

WITHIN-PERSON DIFFERENCES IN UNCERTAINTY MANAGEMENT,  
NEW VENTURE IDEATION AND INITIAL BELIEF FORMATIONS

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## DISSERTATION ABSTRACT

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This three-paper dissertation investigates dynamic performance in uncertain situations. Each chapter in this dissertation represents a stand-alone paper. The first chapter combines literature on sleep processes with decision making in uncertain contexts to create a process model of sleep and uncertainty management. I highlight many mechanisms between sleep and uncertainty management, and explore the recursive relationship between these activities and subsequent sleep. The underexplored mechanisms in Chapter II provide the empirical impetus for Chapters 2 and 3. The second chapter investigates entrepreneurs in new venture settings, providing causal evidence for the effect of sleep restriction on new venture ideation and belief formation. The third and final chapter provides a constructive replication of the second chapter in an angel investing context, where beliefs about new venture potential are formed more frequently and more formally by investors. These chapters work together to inform our collective understanding of dynamic performance in a decidedly uncertain new venture context.

This dissertation contains both previously published and unpublished co-authored material.

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## CHAPTER I: INTRODUCTION

Entrepreneurship starts with an idea to combine resources in a novel way to form a commercial venture. Typical entrepreneurship research delves into when and where a new venture might start, the identification of promising resource combinations, and factors that contribute to the longevity of a venture. These investigations primarily take a macro-lens, more intensely focused on aggregated levels of analysis (i.e., firm, country, or region) than on the individuals that begin these new ventures (e.g., Carnahan, Agarwal, & Campbell, 2012; Granovetter, 2005; Meh, 2005; Quadrini, 2000). Recent years have seen a burgeoning stream of entrepreneurial investigations looking into individual-level decision making among entrepreneur populations (e.g., Baron, 1998, 2004, 2008; Burmeister & Schade, 2007; Kacperczyk & Younkin, 2017; Mathias & Williams, 2017; Mathias, Williams, & Smith, 2015; Uy, Sun, & Foo, 2017). This work has taught us much about who decides to become an entrepreneur, which entrepreneurs are successful, and how new venture teams are formed.

Yet, for all of the knowledge that has been amassed in the area of individual-level entrepreneurship research, individual-level research in the entrepreneurship domain usually focuses on enduring trait-like features of entrepreneurs. That is, entrepreneur performance is usually assumed to be innate and static (Ellis, Aharonson, Drori, & Shapira, 2016), or change slowly over time through deliberate and purposeful practice (Dew, Ramesh, Read, & Sarasvathy, 2018). Some recent inquiries, however, have begun to explore behaviors of entrepreneurs that are more emotionally driven, moving away from the strict adherence to purely rational cognitive factors in the study of individual entrepreneurs and acknowledging some interplay between affect (i.e., moods and

emotions) and cognition. These theoretical works suggest that certain aspects of entrepreneur performance might be susceptible to episodic forces over relatively short periods of time (viz. Grégoire, Cornelissen, Dimov, & van Burg, 2015; Mathias & Williams, 2017; B. T. Mitchell, Mitchell, & Mitchell, 2017). This work seems to suggest, but neither asks nor answers, questions regarding the unwavering performance of entrepreneurs.

Given the lack of empirical support in this area and the recent uptick in theorizing around the interplay between affective and cognitive factors among entrepreneurs, I ask the following overarching research question in this dissertation: Are an entrepreneur's behaviors subject to episodic modulation? To answer that question, I ask the following, more specific questions: Does an entrepreneur's ability fluctuate dynamically across various stages of firm inception and development, where the same entrepreneur might perform well in one situation and poorly in another seemingly similar situation? What are the conditions under which these behaviors and abilities change? Do affect and cognition interact similarly each day for entrepreneurs? Does an entrepreneur evaluate each prospective opportunity with consistent cognitive strategies? Do those who provide funding to entrepreneurs exhibit similar dynamism in their decision-making processes? Although most current research assumes behaviors and abilities are stable (cf. Grégoire, 2014), providing an anti-climactic answer to many of my questions above, I intend to answer these questions with novel and disparate methods that are suited for individual-level analysis, engaging representative samples with high external validity.

I investigate these research questions in a series of three papers, the combination of which represent three chapters of my dissertation. These chapters revolve around

dynamic performance in uncertain and entrepreneurial undertakings. The first chapter is a conceptual review that introduces the dual-process model of sleep as a dynamic influence on the management of uncertainty. The first chapter is followed by two empirical chapters that test some of the relationships proposed in the initial review chapter. Both empirical works are situated in an entrepreneurial context, the first with entrepreneurs and the second with angel investors.

Chapter II represents a conceptual review that provides a thorough integration of existing work that suggests managerial decision-making is susceptible to dynamic variation. I use a two-process model of sleep (Borbély & Achermann, 1999) to highlight various mechanisms that influence uncertainty perceptions. This work uncovers the various paths through which these mechanisms interact with uncertainty. The review elucidates sleep's effect on varying types of uncertainty (i.e., state, effect, and response uncertainty; Milliken, 1987). Whereas much of the literature posits that uncertainty management is unlikely to exhibit substantial variation over shorter periods of time, I propose in this chapter those areas in uncertainty management that could be susceptible to variation due to upstream influences on affect and cognition across a broad spectrum of decision-making experiences. These propositions are based on an integration of literatures from various fields including economics, psychology, management, and sociology. Chapter II is subsequently opened up to precise empirical examination in entrepreneurial contexts throughout Chapters 2 and 3. This chapter contains unpublished coauthored material with Stuart Read and Christopher Barnes.

Chapter III questions sleep's dynamic influence on new venture ideation and belief formation. Sleep is a stimulus that has an established influence on both affect and



cognition (Lim & Dinges, 2010; Pilcher & Huffcutt, 1996), and the potential for specific domain effects in the study of entrepreneurs. The chapter engages a literature on structural alignment theory to uncover specific detriments caused by sleep restriction and deprivation. The hypotheses are tested over three studies. The first study surveys a cross-section of 784 entrepreneurs and finds that sleep restriction impairs the ability to correctly identify a low-promise new venture idea. The second study follows 101 entrepreneurs over the course of two weeks with experience sampling methodology (ESM) to determine whether entrepreneurs waver in their evaluation of opportunities over multiple days, specifically measuring sleep as an independent variable. I find that sleep is important for entrepreneurs to move beyond a superficial analysis of opportunities, meaning that more sleep leads to better recognition of non-obvious good or bad opportunities. The third study in Chapter III uses a strong sleep deprivation manipulation to support the conclusions drawn in the first two studies, and adds a qualitative opportunity ideation task. Altogether, these studies suggest that that sleep is important for entrepreneurs as the form ideas and initial beliefs about new ventures, in theoretically rich ways that move beyond hypotheses that note previously-established human errors associated with less sleep. Furthermore, the results support the overarching theme of the dissertation; entrepreneurs are subject to episodic forces that influence performance, in this case during the ideation and evaluation of opportunities. This chapter has been conditionally accepted for publication at the Journal of Business Venturing with coauthors David Wagner, Denis Grégoire, and Christopher Barnes.

Chapter IV moves into an angel investing context, where evaluation tasks happen more frequently than they might for an average entrepreneur. Angel investors evaluate

numerous opportunities and choose to invest in the strongest candidates among those evaluated. Just as in entrepreneurs form initial beliefs about which new venture ideas to pursue, angels are making bets on decidedly uncertain future performance. In this context, I examine both internal (sleep habits) and external (language in the pitch) predictors of dynamic performance among investors. I hypothesize that entrepreneurs, angel investors, and aspiring angel investors will vary their initial belief formations based on these predictors, and engage structural alignment theory once again (see Chapter III as well) along with dual process cognition theory. I find mixed support for my predictions among angel investors, but uphold the notion that angel investors utilize more superficial logic when forming initial beliefs about new venture ideas. This investigation contributes to the overarching questions of dynamic performance in an entrepreneurial context by exposing how angel investors think about new venture ideas differently based on both internal and external factors. The current conversation around these thought processes is that they are stable or develop slowly as a person engages in purposeful and deliberate practice.

The empirical portions contained in Chapters 2 and 3 of the dissertation pay particular attention to dynamic decision making in early stages of new businesses. Entrepreneur and angel decisions in these early stages wield high leverage over eventual outcomes. The dissertation contributes to literatures concerned with dynamic human performance, of interest to both psychology and organizational scholars and entrepreneurship literatures as well. Although not a primary aim of the dissertation, this work also helps inform the argument over whether entrepreneurs are born or whether they can be made. The answer to this question is undoubtedly somewhere in between

“born” and “made.” There are certainly innate factors or tendencies that predispose some individuals to entrepreneurial careers. But even those high in entrepreneurial proclivity are subject to the dynamic fluctuations put forth in this dissertation. By highlighting these dynamic states, and how they apply to entrepreneurs and investors in different contexts and over time, I intend to contribute a dynamic perspective to entrepreneurship research that acknowledges the interplay between enduring traits and dynamic states at various stages of new venture development.

## CHAPTER II

*Note.* This chapter of the dissertation narrows the focus on dynamic entrepreneurial performance to the management of uncertainty. I frame the dissertation around dynamic entrepreneurial performance Chapter I. That is, dynamic performance in an entrepreneurial context constitutes an overarching theme in the dissertation. Although this chapter's primary focus is the management of uncertainty, subsequent chapters will delve into the empirical measurement of dynamic entrepreneurial performance. This chapter contains previously unpublished coauthored material with coauthors Stuart Read and Christopher Barnes.

### Introduction

Tesla's uncertain trajectory toward mainstream electric car adoption has been accompanied by quirky and erratic management from its founder Elon Musk. Similarly, Len Riggio, founder of Barnes & Noble, has made rapidly successive CEO changes as he faces an uncertain future for his organization. Even though these represent very public cases of management in uncertain situations, every organizational employee who makes management decisions is likely familiar with the colloquial notion of uncertainty. For the purposes of this paper, uncertain situations are distinguished by an undeterminable set of decision options with similarly undeterminable outcome probabilities (Knight, 1921; Packard, Clark, & Klein, 2017). Accordingly, individuals who make decisions in uncertain situations must perform without foreknowledge about cause and effect. Put another way, uncertain situations are characterized by an inability to know a decision's consequences *ex ante*, no matter how comprehensive the decision making calculus might be.

The lack of knowledge about future outcomes, coupled with a desire to know what the future holds, embody key determinants of information search as employees attempt to resolve their unknowingness. Uncertainty about future outcomes has been proposed as the rationale for business itself, described as a formative reason that organizations exist since fewer profit opportunities exist in the absence of uncertainty (Barney, 1986). As employees and managers encounter uncertainty about future outcomes, they naturally strive to resolve the uncertainty (McKelvie, Haynie, & Gustavsson, 2011; Townsend, Hunt, McMullen, & Sarasvathy, 2018). The zeal to overcome unknowingness represents a seminal reason management scholars remain interested in uncertainty as a construct in organization theory (S. Alvarez, Afuah, & Gibson, 2018; Segal, 2011). Organizational scholars have amassed a large body of knowledge on the topic, and witnessed a resurgence in recent years.

At the firm level of analysis, uncertainty looms as a contemporary and integral part of theorizing on the emergence of new firms (e.g., Belderbos, Tong, & Wu, 2019; Doshi, Kumar, & Yerramilli, 2018), open innovation (e.g., Almirall & Casadesus-Masanell, 2010; Laursen & Salter, 2006), protection of firm-specific investments (e.g., Hoskisson, Gambeta, Green, & Li, 2018), and firm legitimacy and survival (e.g., Goldfarb, Zavyalova, & Pillai, 2018; Jia, 2018). At the decision-maker (individual) level of analysis, we know that uncertainty affects learning (e.g., Ke, Li, Ling, & Zhang, 2019), organizational commitment (e.g., Diehl, Richter, & Sarnecki, 2018), and team coordination (e.g., Jang, Shen, Allen, & Zhang, 2018; Sverdrup & Stensaker, 2018). Indeed, there is no shortage of recent interest in uncertainty among organization scholars. Yet there is a notable gap in theoretical understanding of how an individual might vary in

his/her approach to uncertainty management moment-to-moment or day-to-day. The purpose of this paper is to explore how individuals vary their management approach in uncertain organizational contexts.

Sleep represents a day-to-day variable that facilitates the exploration of within-person changes in management strategies. Both the daily need for sleep and the timing of sleep work together to influence decision-making (Borbély, 1982, 2009; Borbély & Achermann, 1999), and variations in sleep hold particularly salient influence over decision making in uncertain contexts. Since uncertain situations lack cause-and-effect determinations, decisions in these contexts do not require comprehensive information and need not predict future outcomes (Forbes, 2007; Sarasvathy, 2001). Nevertheless, decisions often need to be made by individuals faced with these situations in order to manage and lead the organization. This individual-decision nexus may come on a sub-optimal day or stretch of days when the individual decision-maker struggles with poor sleep hygiene. This process causes the individual to interpret an uncertain situation in a different manner than his/her well-rested self, creating a within-individual difference in uncertainty management. As I develop how these within-individual differences influence uncertainty management, I adopt Milliken's (1987) state, effect, and response uncertainty framework to uncover the ways in which sleep influences the management of uncertainty, and how the management of uncertainty can in-turn affect subsequent sleep activity.

The relationships described in this paper contribute a dynamic conceptualization of individual uncertainty management and the model I develop represents a particular lens, namely sleep, through which individual variation in management strategies can be observed. The paper also contributes a process model (cf. Cornelissen, 2017) that

highlights specific mechanisms explaining how the amount and/or rhythm of sleep can influence an individual's cognitive approach to resolve an uncertain situation, and proposes how jobs in uncertain contexts can recursively influence recovery activities such as sleep. This process model helps organizational scholars and managers understand how individuals vary from one day to the next in their perception, interpretation, and response to uncertain situations.

### **Uncertainty Management in Organizations**

#### **Two-process Model of Sleep**

Two separate but related sleep processes hold the potential to influence daily uncertainty management. The homeostatic process (Process S) refers to the body's ascending need for sleep during wakeful hours, and the descending need during hours spent asleep. The circadian process (Process C) refers to the rhythm of sleep, and how that rhythm accords with a roughly 24-hour clock (Lavie, 2001). The two processes were first delimited by Borbély and colleagues as a way to distinguish between two principal constructs in sleep regulation (Borbély, 1982; Borbély & Achermann, 1999). Process S is sleep dependent and Process C is sleep independent. Highly cited<sup>1</sup> and lauded for its simplicity, one major benefit of using the two process model for sleep regulation is, as Borbély puts it, the interaction of only two processes accounts for a multitude of phenomena (Borbély, 2009). Although alternative formulations of sleep regulation exist, the two process model remains the dominant model adopted by psychologists and organizational scholars.

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<sup>1</sup> At this writing the initial sleep processes paper (Borbély, 1982) has amassed 3,664 citations on Google Scholar.

Sleep problems are pervasive, and seem to transcend cultures in the developed world. Peer-reviewed research has documented sleep complications in Australia (Adams et al., 2017), Canada (Daley, Morin, LeBlanc, Gregoire, & Savard, 2009), Finland (Kronholm et al., 2016), Germany (Hinz et al., 2017), Japan (Itani et al., 2016), Korea (Joo et al., 2009), Sweden (Ravan, Bengtsson, Lissner, Lapidus, & Bjorkelund, 2010), Switzerland (Hammig, Gutzwiller, & Bauer, 2009), U.K. (Chatzitheochari & Arber, 2009), and the United States (Basner et al., 2007). Sleep problems seem to be getting worse in recent decades (Kronholm et al., 2008), and those who hold creative problem solving positions and set their own working hours seem to be particularly susceptible to sleeping less, sleeping poorly, or sleeping at suboptimal times (Portes & Zhou, 1996; Wiklund, Patzelt, & Dimov, 2016).

### **Sleep and Uncertainty Management**

*State uncertainty.* Sleep influences perceptions of environmental uncertainty by modifying alertness and scanning capabilities (Leone, Slezak, Golombek, & Sigman, 2017), diminishing mood (Gujar, Yoo, Hu, & Walker, 2011), and promoting depression (E. Altena et al., 2016) as well as anxiety (Hockey, Maule, Clough, & Bdzola, 2000). Sleep rhythms can influence one person to adopt a more deliberate and exploratory approach in the morning, and a more cavalier exploitation approach in the afternoon (Leone et al., 2017). These effects and others can alter how a manager scans and envisions uncertain decision criteria.

*Effect uncertainty.* Decision makers vary their interpretations of how an uncertain environment might affect their decisions as a result of sleep amount and rhythm. Sleep influences risk assessments (Killgore, Balkin, & Wesensten, 2006), task switching



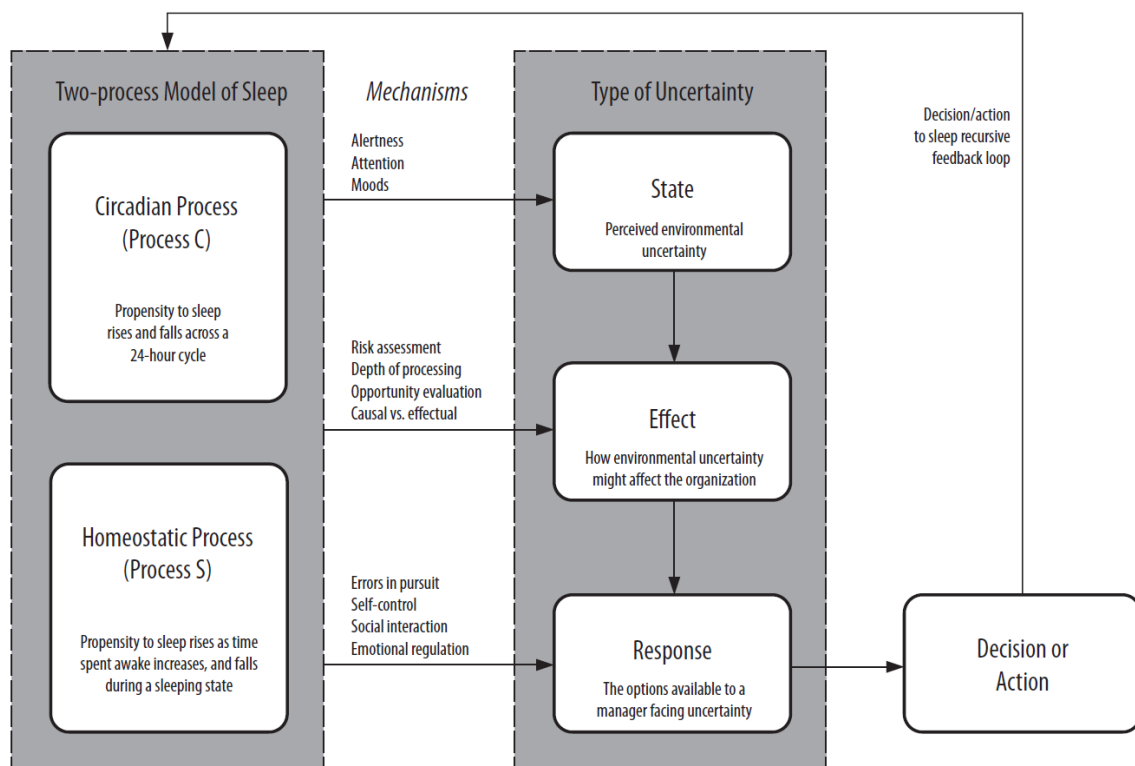
abilities (Haavisto et al., 2010), and working memory (Tucker, Whitney, Belenky, Hinson, & Van Dongen, 2010) relevant to higher-order thinking processes (i.e., depth of processing). Errors in the management of effect uncertainty can lead a decision maker to overlook a potential opportunity or misinterpret the importance of uncertain contingencies in evaluation tasks.

