in themselves, monastic training is a means to an end. The explicit goal is to cultivate insight into the causes and conditions of first-person experience with the aim of aiding the practitioner in eradicating suffering and, consequently, attaining a more enduring sense of well-being by reducing harmful emotions and fostering ones that are advantageous. In this context and as means to this end debate can serve several functions: to learn, to dispel doubts, to develop critical thinking, to gain a long-term, holistic, and comprehensive understanding of a topic, and to foster compassion and gentleness (Perdue, 2014; van Vugt et al., 2019). In this light it makes more sense that applying cognitive skills beyond the monastic training structure is not an essential skill, on the contrary it may be actively discouraged as irrelevant. Some of our monastic collaborators mentioned instructors dissuading them and other students from elaborating their own ideas and abstracting too much beyond the actual text material and instead reinforced focusing on repeating the literal words and learning what terms fit in which context. A western science student might be similarly discouraged from delving deeply and systematically into a niche topic like an introspective analysis of parapsychology; at least not until he or she hasn't completed his or her main curriculum. The cross-cultural difference here may therefore lie in the area-specific divergent thinking that is respectively encouraged.

Yet another way to approach the findings is to place them amongst the literature of previous cross-cultural comparisons. Oral cultures have often been found to have an advantage for remembering meaningful rather than meaningless information (relative to western populations that is; Cole, 1971). Ergo, one might argue that they have a comparative disadvantage for meaningless information. Anecdotal reports and our own observations attest to the vast amount of meaningfully integrated information the monks are able to learn by heart. This may be associated with another finding: that many non-western cultures tend to exhibit more holistic information processing, which is less analytic and less abstract. This style of cognition is associated with different constructs, but one term that may be useful for this discussion is field dependence/independence (FDI; Witkin & Goodenough, 1981). FDI connotes the ability but also the necessity to take the context into account when solving problems (e.g., how much the background of a stimulus distracts from a task).

Cultures with a high amount of social structure and a strong emphasis on conformity in socialization have been shown to be fairly field-dependent. This fits in terms of multiple aspects, as Tibetan culture in general but especially monastic culture is highly hierarchical and compliance is valued greatly.

Lastly, there also seems to be an effect of how oral a culture is on how easily they can process and manipulate written (e.g., experiment stimuli on a screen; Ross & Millsom, 1970). Tibetan monks receive and internalize a large amount of their teaching through speech and chanting. Moreover, the script used for presenting the stimuli may matter as much as the content, which appears on the screen. If a given culture is less comfortable with Western writing conventions (e.g., even pressing buttons on a computer or tablet) this may further impede task performance. Cole and colleagues (1971) recount that when their subjects found themselves in a test situation that was unfamiliar to them, they had difficulty knowing where to begin. However, when given more familiar tools and context, their performance improved significantly. A preliminary test of this assumption could be seen in the finding that both novices and experienced monks benefited from a paper version of the logic task compared to the tablet version. There is however a wrinkle in this argument, as the results hinted at a non-significant differential effect between novices and experienced monks, with novices surprisingly benefitting more from the switch to paper than their more experienced counterparts (although descriptively they did as well, but much less so). This contradicts or at least complicates the initial hypothesis about familiarity, which would have predicted that the more experienced and older monks would prefer the more traditional paper format more than the novices, who showed greater acuity with digital devices (e.g., faster response times in all tasks). So, while the impact of the medium of presentation played an important role in the logic task, it seems unlikely that the cultural differences can be solely attributed to the medium, but rather, there seem be other and more nuanced factors at play.

Diving Deeper into the Logic Task Performance Gap

While Tibetan monk's performance gaps in the complex working memory and association memory tasks can be quite plausibly explained by cultural differences regarding abstraction, divergent thinking and familiarity with such tasks (e.g., manipulating meaningless spatial information), the logic task performance gap is more difficult to account for and warrants a detailed discussion. Both memory tasks are quite distinctly abstract and foreign to the monks' usual way of thinking and learning, whereas logic and reasoning are integral parts of their monastic education and everyday life. This aligns with the fact that it is the only task, in which the experienced monks did better than the novices (although not significantly) and had the smallest performance gap compared to the Western students. The pattern between the logic task and the two others therefore points in a direction which is consistent with the cultural differences hypothesis. However, it is still puzzling why the performance gap in the logic task is not smaller or even reversed, given the monks' extensive training in logical reasoning and debate.