*Response uncertainty.* Generation and perception of options available in uncertain situations are particularly susceptible to sleep processes. As a manager mulls potential alternatives in uncertain situations, sleep can affect emotional regulation (Yoo, Gujar, Hu, Jolesz, & Walker, 2007), and self-control (Kühnel, Syrek, & Dreher, 2018). Lack of sleep can also cause a decision maker to emphasize familiar options (as opposed to thinking more divergently; J. Chen et al., 2017), become more suggestible (i.e., thinking less autonomously; Häusser, Leder, Ketturat, Dresler, & Faber, 2016), or to even disengage from work (Lanaj, Johnson, & Barnes, 2014) during the management of response uncertainty. Further, sleepy managers imagine fewer outcome possibilities and options due to limited creativity (Weinberger, Wach, Stephan, & Wegge, 2018). This phenomenon restricts available responses to uncertainty. A manager might also find it difficult to discuss potential actions with direct reports and other employees (Kahn-Greene, Lipizzi, Conrad, Kamimori, & Killgore, 2006), further constraining response criteria as a result of limited viewpoint inclusion.

*Decision making/action to sleep feedback.* As mentioned above, managers who make a lot of decisions lead busy lives and frequently forgo sleep to advance business interests (Wiklund et al., 2016). This tradeoff exacerbates the deleterious effects of sleep on uncertainty management, leading to a cycle of less sleep and ill-timed sleep that beget

further errors in alertness, judgment, and pursuit (e.g., Åkerstedt et al., 2015; N. Goel, Abe, Braun, & Dinges, 2014). Figure 1 displays the proposed processes at play between uncertainty management and sleep. The following sections unpack each type of uncertainty management, how sleep problems might influence decision making when faced with uncertainty, and how making these decisions in uncertain contexts can recursively exacerbate negative sleep outcomes.

**Figure 1** – *Process model of sleep and uncertainty management*



### State uncertainty

Recall that state uncertainty refers to existing environmental uncertainty that holds the potential to affect a decision or its downstream consequences. This type of uncertainty can be known or unknown by the decision maker. Changes in sleep can influence managers’ assessments of state uncertainty. Changes in sleep influence motivation, attention, and overconfidence, and all of these mechanisms play a role in

whether or not scanning of uncertain criteria happens or not. Sleep's power over moods can moderate which environmental cues a manager pays attention to. And sleep can even determine the approach to uncertainty management that a manager might take, spurring wither more causal or effectual approaches. The following section will address each of these effects in turn.

### **Alertness**

Perceiving uncertainty begins with alertness. Both sleep processes have an effect on alertness, which should in-turn influence the scanning and assessment of state uncertainty. From a daily rhythm standpoint, and employing theory on Process C, Borbély and Achermann (1999) find that forcing desynchronization between normal amounts of sleep and a 24-hour clock hurts daytime alertness. In a similar effort to uncouple Process S and Process C by measuring circadian body temperature and wakefulness, Dijk, Duffy, and Czeisler (1992) find that normal daily alertness rhythms are disrupted following a period prior wakefulness. Perhaps unsurprisingly, Kraemer et al. (2000) report that we experience peak physiological alertness in the morning and then again in the late evening before our normal bedtimes. Contrarily in the same study, self-assessments of alertness peaked at mid-day, indicating that participants in this study were poor judges of their own rhythmic alertness. In a series of tests that shifted the time of day when participants sleep by a total of six hours, both in 30-minute increments (Monk, Buysse, & Billy, 2006) and in 2-hour increments (Monk, Buysse, Billy, & DeGrazia, 2004), Monk and colleagues found that the shifts impaired participant alertness. Importantly, the participants in these studies still received the same amounts of sleep, but those sleep quantities (i.e., wake-up-time minus fall-asleep time) were shifted each day of

the study. These changes in alertness were most pronounced with the 2-hour shift changes, but still significant with the 30-minute shifts. Changes in rhythmic sleeping habits harms alertness, but what about changes in the amount we sleep? I turn to these results next.

Total sleep deprivation (i.e., pulling an all-nighter) leads to diminished performance in psychomotor vigilance tasks, a robust measure of alertness (Zhu et al., 2017). In fact, Drummond and Brown (2001) use fMRI to show that total sleep deprivation promotes the use of wholly different portions of the brain during alertness tasks (also see Hsieh, Cheng, & Tsai, 2007). Even though managers might pull all-nighters in extreme cases, sleep restriction, defined as sleeping less than the recommended 7-9 hours during the night (National Sleep Foundation, 2005), happens more frequently than total sleep deprivation. Constraining sleep slows the amount of time it takes to become aroused (Cote et al., 2009). By constricting sleep to five hours over a period of four nights, Elmenhorst et al. (2008) found that daytime alertness suffered significantly. As individuals string together consecutive days of sleep restriction, their attention suffers more on each successive day, necessitating recovery sleep to return to normal performance on attention-based tasks (Johnson et al., 2004). Closely related to alertness, attention also suffers when we alter sleep rhythm and quantity.

### **Attention**

In a curious finding, Ikeda, Kubo, Kuriyama, and Takahashi (2014) show that after a period of sleep deprivation, sleeping participants exhibited an improved ability to wake themselves up at a specific time. This suggests that the body's rhythmic circadian

clock revises attention to waking cues even when a person is asleep.<sup>2</sup> Turning to waking attention, E. A. Schmidt et al. (2009) find that individuals lose the ability to self-monitor and accurately assess their ability to pay attention after a few hours of work. Although there is scant evidence of rhythmic effects from sleep to attention, there is a wider body of knowledge on Process S effects, assessing sleep quantity, on attention the following day (see Krause et al., 2017 for an exhaustive review).

Poh, Chong, and Chee (2016) report that restricting sleep causes the mind to wander. Muto et al. (2012) observe results similar to Drummond and Brown (2001) in a sleep deprivation experiment that measures attention the following day. Their fMRI tests reveal that participants devote separate portions of the brain to attention than participants who sleep a normal amount. Barnes, Gunia, and Wagner (2015) find that, within the same individual over multiple days, sleep restriction on one night diminishes attention to moral awareness the following day. These findings have wide-sweeping implications for understanding uncertainty, such that moral considerations may not even be part of a sleep-deprived manager's decision calculus. Indeed, attention lapses come faster when sleep is restricted, and sustained attention spans are shorter in length (Doran, Van Dongen, & Dinges, 2001; Durmer & Dinges, 2005). Privation of alertness and attention are both associated with a wandering mind, and wandering minds lead to unhappy personal outcomes such as a generally negative mood (Killingsworth & Gilbert, 2010). Mood is another mechanism that influences perceptions of state uncertainty. I turn now to review the findings on sleep and mood.

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<sup>2</sup> Although it is unlikely that conscious uncertainty estimation happens when someone is asleep, these findings suggest that the homeostatic (S) and circadian (C) processes work in conjunction to influence attention.

## **Mood**

Sleep impacts mood to a greater degree than either cognition or motor skills according to Pilcher and Huffcutt's (1996) meta-analysis. A poor mood can influence a manager's perception of uncertainty by coloring that perception with an more emotional affective tone (Walker, 2009). From a rhythmic point of view, individuals who tend to have an evening chronotype see their moods particularly affected by rhythmic disruptions to sleep, especially in cases of insomnia (Hasler et al., 2012). Selvi, Gulec, Agargun, and Besiroglu (2007) found that circadian preference predicts negative mood swings after a period of sleep deprivation, such that individuals who prefer eveningness had worse mood in the morning, and vice versa. Mood experiences fluctuate during the day as well, with greater subjective and objective affective experiences coming in latter periods of wakefulness (with greater emotional experiences coming after approximately 6 hours of wakefulness; Hot, Leconte, & Sequeira, 2005). Thus sleep effects mood based on a person's chronotype and the amount of time elapsed since the previous period of sleep.

Sleep restriction plays a role as well. After twelve consecutive days of sleep restriction (i.e., no more than four hours of sleep each night), participants saw dramatic negative consequences in diminished positive moods and heightened negative moods (Banks, Van Dongen, Maislin, & Dinges, 2010). Even a night of uninterrupted recovery sleep did not bring the participants back to normal pre-study mood levels, suggesting that it may take more than one night of recovery to regain normal mood states after accruing such a sleep debt. Gujar and colleagues (2011) found that sleep deprivation caused participants to revise, in a positive direction, judgements of negative stimuli, biasing appraisals when sleep deprived. Emotional empathy, defined as the ability to process

emotions while observing the experience of others, is also diminished when sleep deprived (Guadagni, Burles, Ferrara, & Iaria, 2014). These results point to the notion that the ways in which sleep influences mood hold broader implications for motivation to search for information, further coercing estimations of state uncertainty.

Reward processing centers of the brain are affected by chronotype and sleep (Hasler et al., 2012). Motivation decreases during times when sleep and circadian rhythm are mismatched (Adan & Almirall, 1991). Sleep deprivation, through both Processes S and C, causes individuals to pursue immediate monetary rewards (Mullin et al., 2013). This creates motivation to assess environmental uncertainty, but not necessarily optimal motivation as the individual who is sleep deprived will pay disproportionate attention to immediate monetary incentives. Taken together, the empirical evidence indicates that inadequate sleep rhythm and quantity lead managers to assess uncertain situations differently, usually with implied negative consequences, than they would in more normal sleep circumstances. The results above indicate that modification of sleep timing and amount should have an effect on a manager's daytime alertness, which in turn should affect that manager's perception of state uncertainty. These effects can have downstream consequences since perception of uncertainty influences how a manager interprets potential effects the uncertainty might precipitate, and possible steering responses from the manager. I now turn focus to effect uncertainty, the manager's estimation of how uncertain situations will affect management activity.

### **Effect uncertainty**

Effect uncertainty refers to a decision-maker's interpretation on how unknowingness will affect a decision at-hand. How will the uncertainty I face influence

the outcomes of my decision? Would I make a different decision if the outcomes were more clearly defined? These are the types of questions at play within effect uncertainty. Changes in sleep rhythms and quantities influence estimations of effect uncertainty by revising the revising the outlook of the decision maker and by potentially amending the approach taken by the decision maker. In general, less sleep leads to faulty risk assessments, an inability to navigate task switching, and shallow processing of complex problems. Sleep can also change the way that managers evaluate potential opportunities. The following research highlights these effects in greater detail.

### **Risk assessment**

As managers contemplate an uncertain future, they try to calculate relative probabilities for potential effects borne out of their decisions. As I have highlighted above, uncertain situations differ from risky situations since potential outcome sets are unknown, but that does not stop managers from hypothesizing what may happen as a result of a policy change. And it turns out that sleep influences a manager's conjectures of risk. For example, Killgore and colleagues conduct several risk-taking experiments with sleep deprived participants and consistently find that sleep restriction lowers aversion toward risky bets when gambling (Killgore et al., 2006; Killgore, Grugle, & Balkin, 2012; Killgore, Kamimori, & Balkin, 2011). Basner and colleagues (2008) found that sleep loss interfered with the ability to detect a risk in transportation security workers; sleepy security screeners were less likely to detect a weapon among complex and cluttered images. Interestingly, one study of young adult men found that sleep restriction boosted risk taking more than complete sleep deprivation (Maric et al., 2017), suggesting that individuals may be particularly susceptible to decreased inhibition in



conditions of restricted sleep where individuals still may believe their brains are functioning normally. Adding nuance to this perspective, McKenna, Dickinson, Orff, and Drummond (2007) find that sleepy individuals will pursue risk when the potential outcome is framed as a gain, but avoid that risk when the outcome is framed as a loss. Strategy seems to shift from defending against losses to seeking gains in conditions of less sleep (Venkatraman, Huettel, Chuah, Payne, & Chee, 2011) in anticipation of higher rewards from following riskier choice (Venkatraman, Chuah, Huettel, & Chee, 2007). In sum, individuals increase their risk seeking behaviors when sleep deprived, which should also apply in more fuzzy and uncertain situations.

### **Depth of processing**

Uncertain situations often have infinite possibilities for potential options and potential outcomes (Packard et al., 2017). The complexity that defines these situations often calls for managers to think creatively about what complex combination of factors could influence a decision. If an individual makes a decision at a chronotypically non-optimal time of day (e.g., in the morning for an evening person or in the evening for a morning person), that person is more likely to rely on superficial preconceptions about the decision, as opposed to learning more about the details (Bodenhausen, 1990). This is likely due to the inability to effectively utilize working memory at these suboptimal times (C. Schmidt et al., 2015). The reason that working memory is so important in decision making is that, in the absence of a crystal ball that foretells the future, managers draw on their learning and experiences to posit how an uncertain situation might affect their decision. This requires that an individual make an integrated decision by holding the contemporary situation in working memory while retrieving long-term memories about

analogous situations for comparison. Schnyer, Zeithamova, and Williams (2009) find that these types of integrated decisions are particularly affected when sleep is restricted. They use fMRI evidence to reveal an inability to access higher-order cognitive functioning in the prefrontal cortex (PFC). The effects of sleep on executive functioning and working memory are well-documented (Walker & Stickgold, 2006), and these detriments make it difficult for managers to imagine potential solutions to problems, update prior thinking with new information, and increased negative perseveration (Y. Harrison & Horne, 1999). One particularly important task that is susceptible to these impairments is opportunity evaluation.

### **Opportunity evaluation**

Many organizational employees are encouraged to explore potential avenues for process and product improvement, to create new intellectual property and conduct new product development, or to spin-out new venture organizations when an opportunity arises. These opportunities must be evaluated for efficacy before committing to a course of action. Sleep restriction impairs this opportunity evaluation activity as well, reducing capabilities to effectively weigh how inputs and actions might affect an uncertain opportunity. Not only does sleep restriction impair creative pursuits (Cai, Mednick, Harrison, Kanady, & Mednick, 2009; Weinberger et al., 2018), but it also inhibits the ability to think of special cases, scenarios, or possibilities that might be essential for the potential success or potential of the idea (Schnyer et al., 2009). Kobbeltvedt, Brun, and Laberg (2005) suggest that sleep restriction harms decision making in uncertain contexts, particularly with the application of time pressure. Indeed, lack of sleep can harm the executive functions necessary to meet novel challenges, exhibit self-control, and stay

focused (W. S. Chan, 2017; Diamond, 2013). Effectively evaluating opportunities requires many of these abilities in-combination, and sleep can disrupt a manager's ability to perform this cognitive integration, subsequently impairing evaluation tasks.

### **Causal versus effectual logic**

Causal decision making approaches attempt to predict future outcomes by employing assumptions that Input A *causes* Output B. Contrarily, effectual decision making supposes that, to the extent that inputs can be controlled, outcome prediction is not necessary.<sup>3</sup> Effectuation logic further assumes that future adjustments to initial intentions may prove necessary when faced with undesired outcomes (Sarasvathy, 2001). Sleepy managers are more disposed to believe that they can measure and predict future outcomes, a decidedly more causal than effectual approach. As I have shown above, research indicates that individuals enact more risk-approach than risk-avoidance tactics when sleep deprived. These individuals take more risks than their well-rested counterparts. The simple task of assigning risk probabilities in truly uncertain situations is problematic because the full range of outcome possibilities is unknown *ex ante* (Knight, 1921). Yet sleep deprived individuals are prone to engage in this behavior. As Gevers and colleagues (2015) uncover, sleep disrupts top-down (i.e., reconfiguring decisions after discovering incongruent or disconfirming data) but not bottom-up (i.e., repeating established patterns in decisions) components of performance. This leaves poor sleepers bereft of the ability to engage in effectual decision making since these individuals lack the ability to modify initial perceptions (also see Y. Harrison & Horne,

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<sup>3</sup> Effectuation scholars might further argue that prediction is not preferable or even possible in uncertain scenarios such as organizational strategy formation (Wiltbank, Dew, Read, & Sarasvathy, 2006), entrepreneurship (Dew, Read, Sarasvathy, & Wiltbank, 2009), or new venture investing (Wiltbank, Read, Dew, & Sarasvathy, 2009).

1999). Thus causal logic represents the path of least resistance for managers who suffer from sleep restriction.

Tired individuals also suffer from poor self-monitoring of performance (Dorrian, Lamond, & Dawson, 2000), potentially leading to illusory claims of control over outcomes. Effectual managers assume that the future is uncertain, and cannot be controlled. So they control what they can and adjust as necessary. Causal managers clamor to control outcomes, which can prove impossible in uncertain situations (Packard et al., 2017). And a perceived lack of control might even exacerbate sleep problems (Morin, Rodrigue, & Ivers, 2003), which I explore again later in a section devoted to the ways in which uncertainty influences sleep. Although underexplored in current organizational research, sleep could prove an important independent variable in the formation of causal or effectual logics while managing uncertainty.

Now that I have unpacked some of the influences sleep has on attention and perceptions, I will move to exploring the reactions managers adopt in the absence of knowledge. The next section explores the action component of uncertainty where managers must decide the responses they will adopt in uncertain situations.

### **Response uncertainty**

Reactions in uncertain situations make up response uncertainty. That is, response uncertainty represents the actions that a manager envisions taking, or actually takes, in an uncertain circumstance. Response uncertainty is where action becomes visible from the management of uncertainty (McMullen & Shepherd, 2006). Deviations from normal sleep rhythms and amounts can affect a manager's emotions and intentions, and can influence managerial personal and interpersonal actions when faced with uncertainty.

## **Errors in pursuit**

Lack of sleep revises reward-seeking behavior, suggesting that managers who have not slept a sufficient amount will pursue different goals from well-rested managers (Mullin et al., 2013). Sleep deprivation lowers inhibition and increases the propensity to impulsively react to negative stimuli (C. Anderson & Platten, 2011). Libedinsky et al. (2013) found that sleep deprivation increases effort discounting, defined as a propensity to select tasks that offer small rewards requiring little effort over alternatives that promise larger rewards with greater effort inputs. Relatedly, sleep deprivation has been found to decrease the ability to harm our interactions with, or consideration of, other individuals in the workplace. Moral awareness (i.e., the notion that a situation can be viewed with a moral lens) is diminished when sleep deprived (Barnes et al., 2015) along with a consequent inability to integrate emotional and cognitive ideations to make moral judgments (Killgore et al., 2007). Chronotype exacerbates the aforementioned moral judgement incompetence (Gunia, Barnes, & Sah, 2014), leaving sleep restricted managers short of their well-rested abilities to perceive and make moral judgments when considering uncertain outcome sets, especially when they perform this task at the wrong time of day (Kouchaki & Smith, 2014).

Managers may also limit the set of available decision paths when they restrict sleep by letting others lead their decision-making calculus, or by settling for decisions that resemble the status quo, thus curtailing creativity from novel insights (U. Wagner, Gais, Haider, Verleger, & Born, 2004; Weinberger et al., 2018). Blagrove and colleagues uncovered that sleepy participants are more likely to respond in-kind to leading questions, and were more likely to revise initial convictions when receiving

disconfirming feedback (Blagrove, 1996; Blagrove, Colemorgan, & Lambe, 1994). In a follow-on experimental study where researchers manipulated both sleep and the quality of advice given to decision makers, a group of sleep deprived decision makers were more likely to take and employ non-expert advice than a well-rested control group (Häusser et al., 2016). This may be especially true when managers receive more commonplace or non-novel advice since it is more difficult to innovate and think flexibly when sleep deprived (J. Chen et al., 2017; Y. Harrison & Horne, 1999). These findings suggest that managers who sleep poorly or sleep less when encountering uncertainty will be more likely to react impulsively, discount more effortful and higher reward projects in favor of quick-hitting smaller reward projects, and travel down paths that appear more familiar.

### **Self-control**

Managers frequently find the need to exhibit volitional control over initial compulsions for action, especially when an initial compulsion might precipitate longer-term negative outcomes. Yet a yet recent stream of research indicates that sleeping at the wrong times, sleeping poorly, or not sleeping enough might leave managers without the ability to inhibit action in response to an initial ill-conceived impulses. Barnes (2012) penned a review that seemed to incite other papers in the organization sciences around sleep and various facets of self-control. At a very basic level, when working in an internet-connected workplace without active management of internet browsing habits, managers and employees can turn to their computers to perform work or view non-work matters online, known as cyberloafing. Self-control is required to resist the urge to steal time at work for cyberloafing purposes. When managers and employees restrict sleep, more cyberloafing happens (Kim, Kim, Park, Kim, & Choi, 2018; D. T. Wagner, Barnes,

Lim, & Ferris, 2012), indicating diminished self-control. From a Process C standpoint, managers are also less likely to inhibit anger and reactive aggression when making decisions outside their normal sleep rhythms (Hood & Amir, 2018). Whether online or not, procrastination increases at work when work time differs from rhythmic biological clocks and preferred chronotype, as is frequently the case in shift work (Kühnel, Sonnentag, Bledow, & Melchers, 2018). Using self-control as a mediator for other workplace outcomes, Barnes, Schaubroeck, Huth, and Ghumman (2011) find that less sleep diminishes self-control, which leads to an increase in unethical conduct. Christian and Ellis (2011) find similarly negative outcomes when they show that less sleep leads to lower self-control, thereby increasing workplace deviance. Lower inhibition harms the management of uncertain situations by increasing the likelihood that managers might procrastinate and avoid difficult decisions, by exposing uncontrolled initial responses, and by impacting social interaction when managers direct employees.

### **Social interaction**

Managers hold decidedly social positions where their interactions with others influence their own work performance, making social interaction a vital outcome for manager employees. Managers are asked to direct employees through uncertain business situations, and worthy managers may actually inspire employees to out-perform previous benchmarks. Managers who do not sleep well are less-able to inspire their employees (Barnes, Guarana, Nauman, & Kong, 2016). Over time, sleep loss hurts relationship quality, unbeknownst to the individuals suffering from restricted sleep (Guarana & Barnes, 2017). Further exacerbating the deleterious effects observed with sleep loss, managers who sleep poorly beget the same behaviors (Gunia, Sipos, LoPresti, & Adler,

2015), leading to potentially vicious cycle of sleep restriction and poor interpersonal outcomes.

Sleep restriction also diminishes interpersonal functioning through reduced empathy for others (Killgore et al., 2008), and it decreases flexibility that might facilitate better social interactions (Kahn-Greene et al., 2006). Well-rested managers who exhibit mature moral reasoning in their interaction with subordinates fail to use mature reasoning when partially sleep deprived, adhering more strictly to predefined rules regardless of their consequences for all parties involved (Olsen, Pallesen, & Eid, 2010). Gordon and Chen (2014) show that interpersonal conflicts between well-rested dyads are more likely to be resolved, noting that if one or both individuals suffer from sleep loss, resolution efforts are likely to be subdued by negative affect and empathic inaccuracy.<sup>4</sup> Indeed, sleep deprivation has been shown to blunt the recognition of both happy and angry facial expressions displayed by another person (van der Helm, Gujar, & Walker, 2010). Olsen, Pallesen, Torsheim, and Espevik (2016) find that transformational leadership practices suffer and interpersonal avoidance behaviors peak when managers restrict sleep. When managers don't sleep well, their interactions with others in the organization suffer, making uncertainty management a less cooperative task than it might otherwise be.

### **Emotional regulation**

Sleep deprivation increases difficulties associated with learning and decision making. Our memories are colored by an affective tone until the act of sleeping facilitates a shedding of the affective tone, leaving a core memory based less on emotion and more on factual information (Walker, 2009). Sleep restriction also disrupts reactions to

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<sup>4</sup> Empathic accuracy can be defined as the ability to accurately perceive, process, and respond to the preferences of another person in a dyadic interaction (McMullen, 2015).



potentially emotional stimuli. For example, using self-reported sleep quantity as a continuous measure, Killgore (2013) finds that higher sleep quantity enhances functional connectivity between the prefrontal cortex and the limbic region of the brain, a pathway believed to regulate prepotent and emotional responses to stimuli (Yoo et al., 2007). Baglioni et al. (2014) find similar results for individuals who experience insomnia. These individuals were less-able to regulate limbic reactions, leading to an emotional bias in subsequent decision making tasks. Even when emotional stimuli are not induced for sleep deprived participants, and emotional brain activity EEG measurements are taken, individuals show a propensity for compromised emotional regulation (i.e., resting state emotional regulation; Zhang, Lau, & Hsiao, 2018). The mechanisms I highlight in the sections above suggest that managers who sleep poorly or at inopportune times will struggle to effectively manage uncertain situations. Beyond these mechanisms I unpack in prior sections, active management of uncertainty also holds the potential to recursively affect a manager's sleep timing and quantity.

### **Recursive relationship between uncertainty management and sleep**

Working in uncertain contexts takes a toll on a manager's ability to recover in non-work time, and sleep is particularly susceptible to these ill effects. Uncertain contexts require creative problem solving, and creative work begets negative spillovers into non-work time (S. H. Harrison & Wagner, 2016). There are plenty other empirical works that emphasize sleep as an outcome, with uncertainty management playing a plausible role as an antecedent. This section highlights how uncertainty management might influence sleep amounts, quality, and timing, thereby further exacerbating subsequent management of uncertainty.

Managerial work disrupts Process C both by interfering with the time available for sleep (i.e., real conflicts of time) or the inability to fall asleep in-rhythm (i.e., psychological conflicts). Individuals who are naturally more prone to eveningness procrastinate in getting to bed, specifically on workdays, and these results are above and beyond a lack of self-control (Kühnel, Syrek, et al., 2018). Greater work-to-family conflict—something that managers experience more than other work groups—leads to inconsistent nighttime sleep clock times and increasingly rigid wake times (Buxton et al., 2016). Widespread smartphone adoption has intensified sleep timing conundrums by increasing the amount of time managers can be on-call to field work-related concerns (Lanaj et al., 2014). To be sure, staying connected with work leads to later work-day bedtimes, even if the morning alarm remains unadjusted considering the later sleep onset (Brunborg et al., 2011; Ziebertz, Beckers, Van Hooff, Kompier, & Geurts, 2017), leaving connected employees off-rhythm getting to bed and ultimately short of sufficient sleep. On the morning-side of sleep time, getting up earlier for work doesn't necessarily correspond with a congruent phase shift to an earlier bedtime (Åkerstedt, Kecklund, & Selen, 2010), again leaving a person in this situation off-rhythm in the short term and accruing a sleep debt if the pattern persists over several days.

Managerial work in uncertain contexts also disrupts Process S by diminishing the overall quantity and quality of sleep. Several social factors influence both short- and long-term sleep problems (Vleeshouwers, Knardahl, & Christensen, 2016). Higher perceived job demands and higher lower perceived job control—both common aspects of highly uncertain contexts—lead to poor sleep quality (De Lange et al., 2009; Magnusson Hanson et al., 2011). Uncertain workplaces are characterized by change, and workplace

changes—including the anticipation of changes that may or may not occur—disrupt an otherwise sufficient night of sleep.

Increased workplace telepressure, defined as the inclination to always be connected or available for work purposes, also leads to poor sleep quality (Barber & Santuzzi, 2015). Managers that perform highly cognitive work tasks see an increased incidence of insomnia (Henry, McClellan, Rosenthal, Dedrick, & Gosdin, 2008), and if some tasks go unfinished at the end of the day, rumination ensues and further disrupts sleep onset and quantity (Syrek & Antoni, 2014; Syrek, Weigelt, Peifer, & Antoni, 2017).

Even though it might seem that managing creatively in uncertain contexts might wear an individual down and facilitate good sleep that night, these types of activities paradoxically make it harder for an individual to rest. In a recent conceptual article, Sonnentag (in-press) calls this the recovery paradox. The recovery paradox affects managers in particular since the negative effects of work on sleep are not necessarily associated with physical strains or overtime hours, but more so with increased cognitive work demands (Åkerstedt et al., 2015). In addition to the fact that salaried employees—managers usually fall into this category—who operate under self-managed work schedules end up working more hours each week than their hourly-wage counterparts (Beckmann, Cornelissen, & Kräkel, 2015), leaving less time in a 24-hour period for sleep, these types of jobs also disrupt the ability to fall and stay asleep (Clinton, Conway, & Sturges, 2017; Exelmans & Van den Bulck, 2017). This inability to psychologically detach from work (viz. Svetieva, Clerkin, & Ruderman, 2017) leaves managers particularly susceptible to the effects I've outlined above, harming managers' overall well-being and rendering them less effective at managing uncertainty.

## **Discussion and future research**

I offer a novel construct into conversations regarding managerial cognition. Incorporating sleep in the overall cognition picture elevates the conditional influence of human a physiological state in our understanding of the critical decisions managers make on a daily basis, decisions that may influence future behavior through path dependence. This leads to a second more general contribution to the management literature. Though uncertainty is usually handled as a special case of the managerial environment, it is increasingly common as globalization and business complexity both grow. Understanding how sleep impacts cognition and decision making in these settings holds implications for executives in organizations of all sizes, and especially in nascent ventures where the direction of the organization is more nebulous, or at least less defined than the strategic direction of more established firms. New ventures shift organizational directions frequently, and many managerial decisions in this context have high leverage on the future activities of the firm and its employees.

I also open a new conversation in the psychology literature. Much existing core work on sleep has focused on decisions where simple tradeoffs or risk are involved. My work pushes the understanding of sleep into the territory of uncertainty. And while management is often characterized by uncertainty, so are environments well outside the scope of management, ranging from natural disasters to interpersonal relationships.

To the management and sleep literatures from which I draw, I offer future research directions. As the investigation into managerial cognition advances, sleep may prove to be a significant factor in determining when decision-makers are cognitively hot or not (Shepherd, 2015; Thagard, 2006). This implies the need for measuring individual

sleep over multiple time points and accounting for the amount of sleep and time of day when investigating decision making. Within the broader study of management, where decisions are often (a) made by larger teams, (b) guided by bureaucratic processes, and (c) unfold over longer periods of time, sophisticated research designs will determine both how and where in these elaborated processes sleep has or does not have influence on the outcome.

In the sleep domain, the two-process model's homeostatic process (Process S) is fairly well understood. Research examining circadian rhythms (Process C) on uncertainty is nascent by comparison. While these effects of sleep on cognition retain wide importance for organizational decision making in most any business context, the study of managers represents a salient example where sleep processes could play an even more momentous role in cognition and decision making. Not only do managers work longer hours (Beckmann et al., 2015; Portes & Zhou, 1996), but they also flex work hours to match the needs of the day (Wiklund et al., 2016). Process S holds implications for long working long hours, especially when sleep hours are trimmed from a manager's schedule. Process C repercussions become salient when busy managers surreptitiously revise sleeping schedules that do not comport with 24-hour circadian timing. Future investigation should observe and test the influence of both sleep processes, offering clear practical implications for managers.

Finally, mechanisms exist between sleep and the management of uncertainty which have not received scholarly attention but offer ripe areas for future investigation. For example, opportunity evaluation represents an uncertain context where nascent options and outcome sets emerge and change on a consistent basis. The study of sleep's

influence on opportunity evaluation would explain dynamic variance in a manager's assessment of effect uncertainty (i.e., how perceived uncertainty might affect an opportunity under evaluation). These and other high-potential areas for future work are enabled through the work in this review.

### **Conclusion**

This research highlights how physiological reactions to sleep processes impair management in uncertain situations. This may beg the question, aside from sleeping more and sleeping at the right times for our biological clocks, what can be done to ameliorate the negative effects? Considering overbooked schedules and frequent sleep disruption, there are some strategies that managers might employ to amend the effects I highlight above. Recent research on remedial policies and treatments indicates that poor sleep outcomes can potentially be buoyed by increased spousal support (Jakubiak & Feeney, 2016), increasing both goal-directed action and control behavior (Welsh, Mai, Ellis, & Christian, 2018), easily-deployed cognitive behavioral therapy (Barnes, Miller, & Bostock, 2017), mindfulness meditation (Murnieks et al., 2019), and the regulation of work hours (including the abolishment of Daylight Saving Time; Barnes & Drake, 2015). These corrective actions hold the promise to improve managerial approaches to decision-making in uncertain organizational contexts, thereby optimizing the process of uncertainty management and follow-on sleep effects that flow from uncertain management activities.

## CHAPTER III

*Note.* This chapter focuses on sleep's role in opportunity evaluation. Previous chapters have highlighted the importance of investigating dynamism in the management of uncertainty. The chapter immediately preceding this one suggests opportunity evaluation as a promising area for future research, where sleep's influences are underexplored. This chapter dives deeply into how sleep specifically influences an entrepreneur's ideation and belief formation regarding early stage new ventures. This work is coauthored with David Wagner, Denis Grégoire, and Christopher Barnes and was accepted on June 12, 2019 for publication at the *Journal of Business Venturing*.

### 1. Introduction

Entrepreneurship typically starts with one or more individuals forming positive beliefs about a new venture idea (Davidsson, 2015). Some venturing ideas can be relatively well formed (with articulated models of what to offer which customers, how, when, and why), whereas other ideas are more fluid intuitions that something different could be done. Yet not all new venture ideas move forward (McMullen & Dimov, 2013). Some ideas are developed further and eventually pursued, utilizing entrepreneurs' time and resources; others are left on the cutting room floor. Entrepreneurial action thus rests not only on entrepreneurs' abilities to *imagine* new supply-demand combinations (Dey & Mason, 2018; Grégoire, Barr, & Shepherd, 2010; Sarasvathy & Venkataraman, 2001), but also on their initial formation of sufficiently positive beliefs about such possibilities (H. S. Chen, Mitchell, Brigham, Howell, & Steinbauer, 2018; McMullen & Shepherd, 2006; Shepherd, McMullen, & Jennings, 2007; Wood & Williams, 2014).

To date however, models of these cognitive feats have tended to highlight the positive

role of particular kinds of individual resources, such as an entrepreneur's amounts of relevant prior knowledge (Frederiks, Englis, Ehrenhard, & Groen, 2019; Shane, 2000), entrepreneurial experience (Ucbasaran, Westhead, & Wright, 2009) or other forms of human and social capital (Gruber, MacMillan, & Thompson, 2012; Ko & McKelvie, 2018). These individual resources offer important advantages. Among the most salient, they do not deplete with use; using one's knowledge to imagine several new ventures ideas will not leave the entrepreneur with less knowledge. Similarly, the value of these resources remains relatively robust to environmental changes. At least in the short-to-medium term, small-to-moderate changes in circumstances do not render the value of one's social networks obsolete, no more so than such changes reduce the pertinence of the skills one has derived from having successfully grown several ventures. But individual resources like knowledge, skills, and social capital also take a long time to acquire. As a result, current emphases on the positive effects of enduring individual resources raise the question whether sufficient attention has been devoted to the effects of factors exhibiting variations not only between individuals, but also within their day-to-day activities.

Interestingly, a growing body of research draws increased attention to the influence of dynamic factors, like the influence of day-to-day variations in moods and emotions on entrepreneurs' efforts (e.g., Baron, 2008; Delgado García, Quevedo Puente, & Blanco Mazagatos, 2015; Foo, Uy, & Baron, 2009). Moreover, a prominent interest is emerging for examining the impact of biological factors for entrepreneurship (Nicolaou, Patel, & Wolfe, 2018; Nicolaou, Phan, & Stephan, 2018; Nofal, Nicolaou, Symeonidou, & Shane, 2018; Shepherd & Patzelt, 2015; Wiklund, Yu, Tucker, & Marino, 2017). Combining both impetuses, a few scholars have begun investigating the physiological dynamics



underpinning entrepreneurs' capabilities. Focusing on the creative processes fostering entrepreneurship, Weinberger et al. (2018) drew attention to the critical importance of physiological and mental recovery to enable creative problem-solving. Murnieks et al. (2019) highlight sleep as an important recovery activity to stave off perceived exhaustion among entrepreneurs. Kollmann, Stöckmann, and Kensbock (2018) provide evidence that stresses associated with entrepreneurial careers hinder sleep's recovery benefits. A nationwide survey in the U.S. suggests that entrepreneurs who suffer from sleep restriction also report psychological distress (Wolfe & Patel, 2019). This emerging body of work suggests that sleep influences entrepreneurial pursuits, which subsequently affect sleep. For all the possibilities that lie at the interface between biology and entrepreneurship, however, these studies have yet to explain the specific pathways through which physiological variations in recovery and sleep affect entrepreneurs' effective capabilities to think about promising new venture ideas.

To advance academic understanding of these intriguing possibilities, we develop and test a theoretical model articulating the cognitive linkages between the universal physiological necessity of sleep and one's abilities to imagine promising new venture ideas and form congruent 3<sup>rd</sup>-person "confidence" beliefs about the attractiveness of such ideas (Davidsson, 2015). Central to our model are the attentional and cognitive dynamics by which individual entrepreneurs attend to, weigh, and align relevant pieces of knowledge and information in their efforts to imagine and make sense of new venture ideas (Shepherd, McMullen, & Ocasio, 2017). Building on studies that suggested the importance of cognitive processes of association and similarity comparisons not only in creativity and imagination tasks in general (Christie & Gentner, 2010), but also in opportunity ideation

more specifically (Grégoire et al., 2010; Wood, Williams, & Grégoire, 2012), we develop theoretical explanations for *why* sleep influences entrepreneurs' abilities to perform the attentional and associative tasks at the basis of opportunity ideation. We examine these conjectures through a progressive series of empirical studies mobilizing different methodological designs and samples.

By bringing together theoretical advances on the cognitive underpinnings of entrepreneurial capabilities with the emerging interests for examining the influence of physiological dynamics, we contribute new insights about the cognitive linkages between sleep and individual capabilities to both *imagine* new venture ideas and *form* initial 3<sup>rd</sup>-person beliefs about such ideas. Moving beyond prior evidence that sleep matters, our work articulates theoretical explanations on *why* sleep has positive effects on critical entrepreneurial capabilities. In turn, we provide theoretical and empirical bases to guard entrepreneurs against the negative effects of curtailing sleep. Indeed, our findings contradict the oft-heard admonition that in order to be successful, aspiring entrepreneurs should devote all their time and energies to their venture.