Several factors may have contributed to this unexpected result. One is that there are significant differences in the form of the logic itself, which both the Western researchers and the Tibetan collaborators were not aware of in the beginning. The logic which is used in monastic debate was codified first in the 5th/6th century Indian Pramana texts by Dignaga/Dharmakirti and then fashioned into its present form by the Tibetan logician Chapa Chokyi Senge in the 11th century. A thorough comparison with modern western logic has yet to be undertaken. However, there are some parallels with scholastic disputation and medieval forms of logic, rooted in the works of Aristotle. One specific disputation game called *obligatio* involves a similar back-and-forth exchange of questions and answers, as well as a similar focus on the precise use of language, predetermined rules, assymetric roles (opponent and respondent), and the avoidance of contradictions (Novaes,

2005; Uckelman, 2012). A noteworthy difference, among numerous others, is however, that the Tibetan monastic debate is a living tradition that has been continuously practiced and developed for over a thousand years, whereas the Western scholastic disputation has been abandoned and replaced by other forms of argumentation and logic, such as formal logic and the scientific method (Novaes, 2012).

The main argument form in Tibetan monastic debate is a kind of syllogism (a first-order enthymeme; Perdue, 2014), which consists of three components: the subject, the predicate, and the reason. For example, a classic example from Western philosophy would be formulated as follows: "The subject Socrates (subject), is a mortal (predicate), because of being a human (reason)." A debate may begin with a basic statement of logical necessity, which is formally equivalent to a universal statement in Western logic. It would be phrased as follows: "if it's p, then it's necessarily q". Applying this to the above example this would result in: "if something is a human, then it it's necessarily mortal". Yet, this is not simply a plug-and-play logical form where one can manipulate the symbols (for instance, inserting gardeners and astronauts) and get a consistent logical result, because each term has a precise meaning. The salience of the terms for the monastics leads to an approach that differs from one where we assume arbitrary value to the terms. The logical relation between men and mortals itself must be established through a first-person reasoning process. Perdue (2014) holds that a valid argument is not only identifiable by its form in Tibetan logic, but must also be confirmable through first-person epistemic evidence. An argument's validity is therefore relative; it is determined by the person and context it is presented in. It specifically depends on the person's ability to gain further first-hand insight into the true nature of reality, which implies a person who both has the capacity to understand the components of an argument, but has not fully extracted and understood the full breadth of the conclusion on a first-person level. Again, this highlights how monastic debate is not a means in itself but always oriented towards the ultimate end of awakening, which can only occur directly and thus individually. Every component of a syllogism must be directly ascertained by the debater. This difference then also explains why Tibetan monastic debate implies a slightly altered truth table for conditionals (see table 14).

Table 14

Comparison of Western and Tibetan truth tables for conditionals

	Example subject	Human	Mortal	If something is a human, then it is mortal	
				Western logic	Tibetan logic
1.	Socrates	True	True	True	True
2.	Dorian Gray	True	False	False	False
3.	Dog	False	True	True	Indeterminate
4.	Turritopsis dohrnii	False	False	True	Indeterminate

Western and Tibetan logic agree that a statement such as "if something is a human, then it is mortal" is true in the first case, and false in the second. However, in the third and fourth cases, Tibetan logic considers the statement indeterminate. Tibetan logicians that we consulted considered the third and fourth statements indeterminate in the sense that they do not add nor subtract from the truth of the universal statement from the first-person experience of the debater in question. Essentially, the burden of proof is greater in Tibetan logic, as the debater must directly ascertain the truth value of each component of a syllogism and the mere absence of a counterexample is not sufficient to establish validity.

Drawing conclusions about premises (e.g., a mortal dog) that are not directly relevant to the subject at hand (in this case the universal about all humans being mortal) is only done when the challenger is trying to lure or trick the defender into admitting a false or contradictory statement. Such logical games are mostly employed to teach the absolute beginners the basics of logic and debate, and to help them develop a foundation upon which they can build more profound understanding. As debaters progress in their studies, the focus quickly shifts from these formal games to more complex and nuanced discussions that are directly related to the subject matter and the ultimate goal of awakening. The thrill and challenge of debate therefore turns from beginners outsmarting each other on a merely formal level to expert debaters outwitting each other in terms of depth and clarity of understanding.