## **2. Theoretical framework**

### **2.1. Sleep and entrepreneurship**

Sleeping not only satiates our homeostatic, physical need for rest, but also regulates our body's natural rhythm (Borbély, 1982; Borbély & Achermann, 1999; Borbély, Daan, Wirz-Justice, & Deboer, 2016). Several meta-analyses corroborate the benefits of adequate sleep (Lim & Dinges, 2010; Litwiller, Snyder, Taylor, & Steele, 2017; Pilcher & Huffcutt, 1996). Indeed, research has shown that deep sleep (as opposed to simply resting or taking naps) affixes transient information and experiences into long-term memory (Walker &

Stickgold, 2006) and allows for making novel associations between different pieces of knowledge, thus fostering increased creativity (Cai et al., 2009; U. Wagner et al., 2004). By contrast, reduced sleep hinders the use of working memory, which is important for performing more complex analytical tasks (C. Schmidt et al., 2015). Moreover, sleep restriction impairs other executive functions such as inhibition, attention, and cognitive flexibility (Diamond, 2013). These effects have important implications for entrepreneurship research and practice.

## **2.2. Investigating sleep's effects in early phases of entrepreneurship**

Contemporary research on the initial phases of entrepreneurial action have largely centered on the emergence of entrepreneurial opportunities (e.g., Eckhardt & Shane, 2003; Santos & Eisenhardt, 2009), and on the formation of intentions towards pursuing particular ones (e.g., Autio, Dahlander, & Frederiksen, 2013; Dimov, 2007; Wood, Williams, & Drover, 2017). Several articles debate the ontological nature of opportunities as either objective realities that arise exogenously from changing circumstances (and must thus be discovered by alert individuals), or as subjective ideas that arise endogenously from actors' imaginations and efforts (see S. A. Alvarez & Barney, 2007; S. A. Alvarez, Barney, McBride, & Wuebker, 2017; Ramoglou & Tsang, 2016), whereas more recent papers have advocated abandoning the concept altogether (e.g., Foss & Klein, 2019). Building on the advances permitted by these debates, we acknowledge that venturing ideas can emerge as reasonable deductions "discovered" from a set of external circumstances or can proceed from individuals' enactment efforts to "engage" their circumstances and "create" new possibilities. Our work focuses on the beliefs that individuals form about such emerging ideas.

Theoretical models of entrepreneurial processes have encouraged distinguishing between early-stage 3<sup>rd</sup>-person beliefs about the attractiveness of new venture ideas (Shepherd et al., 2007), one's 1<sup>st</sup>-person beliefs about his/her capabilities and motivations to exploit a particular new venture idea (Wood & Williams, 2014), and the subsequent instantiations of such ideas into concrete entrepreneurial projects (Davidsson, 2015; McMullen & Shepherd, 2006; Wood et al., 2012). In the first “attentional” stage, the formation of 3<sup>rd</sup>-person opportunity beliefs concerns the reduction of one's perceptions of radical uncertainty. By virtue of their prior knowledge, ongoing experiences, the various stimuli they encounter and their imagination (Kier & McMullen, 2019), some people develop the emerging conviction that introducing a new product or service to address a particular problem in a market might be a “worthwhile” and “feasible” idea that could be pursued by anyone with the means and desire to do so. By contrast, the formation of 1<sup>st</sup>-person opportunity beliefs concerns one's willingness to bear uncertainty. As such, the relevant phenomenon is the transition from having a new venture idea to determining whether this might be a good idea for me (knowing who I am, my desires, the resources at my disposal, etc.; Wood et al., 2012).

In this paper we focus on the former processes, opportunity ideation and the initial formation of 3<sup>rd</sup>-person beliefs about such ideas' attractiveness. The reason is simple: ideation starts with individual dynamics that can happen virtually anytime. Even if entrepreneurs can discuss their ideas with others and are undoubtedly influenced by their environment, the tasks of imagining and making initial sense of promising new venture ideas fundamentally rest on individual cognitive dynamics where short-term variations in dynamic physiological states (like sleep) might have some of their most potent effects. By

contrast, the formation of 1<sup>st</sup>-person opportunity beliefs and the transitioning from intentions to action likely takes place over longer periods of time and will typically involve numerous interactions with other people.

### **2.3. Cognitive models of opportunity ideation**

Opportunity ideation concerns entrepreneurs' efforts to imagine new products, services, or ways of doing business (see Sarasvathy & Venkataraman, 2001). While conceptual studies debated the extent to which such ideas were “discovered” (from the environment) or “created” (by one's actions), many empirical studies investigated the influence of enduring traits and resources in explaining why some individuals appear more able than others at imagining promising new venture ideas. For instance, scholars have pointed at the influence of prior knowledge of technologies, markets or industries (e.g., Shane, 2000; Shepherd & DeTienne, 2005), of an entrepreneur's human capital and entrepreneurial experience (Ucbasaran, Westhead, & Wright, 2008), or of one's search of (or exposure to) relevant information signals (Autio et al., 2013; Vaghely & Julien, 2010). In turn, other studies have begun unpacking the cognitive dynamics involved in people's ideation efforts. Gielnik and colleagues (2012; 2014) published a series of studies documenting the import of divergent thinking on business idea generation. For their part, Kier and McMullen (2019) proposed a model emphasizing one's imaginativeness, whereas Frederiks et al. (2019) documented the influence of future-oriented cognitive processes (see also Wood & McKelvie, 2015).

Among the scholars attempting to better understand the cognitive feats by which entrepreneurs are able to identify promising new venture ideas, Grégoire and colleagues integrated an overall conception of entrepreneurial opportunities as new supply-demand

combinations (Venkataraman & Sarasvathy, 2001) with a series of empirical studies documenting the role of cognitive processes of similarity comparisons and structural alignment (see Grégoire et al., 2010; Grégoire & Shepherd, 2012). These authors postulate that at the early imagination stage, new venture ideas concern the matching of mental representations of new means of supply on the one hand, and of latent market needs on the other. Building on this conceptual articulation, they investigated the extent to which entrepreneurs effectively mobilized the similarities between supply and demand representations in their efforts to come up with new venture ideas (Grégoire et al., 2010) and documented that variations in the similarities between technologies and markets influenced entrepreneurs' early-stage beliefs about technology-market pairs (Grégoire & Shepherd, 2012).

From a cognitive standpoint, these studies highlight the influence of one's consideration of different kinds of supply-demand similarities. According to structural alignment theory (Gentner, 1983; Gentner & Markman, 1997), people perceive and process two broad kinds of similarities: superficial and structural. The distinction concerns which aspects of mental representations are being compared. A mental representation's superficial elements consist of the basic parts forming a representation (or the characteristics of such parts), whereas the representation's structural relationships concern the manner how the parts and characteristics "relate" to one another, how they "work" together. Research in this area showed that the perception and processing of the two different kinds of similarities mobilize different neurological structures, with different effects on memory, learning, and reasoning. This insight has had important implications for understanding a host of cognitive phenomena ranging from the way people form new

concepts and categories to the way people make sense of new information, solve problems, or make decisions (see Gentner, Holyoak, & Kokinov, 2001).

Building on this research, Grégoire et al. (2010) showed that entrepreneurs spontaneously mobilize structural similarities in their efforts to identify promising venture ideas for new technologies. For their part, Grégoire and Shepherd (2012) drew attention to the particular challenges of non-obvious technology transfers—for instance, lab-to-market transfers that take place across domains of development and applications that appear conceptually far from one another. From a structural alignment standpoint, these transfers imply that individuals form positive beliefs about technology-market pairs that exhibit low levels of superficial similarities but high levels of structural similarities. Efforts to apply a technology developed by NASA engineers for space shuttle pilots (superficial elements of the technology) in the superficially different context of parents working with educators, doctors and therapists (superficial elements of one's mental representation of a market) to try to alleviate their children's attention deficits illustrate this. Even if the manner in which the new technology operates implies that it has the capabilities to address the same needs that both NASA and parents may have (high structural similarities), the superficial *dissimilarities* between the NASA and family contexts lead people to form less positive beliefs about this real-life application of the technology than when the technology was presented as having been developed by educational psychologists working with students (thereby alleviating the prior superficial dissimilarities). Interestingly, these authors also showed that differences in prior knowledge and entrepreneurial intent influenced the extent to which individuals attend to structural similarities, even when encountering superficial dissimilarities. This hints at the possibility that other factors—including physiological

dynamics—might influence the processes by which individuals imagine new venture ideas. We thus turn to this intriguing possibility, focusing on sleep’s effects on individual capabilities to imagine promising new venture ideas and form positive 3<sup>rd</sup>-person beliefs about such ideas. In this regard, we anchor our work on the assumption that individuals who engage in such efforts typically “operate” in circumstances, employment conditions, family, or other personal situations that could involve some measures of sleep restrictions. In other words, we assume that individuals engaging in early-stage entrepreneurial efforts will naturally exhibit various levels of sleep restriction. The question we ask is what happens when this is the case?

#### **2.4. Sleep’s effects on opportunity ideation**

Sleep supports higher-order thinking. Building on the aforementioned notions that sleep has positive effects on the completion of tasks that require the mobilization of higher-order executive functions (and that lack of sleep has negative effects on such tasks, see section 2.1.), it logically follows that sleep’s effect on efforts to imagine promising new venture ideas should manifest itself in individuals’ abilities to mobilize the cognitively more demanding yet practically important structural relationships evidenced in Grégoire et al.’s studies (Grégoire et al., 2010; Grégoire & Shepherd, 2012). This is not to say that people do not pay attention to superficial features, or that their creative efforts to imagine promising ideas do not also mobilize superficial similarities. Yet prior research indicates that capacities to attend to and process structural similarities are particularly influential in creative ideation tasks. Building on these notions, we add that the more rested someone is, the more this person should be able to perceive, process, use, and interpret various instances of structural similarities between the mental representations he or she forms of different



means of supply and latent market needs. We further postulate that getting less sleep adversely affects one's opportunity ideation capabilities. This is because well rested individuals are more risk averse (Maric et al., 2017), have expanded working memory capacity to attend to more structural cues (Chee & Choo, 2004), and are more cognitively flexible (Diamond, 2013). In sum, sleep-restricted persons should be less able to mobilize higher-level structural considerations.

***Hypothesis 1:** In their efforts to imagine promising new venture ideas, sleep-restricted individuals will pay less cognitive attention to structural similarity considerations than will well-rested individuals.*

A parallel body of research shows that higher-level reasoning, such as one's mobilization of analogies and other structural cognitive processes, fosters creative insights and idea generation (see J. Chan, Paletz, & Schunn, 2012; J. Chan & Schunn, 2015; Clarke & Holt, 2017). Interestingly, sleep has been shown to facilitate the restructuring of memory in ways that lead individuals to gain insight into abstract rules governing novel tasks (U. Wagner et al., 2004). A host of other studies have argued for the benefits of sleep on creative performance (e.g., Weinberger et al., 2018), particularly to the extent that the opportunity or problem is reactivated during the period of rest (Ritter, Strick, Bos, Van Baaren, & Dijksterhuis, 2012). Considered together, these studies suggest that sleep fosters creative production. Thus, we postulate that sleep will have a positive influence on the number and quality of the new venture ideas generated, whereas less sleep will likely hinder an individual's creative output.

***Hypothesis 2ab:** Sleep restriction will be associated with imagining (a) fewer new venture ideas and (b) less attractive new venture ideas.*

## **2.5. The initial formation of 3<sup>rd</sup>-person opportunity beliefs**

Getting an idea for a promising entrepreneurial new venture is one thing. Deciding to pursue this idea is quite another (Dimov, 2007; McMullen & Shepherd, 2006; Wood, McKelvie, & Haynie, 2014). In between these two milestones, scholars interested in unpacking entrepreneurship's early stages have highlighted important theoretical distinctions between forming 3<sup>rd</sup>- and 1<sup>st</sup>-person opportunity beliefs (please see Section 2.2. above).

McMullen and Shepherd (2006) speculated that the initial impetus for forming 3<sup>rd</sup>-person opportunity beliefs proceeds from one's encounter with new information stimuli (for instance, learning about the existence and capabilities of a new technology). By extension, we infer that the formation of 3<sup>rd</sup>-person opportunity beliefs can start from learning about new possibilities for conducting certain business activities "differently," or more generally from "getting" the idea of doing things differently. This inference is directly consistent with Davidsson's (2015) notion of environmental enablers, which he formally defined as "(a) single, distinct, external circumstance, which has the potential of playing an essential role in eliciting and/or enabling a variety of entrepreneurial endeavors by several (potential) actors (Davidsson, 2015: p. 683 Table 5)."

But becoming aware of new information about a potential new technology or the possibility of "doing things differently" is not sufficient. To begin forming 3<sup>rd</sup>-person opportunity beliefs, one must be in position to interpret the new information in light of a motivational frame—what McMullen and Shepherd (2006) label "personal strategy." Accordingly, we theorize that the second "ingredient" for prompting the formation of 3<sup>rd</sup>-person opportunity beliefs is one's awareness of some latent demand in a market context.

This is what provides the motivational contextual frame for applications of new knowledge about (technological) possibilities, which lead an entrepreneur to start making sense of a new venture idea.

From the standpoint of modeling the formation of 3<sup>rd</sup>-person opportunity beliefs, the above considerations highlight two requisites to form 3<sup>rd</sup>-person opportunities: learning (new) knowledge about the “possibility” of doing things differently, and a motivational context where applying these new “possibilities” would become meaningful, and more specifically in this case, because of the presence of latent demand. McMullen and Shepherd (2006) implicitly suggested as much:

*The acknowledgment of a third person opportunity arising from a technological change is configural in the sense that people who have the necessary knowledge and motivation will believe that there is third-person opportunity arising from a technological change, but those who do not have the necessary knowledge and motivation will not believe that the technological change represents an opportunity for someone and will no longer attend to it (McMullen & Shepherd, 2006: p. 141).*

Although derived from unpacking McMullen and Shepherd’s (2006) model, observations about the importance of having *both* the knowledge of new possibilities *and* a motivational context to make sense of these possibilities directly echo the above conceptualization of new venture ideas as concerned with new supply-demand combinations (Grégoire et al., 2010; Grégoire & Shepherd, 2012; Venkataraman & Sarasvathy, 2001). More fundamentally, for the present purposes, these observations reinforce the importance of cognitive processes of similarity comparisons and structural alignment in the formation of 3<sup>rd</sup>-person opportunity beliefs. Accordingly, we theorize that the formation of 3<sup>rd</sup>-person opportunity beliefs proceeds at least in part through one’s consideration of the similarities and dissimilarities between a new venture idea’s proposed

means of supply / technological solution and target market.

## **2.6. The normative conundrum of subjective beliefs about new venture ideas**

Before developing specific hypotheses about sleep's effects on the formation of 3<sup>rd</sup>-person opportunity beliefs, however, it behooves us to briefly establish our position with respect to the relative merits of different new venture ideas—and of the early-stage beliefs formed by different individuals about such ideas. Owing to the high levels of radical uncertainty surrounding innovative new venture ideas in a time-forward perspective (see McMullen & Dimov, 2013; Townsend et al., 2018), the intrinsic value of new venture ideas cannot be determined ahead of time. Because of this, engaging in theoretical developments and results interpretation about the apparent “merits” of new venture ideas calls for a great deal of nuance.

Yet this shall not preclude the relevance of theorizing about the dynamics by which some people might form different 3<sup>rd</sup>-person beliefs about the perceived “attractiveness” of different ideas (Davidsson, 2015). Even within a forward-looking perceptual world, some ideas will tend to be broadly perceived as exhibiting more attractiveness than others. In this regard, Davidsson (2015) recently proposed the notion of “opportunity confidence” to “refer strictly to a particular actor’s subjective evaluation of the *attractiveness*, or lack thereof, of a stimulus (External Enabler or New Venture Idea) as the basis for entrepreneurial activity (p. 675).” Assuming that different individuals can express different levels of “confidence” about the perceived attractiveness of different new venture ideas, the normative challenge is to determine under what theoretical conditions one might be warranted to gauge these expressions of confidence against a relevant benchmark. Building on prior research, we propose (and eventually mobilize) two distinct theory-to-

method articulations for doing this.

The first consists of using the 3<sup>rd</sup>-person beliefs of experts. Prior research has shown that expert entrepreneurs, business angels, and venture capitalists often have converging thoughts on what constitute highly attractive new venture ideas (Baron & Ensley, 2006; Franke, Gruber, Harhoff, & Henkel, 2006; Petty & Gruber, 2011). Though it is normatively impossible to establish the “true” potential of an opportunity idea ex ante (Knight, 1921; Townsend et al., 2018), the ratings of third-party experts provide a defensible benchmark against which to gauge the 3<sup>rd</sup>-person opportunity beliefs that different individuals form about a focal idea. We use such considerations in Studies 1 and 3.

The second approach we propose builds on prior studies’ observations that early-stage perceptions of a new venture idea’s attractiveness rest in large part on considerations that are inherently logical and pragmatically useful, like the size of a new venture idea’s proposed market (see Baron & Ensley, 2006) or the cogency of its product/service’s characteristics (see Petty & Gruber, 2011). We used such logical considerations in Study 2 below.<sup>5</sup>

## **2.7. Sleep’s effects on the formation of 3<sup>rd</sup>-person opportunity beliefs**

Building on the above theoretical developments, we postulate that sleep will have positive influences on the formation of 3<sup>rd</sup>-person opportunity beliefs that are congruent with that of experts (and/or logical principles), just as sleep restriction will have detrimental

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<sup>5</sup> We explicitly acknowledge that neither approach allows us to derive normatively-warranted implications about the “true” merits of different new venture ideas, or of the particular research material we develop to articulate our empirical studies below. We bound these merit-based arguments by suggesting that experts’ ratings and logical principles provide defensible theoretical benchmarks against which to investigate sleep’s effects on the formation of congruent 3<sup>rd</sup>-person “confidence” beliefs about different new venture ideas.

effects. A wide body of research has established that lower amounts of sleep diminish attention paid to relevant situational cues (Frenda & Fenn, 2016; Y. Harrison & Horne, 2000; Lee, Manousakis, Fielding, & Anderson, 2015), an essential capacity for attending to relevant opportunity signals arising in the environment (Shepherd et al., 2017). Moreover, studies have shown that less sleep impedes the memory retrieval of relevant interpretation models (Fortier-Brochu & Morin, 2014) and the ability to draw meaningful inferences from such models (Diekelmann & Born, 2010; U. Wagner et al., 2004).

Further compounding the problems associated with restricting sleep is the likelihood that a sleepy entrepreneur who uncovers a significant risk associated with a new venture idea is more likely to inappropriately consider that risk. Sleep restriction limits inhibition (Chuah, Venkatraman, Dinges, & Chee, 2006), moves individuals from a state of protecting against losses to a state of seeking increased gains (Venkatraman et al., 2011), and diminishes the activation of aversion and punishment systems that might otherwise be enacted (Venkatraman et al., 2007). Restricting sleep also makes decision makers more inclined to pursue short-term gains even when these imply long-term losses (Killgore et al., 2012). This evidence suggests that when trying to form 3<sup>rd</sup>-person beliefs about a potential new venture idea while short on sleep, people are afflicted with diminished abilities to pay attention to those aspects of a new venture idea that would pose a risk to the venture's success. Consequently, individuals who form initial beliefs about new venture ideas while short on sleep are more likely to overlook problematic aspects of certain opportunities. This diminished risk aversion could lead to the pursuit of suboptimal new venture ideas.