And so, to return to the quote by Cole (1971) it seems reasonable, that monastic debaters (and experienced ones more so than beginners) are much better at applying and much more likely to use the first-person relative form of truth standards than the Western abstract one. Only some of these differences in reasoning or formality of the logic were accounted for during the translation process of the task that was then given to the monks. What is more, since the items in our task were more similar to the problems that the beginners' debate (i.e., logical games without much relation to the ultimate goal of awakening), it is possible that the beginners gained an advantage over the more experienced debaters, in terms of familiarity and motivation, as the expert debaters are arguably less interested in these types of problems and more focused on deeper, more profound discussions. This difference in motivation and interest regarding irrelevant material might have also contributed to the performance differences in the other two other tasks. To make matters more complicated, when considering the fact that experienced debaters (at least descriptively) profited more from the presentation on a tablet (relative to the paper version) than the novices, it suggests that there might be an interaction between the familiarity with the logical problems and familiarity with the mode of presentation. It is possible that the relative familiarity with the paper version increased the overall familiarity experts already had with the logical problems, thus leading to even less motivation. At least in the tablet version, where response times were available, experienced monks did not seem to rush through the tasks and took longer to answer than both novices and Western students, which is a possible indication of the aforementioned hypothesis. A key takeaway from this discussion about the logic task is therefore, that even though it was the most similar of the three tasks, it is likely that an interaction of motivation, presentation mode and unexpected culture-dependent differences in reasoning paradigms influenced the results. Moreover, it is clear that the results of the logic task pose more questions than they answer, and further and especially more culturally sensitive research is needed to disentangle these complex interactions.

Conclusion

Cultural differences cannot be simplified down to a single dimension, which is why comparative research is so important. The comparison presented in this article corroborates claims that research on Western populations does not sufficiently represent other cultures and on the contrary may even be an outlier (Henrich et al., 2010a). Our study moreover suggests that this limitation of generalizability also extends to non-western cultures that exhibit and value highly developed systems of information. The performance gap in the logic task, which is arguably an area in which traditional Tibetan monastic debaters should excel, highlights how even ostensibly cross-culturally appropriate Western tasks do not represent the full spectrum of skills and knowledge inherent in different cultural traditions. As the European and American researchers of this project can attest from first-hand experience when they trained in monastic debate, the same is likely true for non-WEIRD settings, such as the Tibetan monastic one, in which the unique methods, implicit

assumptions, and paradigms impeded the Western researchers' ability to fully display their competence and understanding (e.g., debating about definitions of their core research field).

What is more, even though presenting tasks that rely on abstracted information seems like a good strategy for removing cultural biases for non-WEIRD populations, the appreciation of abstraction may in fact be a western artifact in itself (e. g., as in the Raven's matrix test). As has been suggested by some researchers (Nisbett et al., 2001), Western cultures tend to favor analytical thinking and abstraction, whereas Eastern cultures may place more emphasis on holistic thinking and context. In the case of Tibetan monastic culture, even in debate, which by nature is an analytical undertaking, the emphasis on holistic thinking and context is evident. For example, the focus on the relevance of each component of the reasoning process to the ultimate goal and the requirement for the debater to have direct experiential knowledge of the subject matter, both contribute to a more contextualized and integrated approach to logic and reasoning than in the formal logic approaches dominant in contemporary Western logic.

It follows, that when conducting research with currently underrepresented non-western populations, it is crucial to not underestimate the often-latent cultural differences and take them into account when designing tasks. One possibly useful metric is the field dependence/independence construct (FDI; Witkin & Goodenough, 1981), which may provide a useful proxy for exposure to Western education and paradigms. Moreover, as has already been pointed out by various researchers, quite generally there should be more explicit description of cultural background and greater reflection on its function (e.g., Medin & Bang, 2014; Norenzayan & Heine, 2005; Rad et al., 2018). This includes not only the characteristics of the participants but also the researchers themselves, as their own cultural background can influence the research process and the interpretation of results. When possible, collaboration with researchers from the target culture should be sought, as they are likely to have a deeper understanding of the cultural nuances and can help to ensure that the tasks and methods used are culturally appropriate and meaningful.