In sum, we propose that sleep restriction undermines the formation of congruent 3<sup>rd</sup>-

person opportunity beliefs in three primary ways. First, it impairs the process of attending relevant signals about a new venture idea and its particular contexts. Second, this lack of attention undermines the memory-retrieval of more pertinent and/or elaborate criteria for evaluating the idea. And third, sleep restriction impairs the consideration of relevant risk factors. By contrast, sleep should allow for deeper interpretations of what a new venture idea might entail. Taken together, these arguments support the notion that the 3<sup>rd</sup>-person beliefs of well-rested individuals should be more congruent with those of reputed experts than will those of sleep-restricted individuals. We formalize these arguments in the following hypothesis:

***Hypothesis 3:** Sleep restriction will lessen individual abilities to form 3<sup>rd</sup>-person opportunity beliefs that are congruent with external markers of these ideas' attractiveness*

Building on the above structural alignment view of opportunity ideation (see Grégoire et al., 2010), we further hypothesize that one's ability to attend to structural similarities will mediate sleep's effects on the formation of congruent 3<sup>rd</sup>-person beliefs. As mentioned when examining sleep's effect on similarity comparisons above, reducing sleep hinders individual abilities to process relevant information signals, such that it becomes more difficult for individuals to make deep structural comparisons of innovations and markets (see Gentner et al., 2001). The reason for this is that sleep positively affects one's capability to attend to a new venture idea's structural relationships (i.e., the alignment of the underlying "causes" of a new means of supply's capabilities with those of a market's latent needs). Sleep restriction encumbers these capabilities, such that poorly-rested individuals are more likely to limit their consideration of opportunity signals to superficial comparisons of an idea's new means of supply and latent market demand.

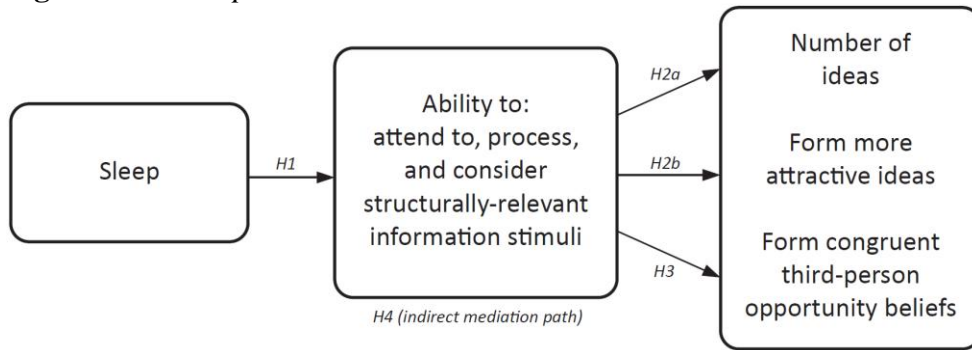
Cognitive research also indicates that working memory plays a pivotal role in enabling individuals to attend to situational cues and enables the comparison of those cues to various relevant criteria, especially in complex or non-superficial comparisons (Kane et al., 2004; Unsworth & Engle, 2007). But research also shows that sleep loss deters working memory (Chee & Choo, 2004). As a result, sleep-restricted individuals will tend to mischaracterize new venture ideas when superficial similarity does not match structural alignment. In these mismatched situations an individual would have to go deeper than the superficial level to form a belief congruent with experts. On the contrary, well-rested entrepreneurs should be more adept at attending to the higher-order structural relationships that are more critical to an endeavor's success, leading to the formation of opportunity beliefs more congruent with those of experts in the mismatched cases. These considerations lead us to postulate that one's ability to attend to relevant structural alignment cues forms the processual conduit through which sleep influences the formation of congruent 3<sup>rd</sup>-person opportunity beliefs.

***Hypothesis 4:** The ability to attend to structural similarity considerations will mediate the association between sleep restriction and one's formation of congruent 3<sup>rd</sup>-person opportunity beliefs.*

We test the above hypotheses and the model depicted in Figure 1 through a progressive series of empirical studies mobilizing different data collection techniques, designs, and samples.



**Figure 1 – Conceptual model**



### **3. Study 1: A First Exploratory Look at Sleep’s Effects “in the Field”**

To better unpack sleep restriction’s effect on opportunity ideation and provide preliminary evidence for sleep restriction’s adverse effects on entrepreneur’s abilities to form 3<sup>rd</sup>-person confidence beliefs that were congruent with experts’ ratings of the same ideas, we began by conducting an exploratory online survey of experienced entrepreneurs ( $N = 784$ ).

#### **3.1. Sample**

In order to conduct our test with a sample of participants who had a minimum of experience in 3<sup>rd</sup>-person opportunity belief tasks, we worked with a medium-sized business-planning software company from the northwestern United States to sample from approximately 60,000 founders, partners, or owners of small- to medium-sized businesses on their customer mailing list. The software company’s CEO sent an e-mail invitation to all potential participants, with a link to the online survey. As an incentive to participate, we offered respondents a chance to win a \$500 gift card. A total of 1,179 English-speaking respondents began the survey. From these, we removed 206 participants who did not complete the tasks, as well as 189 response sets that failed attention checks built into the survey. This left 784 completed sets of answers (66% of the initial responses).

### 3.2. Data collection procedures and research material

Participants first answered a series of questions about the sleep they had the previous night, and then made 3<sup>rd</sup>-person assessments of three executive summaries of new venture projects excerpted from the preliminary rounds of a major business plan competition taking place in the United States<sup>6</sup>. We chose these three particular summaries because a panel of three experts (chosen for their experience as serial entrepreneurs) had first independently scored these summaries and had indicated that the three were representative of the competition yet exhibited varying levels of perceived attractiveness (low, moderate, and high)<sup>7</sup>. Importantly, the highly- and moderately-attractive ideas possessed both superficial similarity and structural similarities. The less attractive idea had high superficial similarity, but low structural alignment between technology and market. This means that the less attractive idea was the only one that required a deeper-than-superficial assessment for accurate assessment.

We asked participants to read each new venture idea one at a time. We presented the summaries in random order so as to prevent order effects from biasing our observations. The survey instructions explicitly informed participants that three experts had reviewed these new venture ideas, and that their beliefs would be compared to those of experts. As a strategy to boost participant attentiveness, we told the entrepreneurs that the extent to which their ratings matched those of the expert raters, their odds of winning the \$500

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<sup>6</sup> Due to confidentiality concerns and our agreement with the business plan competition, we cannot share the executive summaries used for the study. Please contact the corresponding author if you wish to review the material.

<sup>7</sup> The expert judges displayed a high level of agreement on these ideas' attractiveness ( $ICC_3 = .94$ ,  $F(2, 4) = 52$ ,  $p = .001$ ) and willingness to invest ( $ICC_3 = .89$ ,  $F(2, 4) = 25$ ,  $p = .006$ ). The high variation in attractiveness between the three new venture ideas and the consistency observed in the judges' rankings made this particular bundle of new venture ideas particularly well-suited for our study. The length of the proposals did not correlate with the experts' rankings. We presented the new venture ideas to participants in random order in each of the 3<sup>rd</sup>-person ranking tasks.

drawing would be enhanced.

### 3.3. Dependent and independent variables

*3<sup>rd</sup>-person opportunity beliefs.* For each new venture idea presented in the online survey, we asked participants to open a pop-up window where they could review the business plan's executive summary. After they had reviewed all three, we asked participants to rank them from best to worst. To facilitate interpretation, we reverse-coded the responses such that a higher number represents a more favorable belief. These rankings form the dependent measure for Study 1.

*Sleep.* We measured sleep using questions adapted from the Pittsburg Sleep Quality Index (PSQI; Buysse, Reynolds, Monk, Berman, & Kupfer, 1989). The PSQI asks for the time when a participant went to bed the previous night, the amount of time it took to fall asleep, the number of minutes spent awake during the night, and the time when the respondent finally woke up in the morning. We combine these to obtain a continuous measure of participants' sleep quantity from the previous night. We also used a self-report 2-item instrument ( $\alpha = .87$ ) assessing participant sleep quality (Westerberg et al., 2010), and a single item asking how much sleep the respondent normally gets in a single night.<sup>8</sup>

### 3.4. Analysis

In order to identify possible relationships between participants' sleep and their 3<sup>rd</sup>-person opportunity beliefs, we performed an ordinal logistic regression on the participant

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<sup>8</sup> Prior to analyzing the data, we tested the assumption that entrepreneurs in our sample experienced variability in the amount of time they sleep from day to day. The sample average of sleep the preceding night ( $M = 6.48$  hours,  $SD = 1.49$ ) and on a normal night of sleep ( $M = 6.27$  hours,  $SD = 1.64$ ) were roughly equivalent, but a comparison of the prior night's sleep with the individual's typical night of sleep at an individual level revealed an absolute difference across participants of 1.08 hours of sleep. This suggests that the entrepreneurs in our sample exhibit sleep variability, in particular on the night of study as compared to the average amount of sleep reported ( $M = 1.08$  hours,  $SE = 0.02$  hours, 95% CI [1.04, 1.13]), supporting our assumption that entrepreneur sleep varies on a daily basis.

ranking of the three executive summaries. The ordered logit method predicts all three ranking outcomes simultaneously and provides better fit to the data than ordered probit methods, as indicated by a lower Bayesian Information Criterion (BIC; Logit BIC = 1413.58 and Probit BIC = 1423.23).

### 3.5. Results

Data from this first exploratory study show that the participants' average rankings of the ideas was largely congruent with that of the experts (Wald  $\chi^2$  (2,  $N = 2352$ ) = 10.56,  $p = .005$ ) in the sense that on average, the entrepreneurs who responded to our online survey ranked the business summaries in the same order as the panel of experts. As Figure 2 indicates, the idea that experts had ranked as most attractive received a mean ranking of 2.41, whereas the idea that experts had ranked as least attractive received a mean ranking of 1.51 and the other idea fell in between (2.09).

We hypothesized above that sleep will be positively related to participants' abilities to form 3<sup>rd</sup>-person opportunity beliefs congruent with experts' rankings (H3). When all summaries were analyzed together, we did not find statistically-significant evidence for a main effect of sleep on opportunity beliefs (Wald  $\chi^2$  (1,  $N = 2352$ ) = 0.18,  $p = .676$ ).

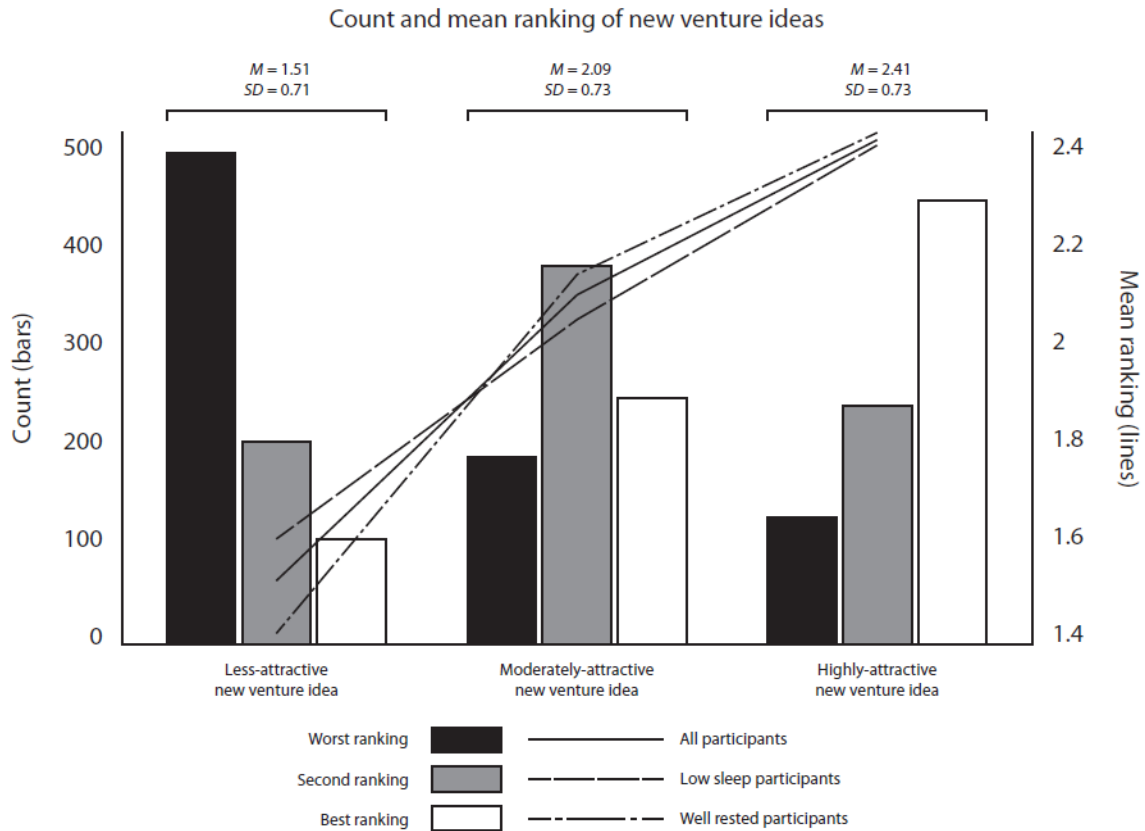
Interestingly, however, analyses revealed that participants who reported *less sleep* ranked the less-attractive idea *higher* than participants who had reported more sleep ( $\beta = -.141$ , Wald  $\chi^2$  (1,  $N = 784$ ) = 3.77,  $p = .052$ , 95% CI [-.282, .001],  $\phi = .07$ ). There was no evidence of a similar effect for the moderately-attractive ( $\beta = .069$ , Wald  $\chi^2$  (1,  $N = 784$ ) = 0.76,  $p = .384$ , 95% CI [-.075, .196]), or highly-attractive ideas ( $\beta = .015$ , Wald  $\chi^2$  (1,  $N = 784$ ) = 0.09,  $p = .770$ , 95% CI [-.084, .114])<sup>9</sup>. Though falling just above the commonly-

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<sup>9</sup> We observed similar results using sleep quality as a predictor. Participants who reported low sleep quality were more likely to rank the less-attractive idea *higher* than the well-rested participants ( $\beta = -.251$ , Wald  $\chi^2$

accepted  $p < .05$  threshold for statistical significance (.052), these results provide initial support for H3's notion that, compared to well-rested individuals, entrepreneurs who slept less may be hindered in their abilities to form 3<sup>rd</sup>-person beliefs about new venture ideas that are congruent with those of third-party experts.

**Figure 2** – Participants' ranking of new venture ideas (frequency count) and mean ranking for each idea



*Note.* Participants were asked to rank three business opportunities of varying attractiveness ( $N = 784$ ). The opportunities were initially assessed by a panel of expert entrepreneurs to determine this attractiveness (low, moderate, or high). The bars above each opportunity represent the count of participants who ranked the idea at each level.

Figure 2 illustrates these effects by partitioning all participants into three terciles (the lower 33% who had slept < 5.93 hours, the 33% who had slept between 5.93 and 7.26 hours and

(1,  $N = 784$ ) = 5.27,  $p = .022$ , 95%CI [-.466, -.037],  $\phi = .08$ ). And there was no evidence of a similar effect for the moderately-attractive idea ( $\beta = -.015$ , Wald  $\chi^2$  (1,  $N = 784$ ) = 0.02,  $p = .885$ , 95%CI [-.220, .190]), or the highly-attractive one ( $\beta = .083$ , Wald  $\chi^2$  (1,  $N = 784$ ) = 1.16,  $p = .281$ , 95%CI [-.068, .233]).

the top 33% who had slept > than 7.26). More pertinently, results from this exploratory between-subject survey remind us that different people might require different levels of sleep. We interpret these results as an invitation to examine sleep's effects with more precision, and notably with a within-subject design that would account for each participant's typical levels of sleep (and variations thereof).

#### **4. Study 2: A Within-Subject Investigation of Sleep's Effects "in the Field"**

To enable a rigorous test of our hypotheses regarding sleep restriction's effects on entrepreneurs' abilities to make sense of attractive new venture ideas, we conducted an experimental experience sampling study (i.e., diary study) with a panel of practicing entrepreneurs, whereby we tracked participants' level of sleep on a daily basis (using short smartphone-enabled surveys) while also asking them to report their 3<sup>rd</sup>-person opportunity beliefs about a series of new venture ideas we had manipulated, such that they exhibited different patterns of similarities.

##### **4.1. Sample**

We conducted Study 2 with 101 small business entrepreneurs from around the world. We recruited participants from a business-planning software company in the United States. The sample was obtained using an email distribution method that only targeted small business founders who were either currently developing business plans using their software or who were considering their business plan development products. The recruiting email yielded 210 click-through responses, of which 134 began the daily surveys. Each of the participants could complete up to 13 morning and 13 afternoon surveys over a two-week period. Since the diary study intended to measure dynamic variations in participants' sleep and their formation of 3<sup>rd</sup>-person beliefs about different new venture ideas, we excluded 28

participants who did not complete at least seven days of daily surveys. We also excluded five participants who exhibited no variation in their opportunity beliefs throughout the study, meaning that they rated each and every business idea with the same score. The remaining sample consisted of self-employed individuals from North America (59.4%), Africa (24.8%), Asia (7.9%), Europe (5.9%), South America (1%), and Australia (1%). Participants' ages ranged from 22 to 75, with an average age of 45.8 ( $SD = 13.54$ ); 42.6 percent were female. Participants reported having started an average of 2.5 businesses and an average of 7.6 years of self-employment experience. In terms of education levels, 78% of participants held a four-year college degree or greater at the time of the study.

To encourage participation, we offered participants an option to receive either a \$50 gift card or six months of free access to the business planning software (approximately a \$115 value). We also offered several random gift card drawings (ranging from \$20 [fifteen of these weighted toward the end of the daily survey period] to \$500 [one of these]) throughout the study. All participants had an opportunity to win one or more gift card. All participants who completed at least 85% of the daily surveys received compensation.

#### **4.2. Data collection procedures**

We began by asking participants to complete an entry survey that captured their demographic information and informed them of the study's procedures. We then launched the diary study whereby we surveyed participants twice each day over a 13-day period. We collected demographic and participation data on a Monday and started the diary entries on a Tuesday, spanning 13 days and including two full weekends. Each morning we asked participants about their previous night's sleep. A separate afternoon survey presented a new venture idea and asked them to assess the idea.

### 4.3. Research design and experimental manipulations

In order to better anchor our study within a structural alignment view of opportunity ideation, we followed the methodological strategy developed by Grégoire and Shepherd (2012) and manipulated the similarity characteristics of the new venture ideas we presented to participants. More concretely, we built from real-life cases of attractive new venture ideas based on emergent technologies and created four theory-consistent versions of each basic idea, such that each version varies in terms of the superficial and structural similarities uniting its core technology and proposed market application (high/low for both superficial and structural similarities, following a two-by-two matrix). To ensure continuity with prior research, we used three of the four stimuli from Grégoire and Shepherd (2012) (the fourth technology presented in that paper (3D-printing) has become a fairly ubiquitous technology) and created ten more scenarios, one for each of the thirteen days of responses from entrepreneurs, and each scenario with four different conditions<sup>10</sup>. The two-by-two matrix (superficial by structural) included two cells in which structural alignment and misalignment should be cognitively more obvious and easier to interpret. When superficial and structural similarities are both high, theory suggests that individuals should more readily “perceive” that the proposed business solution has the potential to address the market problem it is intended to solve. Needless to say, this does not eliminate the ex-ante uncertainty that still surrounds the emergent new venture idea (Dimov, 2011; McMullen & Dimov, 2013; Townsend et al., 2018): it simply means that individuals trying to make sense of such new venture ideas are encountering information signals that suggest a potential “match” between the underlying capabilities of a new venture idea’s proposed means of

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<sup>10</sup> Three of the manipulations were indeed validated in Grégoire and Shepherd (2012), and the other ten manipulations were created akin to those three validated manipulations.



supply and poorly satisfied needs of the idea's proposed target market(s). By comparison, the opposite should arise when superficial and structural similarities are both low. In such cases, it should become more apparent that the business solution does *not* fit the market problem it is intended to solve. Consistent with our theoretical developments above, we did not anticipate that participants' length of sleep would affect their assessment of opportunity scenarios with obviously congruent alignments (or misalignments).

Yet, our theoretical developments suggest a different outcome for those two cells where superficial and structural similarities diverge from one another. In principle, the similarity characteristics of these (manipulated) new venture ideas make their initial interpretation far more difficult cognitively. These scenarios correspond to situations where our theoretical developments posit that sleep's effects would be most apparent, thereby allowing us to test our hypotheses. We structured our data collection procedures such that on each day, each participant assessed a new venture idea related to the same technology and market but saw one (and only one) version among the four theoretical possibilities. We randomly assigned scenario conditions within and between participants (see Appendix A), meaning that on each day for each scenario, approximately one fourth of participants were assessing an opportunity that fell in one of each of the four cells.

#### **4.4. Dependent variable**

We measured participant's 3<sup>rd</sup>-person opportunity beliefs with four items asking participants to indicate their level of confidence (Davidsson, 2015) in the new venture idea's attractiveness (answered on a seven-point scale ranging from *1 = not at all confident* to *7 = completely confident*). Averaged across the thirteen days of the study, the measure's reliability was  $\alpha = .86$ .

#### **4.5. Independent variables**

*Daily amount of sleep.* We measured sleep using questions adapted from the Pittsburgh Sleep Quality Index (PSQI; Buysse et al., 1989). The PSQI asks for the time the entrepreneur went to bed the previous night, the amount of time it took to fall asleep, the number of minutes spent awake during the night, and the time when the respondent finally woke up in the morning. The answers are then combined and divided by sixty to create a single measure of sleep quantity, in hours.

*Idea-specific prior knowledge of technology.* In the afternoon survey, we asked participants to indicate their level of prior knowledge of the technology underpinning the day's new venture idea's proposed means of supply. Given the narrow nature of this question (Wanous, Reichers, & Hudy, 1997), we used a single-item measure on a five-point scale ranging from *1 = not knowledgeable at all* to *5 = extremely knowledgeable* (Grégoire & Shepherd, 2012).

#### **4.6. Analysis**

Data were structured hierarchically, with day-level matched responses (morning and evening) nested within individuals. Prior to conducting our tests, we examined whether sufficient variance exists across days (L1) to justify our examination of the day-level hypotheses. To determine this, we ran a null model, in which each day-level construct is regressed on an intercept and random error term, revealing both day-level (L1) and entrepreneur-level (L2) variances. We found that 61% of the variance in sleep, 54% of the variance in prior knowledge of the technology presented, and 79% of the variance in 3<sup>rd</sup>-person beliefs resides within individuals. Within-individual organizational research routinely reports one-third to two-thirds of variance occurring at level 1 (e.g., Butts,

Becker, & Boswell, 2015; S. H. Harrison & Wagner, 2016; Schilpzand, Houston, & Cho, 2018), including research on entrepreneurs (e.g., Uy, Foo, & Ilies, 2015; Weinberger et al., 2018). The substantial proportion of variance observed in our data at the within-individual level supports the appropriateness of conducting multilevel analyses.

Naturally, day-to-day levels of sleep for a particular individual are related to one another and this lack of independence among measures violates a key assumption of OLS regression. We employed multilevel random coefficient modeling to analyze the data (Hofmann, Griffin, & Gavin, 2000; Nezlek, 2001). Day-to-day variations in sleep over the course of the study were not controlled by the researchers but represented a small sampling of a lifetime of sleep behaviors. Because the reports were drawn from a broader population of each participant's daily sleep experiences, we treat this as a random coefficient, modeling the coefficient's random error parameter (Nezlek, 2001). Moreover, our interest was to examine how day-to-day fluctuations in sleep for a particular entrepreneur would influence the entrepreneur's 3<sup>rd</sup>-person opportunity beliefs. By person-mean centering each of the day-level measures reported by the entrepreneur, we were able to test how fluctuations from the particular respondent's own mean level of that construct would lead to differences in their beliefs about different new venture ideas. We analyzed our data with the lme4 package in R, using restricted maximum likelihood estimation (lmer; Bates, Maechler, Bolker, & Walker, 2015).

#### **4.7. Study 2 results**

Table 1 displays the variables' descriptive statistics as well as their between- and within-person correlations. Consistent with our theoretical developments and research design above (and though we report the results for all manipulated scenarios below), the

featured analyses focus on those manipulated scenarios where superficial and structural similarities are at odds with one another, that is, the new venture ideas that are cognitively more difficult to interpret and where sleep restriction is likely to have its most insidious effects. Our analyses revealed that, when controlling for within-subject daily variance in prior knowledge of new venture’s technology and for the day of the week, there was no evidence of an association between participants reports of having had more (or less) sleep than average and their 3<sup>rd</sup>-person beliefs regarding either the manifestly more attractive ideas (that is, the ideas manipulated to exhibit high levels of both superficial and structural similarity between their proposed means of supply and target market;  $\gamma = -.02, p = .782, 95\% \text{ CI } [-.164, .122]$ ) or the manifestly less attractive ideas (that is, the ideas manipulated to exhibit low levels of both superficial and structural similarity;  $\gamma = .05, p = .438, 95\% \text{ CI } [-.081, .189]$ ).

**Table 1** – Descriptive statistics and between- and within-person<sup>a</sup> correlations for Study 2 variables

Variables	<i>M</i>	<i>SD</i>	<i>Min</i>	<i>Max</i>	1	2	3	4	5	6	7	8	9	10
<i>Level 2 (between-person)<sup>b</sup></i>														
1. Age	45.78	13.47	22	75	–									
2. Gender	1.43	0.49	1	2	-0.01	–								
3. Education	5.05	1.25	1	7	0.17	-0.13	–							
4. Entrepreneur experience	7.61	9.40	0	56	0.56	0.04	0.03	–						
5. Number of startups	2.47	2.06	0	11	0.37	-0.04	-0.00	0.51	–					
6. Avg. sleep across study	6.66	1.03	2.58	8.97	0.02	0.15	-0.12	0.10	-0.21	–				
<i>Level 1 (within-person)</i>														
7. 3 <sup>rd</sup> -person NV idea beliefs	5.03	1.36	1	7	-0.39	-0.03	-0.32	-0.18	0.01	-0.17	–	-0.02	0.19	0.03
8. Daily sleep quantity	6.68	1.51	0	12.17	0.02	0.15	-0.12	0.10	-0.21	1.00	-0.17	–	-0.00	-0.01
9. Daily prior knowledge	2.13	1.06	1	5	-0.14	-0.34	0.17	0.02	0.13	-0.11	0.10	-0.11	–	0.02
10. Day of week	4.16	1.99	1	7	0.08	0.16	0.17	-0.27	0.38	0.08	0.15	0.08	0.27	–

*Note.* Level 1,  $n = 1,229$ ; Level 2,  $n = 101$ . Gender (1 = male, 2 = female, 3 = non-binary). Education (1 = less than high school, 2 = high school graduate, 3 = some college, 4 = two-year degree, 5 = four-year degree, 6 = professional degree, 7 = doctorate). Entrepreneur experience (years of self-employment). Number of startups (number of businesses started). Daily prior knowledge (knowledge of technology presented for assessment). Day of week (1 = Sunday, 2 = Monday, 3 = Tuesday, etc.). Day of week was treated as a categorical variable in all models. All between-person (within-person) correlations greater than or equal to .057 (.196) are statistically significant at the .05 level.

<sup>a</sup>Within-person correlations appear above the diagonal. <sup>b</sup>Level 2 control variables

Interestingly, however, we observed that on days when participants reported sparser amounts of sleep than is typical for them, they appeared less able to make sense of the less-obvious opportunity ideas (that is, the ideas manipulated to exhibit divergent levels of

superficial and structural similarities). By contrast, we observed the opposite on days when participants reported having had more sleep than they typically do. These are the key observations supporting H3. Table 2 displays our model results.

For new venture ideas manipulated to exhibit high levels of superficial similarity but low levels of structural similarity (that is, ideas that should be perceived as less attractive in principle), we obtained statistically-significant evidence that the *more sleep* participants had relative to their average, the *more negative* their 3<sup>rd</sup>-person assessment beliefs of these otherwise questionable new venture ideas ( $\gamma = -.15, p = .017, 95\%CI [-.278, -.030]$ ). By correlate, participants who had slept *less* than their average tended to view these questionable ideas more positively, and thus seem less able to perceive, attend to, and consider the apparent misalignment between the new venture ideas' technological capabilities and the root causes of the presented target market's problems.

We observed a mirror pattern with the new venture ideas manipulated to exhibit low levels of superficial similarity but high levels of structural similarity. In principle, these ideas should be perceived as more attractive, on the basis that in spite of exhibiting different superficial characteristic, the proposed means of supply and technologies have underlying capabilities that address the root cause of the target market's problems. For these particular scenarios, we observed that the *more sleep* participants report, relative to their average, the *more positive* their 3<sup>rd</sup>-person assessment beliefs of these arguably more difficult to interpret but structurally-coherent new venture ideas ( $\gamma = .12, p = .058, 95\%CI [-.002, .245]$ ). By correlate, participants who had slept *less* seem less able to overcome the ideas' superficial misalignment and latch on the more relevant structural alignment between the capabilities of these new ventures ideas' technology and the root cause(s) of the presented

target market problems.

**Table 2** – Study 2 model results for non-obvious opportunity manipulation cells

	Model HL0		Model HL1		Model LH0		Model LH1	
	High superficial and low structural (null)		High superficial and low structural (hypothesized)		Low superficial and high structural (null)		Low superficial and high structural (hypothesized)	
	<i>coeff.</i>	<i>SE</i>	<i>coeff.</i>	<i>SE</i>	<i>coeff.</i>	<i>SE</i>	<i>coeff.</i>	<i>SE</i>
Intercept	5.10***	.09	4.63***	.22	5.11***	.10	4.48***	.26
Sleep			-.15*	.06			.12 <sup>†</sup>	.06
Prior experience			.25***	.07			.21**	.07
<i>Model information</i>								
Observations	279		279		264		264	
Day controls	NO		YES		NO		YES	
AIC	958.42		909.44		900.38		873.03	
Residual variance	1.286		1.156		1.195		1.132	
Pseudo $R^2$	–		.101		–		.052	

*Note.* HL Models ask participants to evaluate non-obvious less attractive opportunities. LH Models ask participants to evaluate non-obvious more attractive opportunities. The statistical package lme4 uses Satterthwaite approximations for degrees of freedom, and these values vary for each variable. The symbols †, \*, \*\*, and \*\*\* indicate statistical significance at the 10%, 5%, 1% and 0.1% levels, respectively.

Although the latter finding slightly exceeds the  $p < .05$  threshold for statistical significance (.058), the overall pattern of empirical results lends support to H3 and is consistent with our theoretical developments that restricting sleep hinders one’s abilities to perceive, attend to, and consider the cognitively more demanding signals of structural similarity and dissimilarity. Unfortunately, the correlational nature of this field-study limits our ability to establish causality and rule-out alternate explanations. To address these challenges and provide direct tests of H1, H2ab and H4, we conducted a third study mobilizing a more stringent experimental protocol.

### 5. Study 3: Establishing Causal Effects of Sleep Restriction

To causally establish that sleep restriction negatively impacts individual abilities to imagine promising new venture ideas and form congruent 3<sup>rd</sup>-person beliefs about these ideas’ attractiveness, we conducted a laboratory experiment where we directly manipulated the extent of participants’ sleep. Moreover, Study 3 mobilized creativity and imagination

tasks that allow us to examine our theoretical developments in more breadth and test all our hypotheses.

### **5.1. Sample**

We conducted Study 3 with 89 upper-level business-school students from a large research university from the United States. We recruited participants during several in-class presentations inviting them to join a study investigating sleep and decision-making. Five students who signed up did not show up for their assigned time. We excluded from our analyses another four who reported a low level of comfort in speaking, reading, and writing English. We also removed four participants who did not comply with the control-group requirements, and three additional participants who failed attention checks. Culling these individuals yielded a final sample of 73 participants. Their ages ranged from 19 to 27, with an average age of 21.8 ( $SD = 1.38$ ), and 30 were female (41.1%).<sup>11</sup>

### **5.2. Procedures for the experimental manipulation of sleep**

We randomly assigned about half of the participants to a two-day sleep deprivation condition (SD,  $n = 38$ ), requiring that they would stay up all night prior to completing a few tasks and answering a series of questions during a lab session the next morning. We oversampled for the SD condition, due to the possibility that some participants either might

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<sup>11</sup> Though some critics have lamented the (over)use of student samples in entrepreneurship research, we offer that our methodological choice is warranted to our particular purpose. First, conducting an experiment where entrepreneurs would be randomly assigned to be sleep deprived would not only be impractical: it would pose important risks to the successes of their real-life ventures, thus creating unacceptable ethical problems. Perhaps more importantly, our sample frame meets Hsu, Simmons & Wieland's (2017: p. 385) first condition that participants resemble the population of interest: because *all* students graduating with an entrepreneurship degree from the institution where we sampled them are *required* to take the course we sampled from, our study participants are arguably representative of first-time founders with minimum levels of experience (see McGee, Peterson, Mueller, & Sequeira, 2009). Our sample also meets another of Hsu et al.'s (2017) condition warranting the use of student samples, that is, "when the relationships under investigation are grounded in a broad theory (Hsu et al., 2017: p. 385)" that has been shown to apply under various populations and contexts.

not report for the study or might not be able to stay up all night. There was no difference in age ( $t(45) = 0.91, p = .367$ ) or gender ( $t(45) = 1.18, p = .246$ ) among those who failed to report for the SD condition. The non-sleep deprivation group (NSD,  $n = 35$ ) participated in the same lab session after sleeping for at least seven hours the previous night.

We instructed SD Participants to wake before 9:00 AM on Day 1 to ensure a minimum of 24 hours of total sleep deprivation at the time they performed the research tasks. We also instructed them to refrain from napping. SD participants reported to the overnight meeting room at 10:00 PM on Day 1, after which they began playing board games, read books, did homework, and watched movies. SD participants were not allowed to consume caffeine or alcohol during the night and confirmed compliance to the napping and consumption rules on Day 2. Research assistants provided snacks and drinks throughout the night and breakfast the following morning. They also monitored participants to ensure compliance with the experimental manipulation. SD participants reported to the lab at 9:00 AM on Day 2 to complete the rest of the research tasks and surveys.

For their part, the NSD participants received instructions to sleep at least seven hours the night before Day 2; they were allowed discretion in their activities and could play board games, read books, do homework, or watch movies, in addition to getting a full night of sleep. The NSD participants reported to the lab at 9:00 AM on Day 2 to complete the rest of the research.

In addition to the above protocol, we measured sleep using the Pittsburg Sleep Quality Index (PSQI) (Buysse et al., 1989). Participants in the control condition (non-sleep deprived; NSD) slept more than those in the sleep deprivation condition (NSD:  $M = 8.16$  hours,  $Std. Dev. = .64$ ; SD:  $M = 0.00$  hours,  $Std. Dev. = 0.00$ ). This confirms the effective



validity of our sleep manipulation.

All participants received course credit for completing the morning survey on Day 2. To help foster active participation and attention during the survey, we entered all participants into a drawing to receive a \$25 gift card, given to a randomly selected participant who finished the Day 2 survey. All participants had an opportunity to win the \$25 gift card and, in order to encourage participant's diligent efforts, the probability of winning increased with their agreement with the experts' ranking of the new venture ideas we presented them. Student participants in the SD group were also compensated \$60, regardless of their performance.

### **5.3. Data collection procedures and focal measures**

In order to test all our hypotheses, we asked all participants to complete two relevant research tasks. We describe below the procedures and key measures in each task.

#### ***5.3.1. Research task #1: Imagining new venture ideas***

In order to examine sleep deprivation's effects on participant's abilities to imagine attractive new venture ideas, we presented participants with the description of a nascent video recognition technology and asked them to describe how they might commercialize it (see Appendix B). Participants could propose as many ideas as they wanted and could expand on them as much as they chose. This allowed participants to reveal the manner in which they navigate the thought processes involved with idea generation without anchoring them on a specific business application.

In order to obtain a relevant outcome measure for testing our prediction that sleep restriction will hinder cognitive attention towards structural alignment considerations, we content-analyzed participants' verbalizations to assess not only the extent of their attention

focus on technology, market, or neither, but also the extent to which participants' reasoning was articulated at the superficial, first-order, and higher-order levels. Two research assistants (blind to experimental condition) independently coded the open-ended responses that identified and explained possible applications of the technology (please see Appendix C for the adopted coding scheme). Building on these content analyses, we isolated the extent of participants' mobilization of higher-order structural alignment considerations in their answers (combining a scale of 0 to 7 for first-order considerations and a scale of 0 to 7 for higher-order considerations, creating a final scale of 0 to 14 for structural considerations; see Appendix C for details). This formed the focal outcome measure for testing H1. In addition, the extent of participants' attention to structural alignment considerations evidenced in the first research task formed the measure for the H4 mediation relationship we test with Research Task #2.

The research assistants independently scored superficial, first-order, and higher-order thinking in five responses and compared the assigned codes, adjusting for discrepancies in coding interpretation. Then, they iteratively coded another ten responses and discussed any persisting discrepancies before coding the remainder of the responses. The independent coders showed sufficient agreement (Krippendorff's  $\alpha = .866$ ), which indicates high reliability and lends sufficient rationale for combining the scores from two raters for analysis (Krippendorff, 1970, 2004).