In the end, all of these findings suggest that the most meaningful research on cognitive abilities may well come from studying cognitive abilities in their natural environment – i.e., the cultures in which they evolved using tasks that are compatible with them. Specifically, future research should consider carefully selecting and adapting tasks to be culturally appropriate and relevant. In our case, it became evident that it is necessary to develop and validate entirely new cognitive tasks and measures that are specifically designed for use in the Tibetan monastic settings (e.g., a purely oral logic task that relies on stimuli, which are relevant to and embedded in a greater context). When possible cross-cultural studies should employ a diverse range of cognitive tasks to ensure a comprehensive understanding of cognitive abilities across different cultural contexts. This kind of in-depth investigation will not only help to uncover the unique strengths and weaknesses of different cultural groups but also has the added benefit of helping to preserve diverse cultural traditions and their inherent knowledge systems for future generations. This is especially true for the case of the long sheltered Tibetan monastic heritage, which is now facing rapid modernization and globalization. In order to effectively adapt and pilot these new cognitive tasks, we highly recommend collaboration with members of the culture in question. As we have advocated (van Vugt et al., 2019), the central role of Tibetan monastic collaborators in research cannot be overstated. Their deep immersion in monastic tradition enables precise scientific inquiries into analytical meditation and debate. Further, their bilingual proficiency bridges the language gap, facilitating communication, guiding study procedures, and translating research findings. This inclusive approach also ensures that the source community remains informed and involved, fostering a mutual respect and equitable dynamic. In order to successfully include monastics in the research, they must be trained in scientific methods. This not only enables them to more effectively participate in the research but also enhances their understanding of practical science applications, providing a pathway to examine

monastic debate complexities from a Western scientific angle, while also offering benefits to both Western and Eastern societies. This research approach therefore not only fosters reciprocal intercultural relationships but also offers a fresh perspective on investigating traditional practices to modern contexts without missing their essence.

In closing, our study highlights the importance of considering cultural differences in cognitive research and the need for more inclusive and culturally sensitive research methodologies. By acknowledging and embracing the diversity of human cognition, we can gain a deeper understanding of the various ways in which people think, reason, and solve problems across different cultural contexts. This will ultimately contribute to a richer, more comprehensive and nuanced understanding of human cognition as a whole, and pave the way for more effective cross-cultural collaborations and interactions in an increasingly globalized world.

References

Anderson, R. B. W. (1967). On the comparability of meaningful stimuli in cross-cultural research. *Sociometry*, 124–136.

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2015). Fitting Linear Mixed-Effects Models Using lme4. *Journal of Statistical Software*, *67*(1), 1–48. https://doi.org/10.18637/jss.v067.i01

Borst, J. P., Schneider, D. W., Walsh, M. M., & Anderson, J. R. (2013). Stages of processing in associative recognition: Evidence from behavior, EEG, and classification. *Journal of Cognitive Neuroscience*, *25*(12), 2151–2166.

Cole, M. (1971). *The Cultural Context of Learning and Thinking: An Exploration in Experimental Anthropology*. Basic Books.

Cole, M., & Bruner, J. S. (1971). Cultural differences and inferences about psychological processes. *American Psychologist*, *26*(10), 867–876.

Day, R. H. (1989). Images, depth cues, and cross-cultural differences in perception. *Behavioral and Brain Sciences*, *12*(1), 78–79.

Dreyfus, G. (2003). *The sound of two hands clapping: The education of a Tibetan Buddhist monk*. University of California Press.

Gallucci, M. (2019). *GAMLj: General analyses for linear models. [jamovi module]*.

Goyal, M., Singh, S., Sibinga, E. M., Gould, N. F., Rowland-Seymour, A., Sharma, R., Berger, Z., Sleicher, D., Maron, D. D., & Shihab, H. M. (2014). Meditation programs for psychological stress and well-being: A systematic review and meta-analysis. *JAMA Internal Medicine*, *174*(3), 357–368.

Greenfield, P. M. (1997). You can't take it with you: Why ability assessments don't cross cultures. *American Psychologist*, *52*(10), 1115–1124.

Grossmann, I., & Na, J. (2014). Research in culture and psychology: Past lessons and future challenges. *Wiley Interdisciplinary Reviews: Cognitive Science*, *5*(1), 1–14.

Henrich, J., Heine, S. J., & Norenzayan, A. (2010a). Beyond WEIRD: Towards a broad-based behavioral science. *Behavioral and Brain Sciences*, *33*(2–3), 111–135. https://doi.org/10.1017/s0140525x10000725

Henrich, J., Heine, S. J., & Norenzayan, A. (2010b). The weirdest people in the world? *Behavioral and Brain Sciences*, *33*(2–3), 61–83. https://doi.org/10.1017/s0140525x0999152x

Huijser, S., van Vugt, M. K., & Taatgen, N. A. (2018). The wandering self: Tracking distracting self-generated thought in a cognitively demanding context. *Consciousness and Cognition*, *58*, 170–185.

Jahoda, G., & Stacey, B. (1970). Susceptibility to geometrical illusions according to culture and professional training. *Perception & Psychophysics*, *7*, 179–184.

Khoury, B., Lecomte, T., Fortin, G., Masse, M., Therien, P., Bouchard, V., Chapleau, M.-A., Paquin,

K., & Hofmann, S. G. (2013). Mindfulness-based therapy: A comprehensive meta-analysis. *Clinical Psychology Review*, *33*(6), 763–771.