We derived the outcome measure for testing H2a by counting the number of ideas generated by each participant. For the H2b's outcome measure, we asked the same research assistants as above to rate the effective congruence between participants' proposed market application (new venture idea) and the technology prompt we gave them. Research

assistants entered their rating on a seven-point scale ranging from “1 = the target market the participant presents to apply the new technology in a new venture is completely incongruent with the prompt” to “7 = the target market the participant presents to apply the new technology in a new venture is completely congruent with the prompt.” For all intents and purposes, such congruence ratings provide insight on whether the application suggested by the participant seems logical, and if it appears as a plausibly attractive application of the presented technology.

### ***5.3.2. Research task #2: Forming 3<sup>rd</sup>-person beliefs about new venture ideas***

In similar fashion to Study 1, we asked participants to read and rank three new venture ideas sampled from a real-life business plan competition. For each idea presented in an online survey, we asked participants to open a pop-up window where they could review the business plan’s executive summary. After they had reviewed all three, we asked participants to rank them from best to worst. To facilitate interpretation, we reverse-coded the responses such that a higher number (3) represents a more attractive 3<sup>rd</sup>-person opportunity belief (best).

These rankings form the outcome measure for our tests of H3 and H4. Because participants ranked three venture ideas that had been independently assessed by third-party experts beforehand, we are able to examine the congruence between participants’ 3<sup>rd</sup>-person beliefs relative to those of experts. In addition, we highlight that the new-venture idea experts had deemed least attractive was the only idea exhibiting a mis-match between superficial similarity and structural alignment (i.e., high superficial similarity but low structural alignment between technology and market). Since the other two opportunities showed both superficial and structural alignment (i.e., no structural or superficial

mismatch), we center our analyses on the non-obvious / less-attractive new venture idea.<sup>12</sup>

#### 5.4. Additional measures and control variables

**Verbosity.** To control for the possibility that participant’s verbosity in Research Task #1 explained their higher / lower mobilization of structural alignment reasoning, we controlled for the total number of words of the answer they gave in the open-ended creativity task.

**Divergent thinking.** We used the count of ideas generated in Research Task #1 as a proxy for measuring participants’ ability to engage into divergent thinking. We used this measure as a control variable in tests of H2b, H3 and H4 (that is, tests where the count of idea was not otherwise a focal variable of interest). Doing so allows us to rule out alternate explanations that the observed effects are associated not with participants’ abilities to engage in structural alignment reasoning, but in divergent thinking (Gielnik et al., 2014). Table 3 displays descriptive statistics for each variable.

**Table 3 – Descriptive statistics and correlations for Study 3 variables**

Variables	<i>M</i>	<i>SD</i>	<i>Min</i>	<i>Max</i>	1	2	3	4	5	6	7	8	9
1. Experimental cond.	.48	.50	0	1	–								
2. Age	21.77	1.38	19	27	-.08	–							
3. Gender	1.41	.50	1	2	-.08	.00	–						
4. Work experience	3.30	2.03	0	8	-.17	-.21	-.12	–					
5. Sleep	3.91	4.13	0	9.83	.99*	-.07	-.07	-.16	–				
6. 3 <sup>rd</sup> -person beliefs	2.58	.71	1	3	.23	-.40*	-.17	.03	.22	–			
7. Structural reasoning	4.27	3.61	0	13.5	.25*	-.20	-.16	-.03	.24*	.31*	–		
8. Divergent thinking	2.12	1.07	0	5	.20	-.13	-.22	-.05	.20	.23	.41*	–	
9. Idea congruence	4.36	1.66	1	7	.31*	-.23*	-.16	.02	.30*	.35*	.82*	.34*	–
10. Verbosity	84.18	65.93	2	387	.10	-.20	-.20	-.01	.08	.28*	.57*	.59*	.53*

*Note.* *N* = 73. Experimental condition (0 = sleep deprived, 1 = not sleep deprived). Gender (1 = male, 2 = female). Divergent thinking is represented as a count of different ideas in Research Task #1. \* *p* < .05

#### 5.5. Analyses

Given the between-subject nature of the measures for testing H1 and H2ab, our tests

<sup>12</sup> As noted in the Study 1, three expert judges had a high level of agreement on these new venture ideas’ attractiveness when they were presented in a business plan competition. As another indication of attractiveness, only the top-rated idea continues as a going concern four years after the business plan competition.

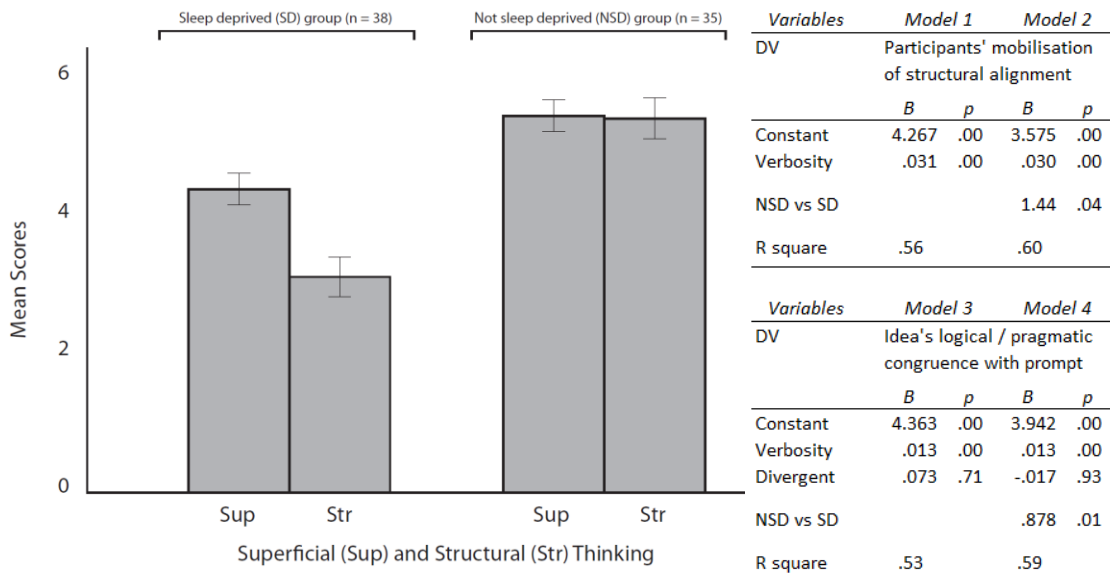
mobilized simple means comparison supplemented by relevant regressions. For H3, the Kolmogorov-Smirnov (*K-S*) test of normality showed that both the most-attractive (*K-S* = .321,  $p < .001$ ) and least-attractive (*K-S* = .425,  $p < .001$ ) ranking distributions were not normally distributed, violating a standard assumption for these techniques. Hence we used a Wilcoxon rank-sum test (Wilcoxon, 1945), also known as a Mann-Whitney U non-parametric test of difference between means (Mann & Whitney, 1947) for the Z-scores reported below. Results obtained with these non-parametric tests are consistent with results derived from a standard *t*-test. We test H4's mediation hypotheses by mobilizing Hayes' PROCESS macro (Hayes, 2018; Preacher & Hayes, 2008).

## **5.6. Study 3 results**

### ***5.6.1. Imagining new venture ideas***

H1 predicted that sleep-restricted entrepreneurs would pay less attention to an idea's structural relationships than would well-rested individuals. Analyses from the ideation task revealed that on average, participants in the non-sleep-deprived (NSD) control group devoted *more* attention to structural alignment information ( $Mean_{NSD} = 5.21$ ) than participants in the sleep-deprivation (SD) group ( $Mean_{SD} = 3.39$ ) when trying to imagine an attractive market application of a new technology ( $t(71) = 2.21$ ,  $p = .031$ ,  $d = 0.57$ ). Figure 3 displays the disparity of structural reasoning between the two groups, supporting H1. Regression analyses that include verbosity as a relevant control variable corroborated this result (see Figure 3, Models 1 and 2).

**Figure 3 – Study 3 Participants’ Relative Focus on Superficial and First-order/Higher-order Relationships**



*Note.* N = 73. The bars represent the amount of focus on superficial and structural (i.e., first-order/higher-order) relationships between a novel technology and suggestions made for potential market applications of that technology. The amounts were determined by RA coding of open-ended responses to Study 3, Research task #1.

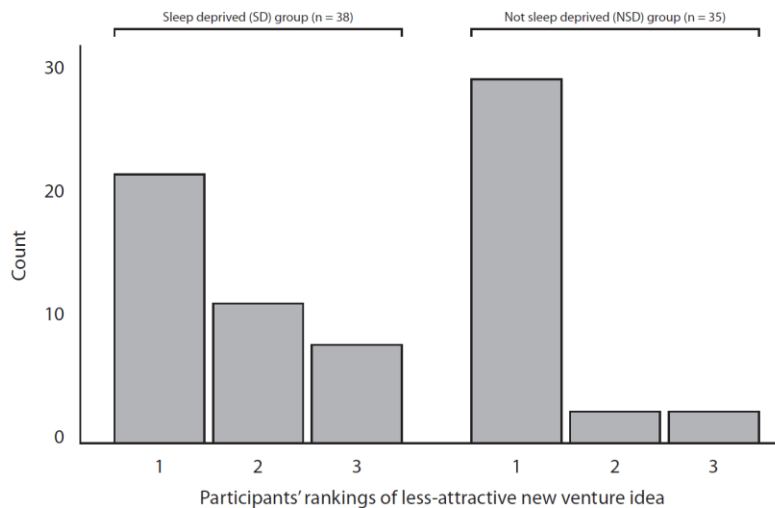
H2 predicted that sleep restriction will be associated with participants imagining (a) fewer and (b) less attractive new venture ideas. We did not observe statistically-significant evidence for a difference between the number of ideas posited by either group ( $Mean_{NSD} = 2.34$ ;  $Mean_{SD} = 1.92$ ;  $t(71) = 1.68$ ,  $p = .099$ ), denying support to H2a. In support of H2b, however, individuals in the well-rested group submitted new venture ideas that were deemed as more attractive on average (i.e., exhibiting greater congruence with the prompt;  $Mean_{NSD} = 4.90$ ) than participants in the sleep deprived group ( $Mean_{SD} = 3.87$ ;  $t(71) = 2.77$ ,  $p = .007$ ,  $d = 0.65$ ). Here again, regression analyses illustrate these results (see Figure 3, Models 3 and 4).

### 5.6.2. Forming congruent 3<sup>rd</sup>-person beliefs about new venture ideas

H3 suggested that sleep restriction will hinder the formation of congruent 3<sup>rd</sup>-person

beliefs. Consistent with Study 1 and Study 2 results, the Mann-Whitney U test did not reveal statistically-significant evidence that the experimental groups formed different 3<sup>rd</sup>-person opportunity beliefs regarding the most attractive idea ( $Z = 1.54, p = .123$ ). However, we observed that the experimental condition had an effect on participants' beliefs about the less attractive idea ( $Z = 2.19, p = .029, r = .26$ ), with SD participants ranking this idea higher than the control group. These findings support H3 and align with our other studies' findings. Figure 4 shows the disparity of the two groups' rankings. In concrete terms, these results imply a sleep-deprived participant was 2.61 times more likely than a well-rested control participant to “mis-rank” their belief in the less-attractive idea in a position higher than one or both of the other two new venture ideas.

**Figure 4** – Study 3 Participants' Rankings of Less-attractive New Venture Ideas

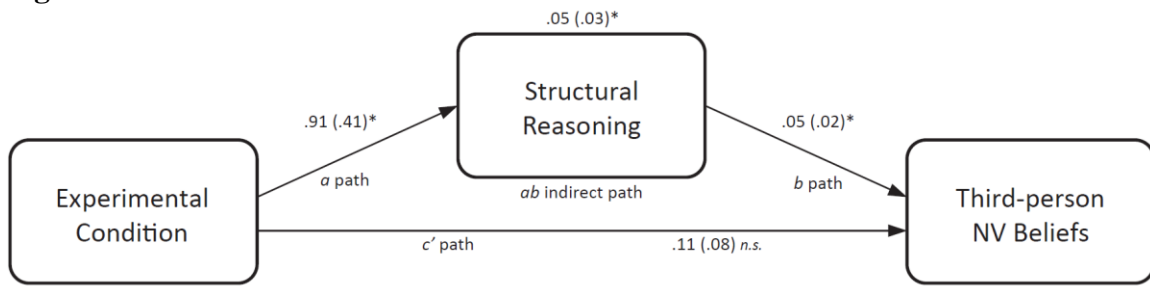


*Note.* N = 73; 1 = lowest ranking, 3 = highest ranking.

H4 advanced that participants' abilities to engage in structural reasoning should mediate H3's relationship. To test this, we mobilized Hayes' PROCESS macro (Hayes, 2018; Preacher & Hayes, 2008), utilizing 5,000 bootstrap samples to construct bias-corrected bootstrap confidence intervals, testing the mediation model depicted in Figure 1,

results shown in Figure 5. The results indicate that the mediation model fits the data well, ( $F(2, 70) = 4.78, p = .011, R^2 = .12$ ). Sleep influenced participants' abilities to engage in structural reasoning in Research task #1 (*a*-path; *coeff.* = 0.91,  $p = .031$ , 95%CI [.09, 1.73]). More structural reasoning was associated with ranking the high-superficial/low-structural (i.e., mismatched) new venture idea of Research task #2 in a manner more congruent with the separate ranking of third-party experts (*b*-path; *coeff.* = .05,  $p = .023$ , 95%CI [.01, .10]), and the indirect effect from sleep to structural reasoning to ranking was significant as well (*ab*-path; *coeff.* = .05, 95%CI [.002, .112]). The evidence for a direct effect of sleep on ranking was no longer significant when structural reasoning was introduced as a mediator in the model (*c'*-path;  $b = .11, p = .168$ , 95%CI [-.05, .28]). These results suggest full mediation and provide support for both H3 and H4.

**Figure 5 – Mediation model results**



*Note.* We entered the two experimental categories, sleep deprived (-1) and not sleep deprived (+1) as a categorical independent variable in the PROCESS analysis. The mediating variable was coded by RAs to reflect the amount of structural reasoning the participant used during the exposition portion of Research Task #1. The dependent variable, measured in Research Task #2, is the ranking (1 is best, 3 is worst) of the new venture idea characterized with high levels of superficial similarity and low levels of structural alignment. \*  $p < .05$

## 6. Discussion

Prior research on entrepreneurs' creative abilities to imagine new venture ideas has long emphasized the influence of individual differences in task-relevant resources like prior knowledge, entrepreneurial experience, self-efficacy, or other forms of human and social capital. By definition, such resources tend to be relatively enduring. Once acquired, an



individual's stocks of knowledge and experience do not deplete with use, and only in rare occasions are these stocks likely to rapidly become irrelevant. By contrast, a number of recent studies have drawn increasing attention to the influence of affective, motivational, and physiological dynamics that exhibit broad day-to-day variations not only *between* but also *within* individuals (Gish & Wagner, 2016). Among these dynamics, sleep has emerged as a particularly salient topic (e.g., Gunia, 2017; Kollmann et al., 2018; Murnieks et al., 2019; Weinberger et al., 2018; Williamson, Battisti, Leatherbee, & Gish, 2019; Wolfe & Patel, 2019). Yet in spite of these advances, theoretical explanations are lacking for *why* sleep has the effects it appears to have on entrepreneurs' cognitive abilities. This uncertainty limits our ability to design proper interventions for entrepreneurs, short of naïve admonitions to simply sleep more.

To help advance broader academic understanding of the neuro-physiological dynamics at the basis of entrepreneurs' abilities, we developed a theoretical model articulating the cognitive mechanisms explaining the particular influence of sleep on individual abilities to imagine new venture ideas and form congruent 3<sup>rd</sup>-person beliefs about such ideas. We tested these notions empirically through a series of studies combining different data collection methods, samples and strategies. Results largely supported our hypotheses, reinforcing prior observations that shortchanging one's sleep has adverse effects on ideation capabilities. More importantly, our study makes two primary contributions to research. We discuss each in turn.

### **6.1. With Respect to Imagining New Venture Ideas**

We first contribute new insights to the emerging research on the physiological bases of entrepreneurial action by unpacking the neuro-cognitive linkages explaining sleep's effects

on entrepreneurs' abilities to *imagine* new venture ideas. By combining psychology research's insights about sleep's effects on working memory and the performance of higher-order executive functions (see Diamond, 2013; C. Schmidt et al., 2015; U. Wagner et al., 2004; Walker & Stickgold, 2006) with entrepreneurship research on the cognitive processes underpinning opportunity ideation (Grégoire et al., 2010), we developed theory about the cognitive mechanisms explaining sleep's enabling role in supporting individual abilities to imagine attractive new venture ideas.

More specifically, we show that sleep allows for devoting increased attention towards the structural similarities between an idea's underlying technology and market application (H1). In addition, we found that individuals who had slept more were able to generate market application ideas characterized with higher levels of structural-similarity with a given technology prompt (H2b). What unites both findings is that they deal with information elements that are known to be cognitively more demanding to process. Namely, it is more demanding to process information regarding the structural similarity parallels between a new technology's capabilities and the root causes of latent demand for that technology in a market. Seen from this angle, our theorizing and results inform sleep's positive influence on the human mind's abilities to perceive, attend to and actively consider structurally-relevant cues that are pivotal in efforts to imagine new venture ideas. In other words, our key contribution is to uncover a theoretically-consistent pathway by which sleep influences one's attention to and processing of relevant signals (cf. Shepherd et al., 2017).

Doing so augments the depth of academic understanding of sleep's effects on opportunity ideation. More importantly, it opens up promising avenues of future research. For instance, future studies could examine whether one's abilities to engage into future-

oriented cognitions (Frederiks et al., 2019), divergent thinking (Gielnik et al., 2012; Gielnik et al., 2014) or one's imaginativeness (Kier & McMullen, 2019) or repeat entrepreneurial intentions (Grégoire & Shepherd, 2012) might effectively diminish sleep's otherwise detrimental effects on the leverage of structurally-relevant parallels and the imagination of attractive new venture ideas. Other studies could also theorize and test whether other cognitive (and/or affective) conduits might be adversely affected by sleep, negatively affecting an entrepreneurs' opportunity ideation abilities.

## **6.2. With Respect to Forming Congruent 3<sup>rd</sup>-Person Beliefs about New Venture**

### **Ideas**

A second contribution is to augment academic understanding of the cognitive pathways by which sleep has enabling effects on one's abilities to form 3<sup>rd</sup>-person opportunity beliefs that are congruent with those of experts. By integrating the aforementioned research on sleep's cognitive effects with works on both the relevance of cognitive processes of structural alignment in the formation of 3<sup>rd</sup>-person opportunity beliefs (Grégoire & Shepherd, 2012) and one's levels of opportunity confidence (see Davidsson, 2015), we are able to articulate the cognitive mechanisms explaining sleep's enabling role in supporting the formation of 3<sup>rd</sup>-person opportunity beliefs that are congruent with other markers of these ideas' attractiveness.

Concretely, we show that sleep restriction lessens individual abilities to form 3<sup>rd</sup>-person beliefs that are congruent with the beliefs of experts and with logical principles known to foster the initial attractiveness of new venture ideas (H3), and that one's ability to attend to structurally-relevant information (in another task) mediates this relationship (H4). Here again, what unites these theoretical developments and findings is their anchoring on

broader research on the neuro-cognitive linkages between sleep and one's ability to perceive, attend to and interpret relevant information signals. Seen in this light, our work's second contribution is to open up the black box of sleep's effects on entrepreneurs' abilities and articulate the attentional (Shepherd et al., 2017) mechanisms by which sleep supports one's entrepreneurial abilities.