Lutz, A., Slagter, H. A., Dunne, J. D., & Davidson, R. J. (2008). Attention regulation and monitoring in meditation. *Trends in Cognitive Sciences*, *12*(4), 163–169.

Medin, D. L., & Bang, M. (2014). The cultural side of science communication. *Proceedings of the National Academy of Sciences*, *111*(supplement_4), 13621–13626.

Nielsen, M., Haun, D., Kärtner, J., & Legare, C. H. (2017). The persistent sampling bias in developmental psychology: A call to action. *Journal of Experimental Child Psychology*, *162*, 31–38.

Nisbett, R. E., & Masuda, T. (2003). Culture and point of view. *Proceedings of the National Academy of Sciences*, *100*(19), 11163–11170.

Nisbett, R. E., Peng, K., Choi, I., & Norenzayan, A. (2001). Culture and systems of thought: Holistic versus analytic cognition. *Psychological Review*, *108*(2), 291–310.

Norenzayan, A., & Heine, S. J. (2005). Psychological universals: What are they and how can we know? *Psychological Bulletin*, *131*(5), 763–784.

Novaes, C. D. (2005). Medieval obligationes as logical games of consistency maintenance. *Synthese*, *145*, 371–395.

Novaes, C. D. (2012). *Formal languages in logic: A philosophical and cognitive analysis*. Cambridge University Press.

Perdue, D. (2014). *The course in Buddhist reasoning and debate: An Asian approach to analytical thinking drawn from Indian and Tibetan sources*. Shambhala Publications.

Rad, M. S., Martingano, A. J., & Ginges, J. (2018). Toward a psychology of Homo sapiens: Making psychological science more representative of the human population. *Proceedings of the National Academy of Sciences*, *115*(45), 11401–11405.

Ragni, M., Dames, H., Brand, D., & Riesterer, N. (2019). When does a reasoner respond: Nothing follows? *CogSci*, 2640–2546.

Ross, B. M., & Millsom, C. (1970). Repeated memory of oral prose in Ghana and New York. *International Journal of Psychology*, *5*(3), 173–181.

Sedlmeier, P., Eberth, J., Schwarz, M., Zimmermann, D., Haarig, F., Jaeger, S., & Kunze, S. (2012). The psychological effects of meditation: A meta-analysis. *Psychological Bulletin*, *138*(6), 1139–1171.

Segall, M. H., Campbell, D. T., & Herskovits, M. J. (1963). Cultural differences in the perception of geometric illusions. *Science*, *139*(3556), 769–771.

Tang, Y.-Y., Hölzel, B. K., & Posner, M. I. (2015). The neuroscience of mindfulness meditation. *Nature Reviews Neuroscience*, *16*(4), 213–225.

Thalmayer, A. G., Toscanelli, C., & Arnett, J. J. (2021). The neglected 95% revisited: Is American psychology becoming less American? *American Psychologist*, *76*(1), 116–129.

Uckelman, S. L. (2012). Interactive logic in the Middle Ages. *Logic and Logical Philosophy*, *21*(4), 439–471.

van Vugt, M. K., Moye, A., Pollock, J., Johnson, B., Bonn-Miller, M. O., Gyatso, K., Thakchoe, J., Phuntsok, L., Norbu, N., & Tenzin, L. (2019). Tibetan Buddhist monastic debate: Psychological and neuroscientific analysis of a reasoning-based analytical meditation practice. *Progress in Brain Research*, *244*, 233–253.

van Vugt, M. K., Pollock, J., Johnson, B., Gyatso, K., Norbu, N., Lodroe, T., Gyaltsen, T., Phuntsok, L., Thakchoe, J., Khechok, J., Lobsang, J., Tenzin, L., Gyaltsen, J., Moye, A., & Fresco, D. M. (2020). Inter-brain synchronization in the practice of Tibetan monastic debate. *Mindfulness*, *11*(5), 1105–1119.

Wickham, H. (2017). Tidyverse: Easily install and load the 'tidyverse.' *R Package Version*, *1*(1), 2017.

Wickham, H., Chang, W., & Wickham, M. H. (2016). Package 'ggplot2.' *Create Elegant Data*

Visualisations Using the Grammar of Graphics. Version, *2*(1), 1–189.
Witkin, H. A., & Goodenough, D. R. (1981). Cognitive styles: Essence and origins. Field dependence and field independence. *Psychological Issues*, *51*, 1–141.