Doing so augments the depth of academic understanding of sleep's effects on the formation of 3<sup>rd</sup>-person opportunity beliefs. More importantly, it opens up promising avenues of future research. Among other interesting possibilities, we anticipate that future studies could explore whether other affective, cognitive and/or motivational dynamics might augment (or diminish) sleep's effects on entrepreneurs' abilities to form congruent 3<sup>rd</sup>-person beliefs about the attractiveness of different new venture ideas. Likewise we would also encourage further developments of the theoretical conditions under which it might be pertinent and warranted to examine the meaning of new venture ideas perceived as having different attractiveness levels (Davidsson, 2015).

### **6.3. Limitations**

Because shortchanging sleep can have important adverse effects, studying the effects of sleep restriction and sleep deprivation pose important ethical and methodological challenges. To circumvent these challenges, we elected to examine sleep restriction's effects through a series of studies combining different data collection techniques, sample frames, and opportunity stimuli. Studies 1 and 2 used survey questions to document the 'real-life' sleep variations of experienced entrepreneurs, whereas Study 3 directly manipulated the sleep quantity of two groups of entrepreneurship students, prior to asking them to perform a series of relevant tasks and exercises.

These choices imply some limitations. For example, critics could observe that Study 3's causal claims might not be representative of sleep deprivation's effects among entrepreneurs. Because of their prior experiences or idea-relevant prior knowledge, for instance, entrepreneurs might have developed cognitive abilities and mental models that would enable them to counteract sleep restriction's otherwise deleterious effects. If this were the case, the findings we report from Study 3's student sample would likely be over-inflated. This is a valid concern. Yet evidence from prior studies suggests that sleep's effects on the psychological processes that anchored our theoretical developments are robust across many different contexts, and affects individuals' reasoning abilities over and above variations in backgrounds, knowledge and skills (C. A. Anderson, Lindsay, & Bushman, 1999; Litwiller et al., 2017; Mook, 1983). Incidentally, we note that Study 3's results are consistent with what we documented with Studies 1 and 2's samples of entrepreneurs, and that the underlying psychological processes that explain our observed effects are fundamentally human and may manifest in contexts such as entrepreneurial decision making (Mook, 1983). Furthermore, psychological research has shown that field studies and laboratory studies focusing on the same constructs tend to offer converging evidence ( $r = .73$ ; C. A. Anderson et al., 1999), suggesting that the results of our controlled experiment mirror those likely to emerge among active entrepreneurs.

Another limitation is that our studies focus specifically on sleep quantity. Yet other characteristics of sleep may also be relevant. The amount of time it takes to fall asleep, the number of interruptions throughout the night or the degree to which sleep is experienced as restorative are all sleep characteristics which are typically aggregated under the conceptual umbrella of sleep quality (Barnes, 2012; Harvey, 2008; O'Donnell et al., 2009).

Future research should also consider expanding investigations of sleep on entrepreneurial processes to include sleep quality as well.

Like in many other studies, a more general concern is our effective ability to rule out alternate explanations associated with variables not included in our analyses. In this regard, for instance, Williamson et al. (2019) document high-activation positive mood as a mechanism in the relationship between sleep quality and innovative work behavior. Building on such findings, it would seem pertinent to investigate the extent to which the findings documented in our studies are affected by individual variations in moods and emotions. Considering the particular research tasks and stimuli we mobilized, one could also argue that the personal engagement associated with developing one's own venture idea might surpass the effects from sleep we documented in our different studies. Yet here again, evidence suggests that our participants took the studies seriously as evident in the attentiveness of their responses, the number of ideas and amount of writing in the ideation task, and the amount of time spent on the assessment tasks.

#### **6.4. Practical implications**

Finally, our findings highlight an interesting paradox: in spite of common admonitions and other war stories that the best entrepreneurs often devote exceptional amounts of time to their business ventures, such investments could prove quite costly. The popular media is replete with cases of high-profile entrepreneurs who attribute their success to their uncanny devotion to their projects (e.g., Donald Trump, Martha Stewart, and Elon Musk). Although there are exceptions (cf. Huffington, 2017), many entrepreneurs hold sleep low on the ranking of daily priorities. Though most recognize that some sleep is needed to function, many believe that less sleep is better.

Contrary to these popular images, our findings suggest that sleep-restricted entrepreneurs might likely be performing below their potential, with lessened capabilities to imagine high-potential new ventures ideas and forming overly positive beliefs about ideas that otherwise exhibit questionable mismatches. Moreover, the pattern of results from H2ab suggests that sleep-restricted individuals might be able to generate an adequate quantity of new venture ideas, but those ideas will tend to be less attractive. Although sleep is not the only ingredient for success, our work encourages individuals to ensure adequate rest, the more so when engaging in efforts to imagine new venture ideas. When this proves more difficult, Murnieks and colleagues (2019) suggest that mindfulness meditation could help entrepreneurs mitigate the effects of sleep restriction and may have the added benefit of aiding the following night's sleep.

## **7. Conclusion**

Sleep is a necessary fact of life. We all need some rest, and this is also true for entrepreneurs. As we documented in our empirical studies, short-changing sleep is associated with less-effective abilities to imagine new venture ideas, with less-effective abilities to attend to and process the kind of structural similarities known to foster opportunity identification, and with less-effective abilities to form congruent 3<sup>rd</sup>-person confidence beliefs about the perceived attractiveness of new venture ideas. Over and above this focus on sleep restriction's adverse effects, we hope our work will encourage further studies to move beyond the positive influence of individual resource endowments that take a long time to acquire and add increasing attention to physiological factors and dynamics that exhibit important day-to-day variations.

## CHAPTER IV

*Note.* This chapter represents the third and final paper in the dissertation that investigates dynamic performance in entrepreneurial contexts, hallmarked by high uncertainty in eventual outcomes (McMullen & Shepherd, 2006; Townsend et al., 2018). Whereas the first two chapters delve into entrepreneurial cognition, this one moves to the context of angel investing, conducting a constructive replication of the findings in Chapter III. The following chapter builds on the other two by investigating a novel context where evaluation happens more frequently, and using real data from investment decisions, suggesting that investors are subject to dynamic formation of initial beliefs about new ventures.

### **Introduction**

Angel investors are wealthy individuals, or groups of individuals, interested in funding new ventures at an early stage of development. Acting as informal venture capitalists, angel investors directly fund early stage ventures with their own money (Wiltbank et al., 2009). Even though these individuals are wealthy, their resources are not boundless; they must choose among many entrepreneurial businesses seeking funds. Thus these investors usually evaluate many opportunities before deciding which ones to fund, eventually funding only 15-20% of the businesses evaluated (Sohl, 2017). Even though there is a reasonable expectation that some of these investments might fail, angel investors attempt to choose winning opportunities that eventually beget returns from the initial investment. The premium placed on choosing opportunities with the highest likelihood for success makes the formation of initial beliefs about early stage ventures an important angel investing task.



Utilizing intentional thinking processes, defined as serial and slow cognitive processing that is unencumbered by perfunctory judgements (System 2 thinking; Kahneman, 2011), to evaluate opportunities seems the most efficacious method to assess potential investments. This is how expert entrepreneurs identify and evaluate opportunities (Grégoire & Shepherd, 2012) ,and it follows that investors would prefer this approach over a System 1 approach that evaluates more superficial and less consequential features of a new venture idea. System 2 evaluation weighs the potential benefits and associated risks of opportunities in a cogent and sensible fashion. Yet entrepreneurs and angel investors use other, more variable and potentially cursory decision criteria when selecting opportunities. Evaluation decisions in uncertain and risky situations rely on both analytical cognition and more emotional decision making schema (Cardon, Foo, Shepherd, & Wiklund, 2012; Lawrence, Clark, Labuzetta, Sahakian, & Vyakarnum, 2008), sometimes arriving at final decisions that fit more with a preconceived notion than a rational weighting of benefits and risks associated with the new venture idea (Kunda, 1990).

Current literature on opportunity evaluation acknowledges that angel investing outcomes vary by opportunity, but that an angel's selection strategies rely on mostly slow-moving cognitive processes that tend to be less sensitive to subliminal features of a new venture (Lieberman, 2007). For example, Wiltbank et al. (2009) suggest that one angel's control strategy (i.e., a decision to invest in a business that emphasizes the ability to control tangible assets and inputs) out-performs another angel's prediction strategy (i.e., a decision to invest in a business that emphasizes positive future performance), but offer no evidence that these strategies might vary within the same angel from one

opportunity to another, or from one day to the next. Cardon et al. (2012) build an argument for emotion in entrepreneurial research, but only briefly mention the need for advanced methods to capture the nonstatic nature of decisions in a new venture context. To be clear, exploring slower-moving analytical decision-making criteria in entrepreneurship research has contributed greatly to our collective understanding of important antecedents to new venture success. But I contend that other influences might vary the use of evaluation strategies, in this paper from the perspective of angel investors. In other words, there are factors that influence angel evaluation of new ventures over multiple time points. That is to say that a sometimes analytical evaluator may employ more perfunctory decision-making criteria in alternate situations. This contention builds on existing cognition research, adding a dynamic layer to angel investor evaluation, and offers a new contribution to a growing swath of research on new venture opportunity evaluation (e.g., Haynie, Shepherd, & Patzelt, 2012; Uy, Foo, & Aguinis, 2010; Uy et al., 2017).

The purpose of this paper is to explore conditions under which spontaneous or superficial schema are employed as angel investors form initial beliefs about new venture ideas. One such condition involves allocentric perspective taking biases (Eyal, Steffel, & Epley, 2018) where the investor imagines him/herself in the shoes of the entrepreneur as a result of the language the entrepreneur chooses in the initial pitch of the business idea. This is a social cue provided by the entrepreneur or founder team, one that could impact evaluator judgement (Beveridge & Pickering, 2013). The other condition involves individuals who experience sleep problems as a potential confound that skews initial belief formation. By studying these two situations that might interfere with otherwise

more-analytical evaluation strategies, I explore two conditions, one socially provided cue and another within-individual difference, where merit-based evaluations go awry. This adds nuance an existing opportunity evaluation literature. Studies that assume employment of System 2 cognition alone to explore evaluation decisions use important but inadequate methods to understand how investment decisions are made (cf. B. T. Mitchell et al., 2017). I highlight the incompleteness of the current literature on opportunity belief formation, and identify new constructs that provide a more holistic understanding of evaluation processes. In doing so, I open the study of opportunity evaluation to the notion that initial belief formation can be a more dynamic process subject to frequent variation in assessments. This exploration not only accents an inadequacy in our understanding of investment evaluations, but also offers solutions that highlight a more holistic approach to future research in this area. Understanding both fast and slow cognitive processes in initial belief formation contributes to a path toward a more complex understanding of human decision processes in the context of new venture planning and funding.

During the course of the paper, I explore the following questions: Does the way an entrepreneur presents a new venture idea influence the audience to rely on superficial schema, thereby producing greater variability in opportunity evaluation? This question suggests an environmental factor for variance in evaluation tasks. I also ask whether investors' daily experiences influence their performance in evaluation activities, which represents an intrapersonal factor for variance in evaluation tasks. Answers to these questions and others like them should continue to reveal the interplay between rational cognition and non-rational bias in new venture evaluation decisions. I utilize research on

perspective taking to describe why angel investors incorporate more superficial criteria in their initial belief formation on new venture ideas. If an angel investor relies upon superficial assessments, consisting of cursory features that are usually pitched in a positive light by entrepreneurs, we should observe higher ratings regardless of the quality of the startup idea.

In conducting my empirical investigation, I offer three specific benefits to the study of new venture investing. First, I theorize that a dynamic view on initial belief formation can add nuance to our understanding of the early stages leading up to decisions to invest resources in a new venture. This highlights how one angel investor's belief formation might change based on how the entrepreneur presents the idea, or might change based on specific sleep experiences the investor encounters. Second, I conceptualize the relevance of System 1/superficial thinking to initial belief formation in evaluation decisions. This adds a fast-thinking decision-making construct to an established literature that modally and implicitly suggests entrepreneurs and investors employ analytical thinking to opportunity evaluation tasks (Grégoire & Shepherd, 2012; Shepherd, 2015). Although there are several exemplary peer-reviewed studies that investigate what might be considered less analytical (see for e.g., Uy et al., 2017), none of these studies suggest or discuss dynamic performance in initial belief formation during a funding decision process. Third, I specifically test whether sleep problems are associated with non-rational decision-making in angel investing contexts. These contributions work together to create a constructive replication of the findings in Chapter III, improving on the previous effort with a real-world sample of investors forming actual introductory beliefs about new venture ideas.

Many angel investing groups use the online platform in my study as a tool for initial belief formation. These belief formations are consequential insofar as higher beliefs in the idea lead to an escalation of investigation activity from the investment fund to determine whether the new venture idea will receive an investment. If an idea advances beyond the belief formation stage, the fund commits significant time to corroborate the founder statements and research the idea's potential. If the fund makes an investment, the group injects cash into the new venture in exchange for equity. Thus the real-world decisions I investigate in this paper represent consequential events for both investors and entrepreneurs alike. Advanced understanding using a real-world sample provides strong rationale for the potency and necessity of a constructive replication (Eden, 2002; Köhler & Cortina, in-press). As another important marker for a constructive replication, this investigation bolsters the external validity of the empirical chapters of the dissertation (Colquitt & Zapata-Phelan, 2007; Rosenthal, 1991) and opens new avenues for scholarly inquiry into dynamic initial belief formation.

The paper progresses by first outlining fast and slow thinking processes in a new venture evaluation context, integrating dual-process cognition theory with structural alignment theory in business venturing. Then I explain a dynamic mechanism associated with the evaluation of early-stage ventures, namely the incidence of sleep problems for evaluators. I subsequently argue that angel investors make decisions utilizing mechanisms that are not only stable (i.e., personal disposition and experience), but also dynamic (i.e., varying based on emotion, type of opportunity, and time of measurement). I find mixed support for my hypotheses with an archival dataset, using real investment decisions from an angel investing group's online investing platform. This work builds on

the prior two chapters of the dissertation, and should promote greater understanding of angel investors' initial belief formations about new venture investment opportunities.

### **Theoretical tension and hypotheses**

Bazerman (1994) outlines analytical decision-making as defining a problem, identifying relevant criteria, weighting those criteria, identifying alternatives, rating the alternatives on the weighted criteria you've identified, and then computing the optimal decision. This type of decision-making requires serial processing that is subject to interruption in high arousal situations (Lieberman, 2007). Angel investors attempt to make rational decisions about a startup's potential for success, albeit in a nascent and uncertain period of the new venture's lifecycle. When investors attempt to make decisions based purely on factual considerations, J. R. Mitchell, Shepherd, and Sharfman (2011) show that strategic decisions have a tendency to be erratic and inconsistent. Initial belief formation has momentous leverage on which new venture ideas move beyond the screening stage, and which ones are discarded. Although we know much about potential biases in strategic decision-making (e.g., Franke et al., 2006; Murnieks, Haynie, Wiltbank, & Harting, 2011; Thagard, 2006), we understand less about the causes of these biases in initial new venture belief formation tasks that are important for both investors and entrepreneurs. This third paper intends to unpack one such clearly documented bias: the tendency to invest in the person rather than the business, a bias with widespread prevalence in investment decisions. For example, Georges Doriot, an early pioneer of modern venture capital investing, once said, "Always consider investing in a grade-A man with a grade-B idea. Never invest in a grade-B man with a grade-A idea." (Bygrave, 1997) This notion seems sound when considering the amount of effort and resilience that

it takes to effectively begin and sustain a new venture. However, we also know that level-headed investors aspire to make decisions that consider features of both the entrepreneur and the opportunity (Franke, Gruber, Harhoff, & Henkel, 2008; Tyebjee & Bruno, 1984). In an attempt to understand which part of the venture may be more important for growth and eventual IPO, Kaplan and colleagues find that features of the business idea are better predictors of IPO than features associated with the entrepreneur (Kaplan, Sensoy, & Stromberg, 2009). Counter to the Doriot quote above, and viewing performance in retrospect, the business idea would seem more important than the person behind the idea. Or perhaps a better way to put it would be that a grade-A entrepreneur can help a startup succeed, but that person would not represent a sufficient condition for a business idea to succeed.

Recent empirical work suggests that careful investors rely on assessments of the entrepreneur and founding team early on in the new venture's lifecycle (Mitteneess, Sudek, & Cardon, 2012). After the venture has gained market traction, the catalyst for assessment shifts more to the market potential of the business (Mitteneess, Baucus, & Sudek, 2012). However, as this paper describes, the initial belief formation does not consist of deliberate cognitive assessments of the founder(s) or the opportunity as the work above suggests. Instead, I theorize that initial belief formation can be much more dynamic, relying on automatic cognitive processes that skew initial belief formation about the true market potential of the new venture idea. Both the language used by the founder during the pitch influence the use of automatic cognitive processes, but so too can the investor's contemporary mental condition. Even though the use of automatic

thinking processes is far more efficient than more deliberate cognition, automatic cognition can lead to errors in belief formation.

### **Fast and slow cognitive processing**

Current theorizing on human cognition has coalesced around the notion that the mind uses two separate thinking systems. System 1 (Kahneman, 2011) largely reacts automatically, without much conscious effort and tends to focus on making split-second interpretations and decisions. System 2 is more deliberate, more effortful, and tends to be slower at making interpretations and decisions (Kahneman, 2011). Lieberman and colleagues (2002) label these two thinking processes ‘reflexive’ and ‘reflective.’ The two systems are often referred to by the letter ‘X’ (for the letter x in reflexion; X-system) and ‘C’ (for the letter c in reflection; C-system), respectively. Contemporary research on such models has shown that the two systems operate from different parts of the brain (V. Goel, Buchel, Frith, & Dolan, 2000). In the managerial sciences, applications of dual-process theories have been associated with models of creative judgments (see Elsbach & Kramer, 2003) and ethical decision making (Reynolds, 2006; Welsh & Ordóñez, 2014).

More pointedly for the purposes of this dissertation, dual-process theories of the mind provide a conceptually-sound basis upon which to review models of investors’ efforts generate initial beliefs about new venture ideas. Investors form initial beliefs from very little information and in a very short period of time. This means that investors seldom rely on slower and more effortful thinking process when forming initial beliefs. Forming rapid initial beliefs may cause investors to overlook more important relationships between a developing innovation and an intended marketplace. Structural alignment theory (Gentner, 1983) gives us a lens to compare fast and slow thinking



processes in an entrepreneurial context. The following section draws parallels between dual-process cognition and structural alignment theory.

### **Structural alignment theory**

Table 1 outlines the key tenets and parallels of dual-process cognition theory and structural alignment theory. The left column in the table is the fast-thinking System 1, which would likely yield a cursory overview of a promising new venture idea, one primarily focused on superficial-level considerations that are less important for new venture success (Grégoire et al., 2010). The right column in the table represents the slower-thinking System 2, which would more likely be associated with more effortful processing of the same idea and would consider structural parallels and connections, even in the absence of superficial similarities. It is the parallel processing capability that enables System 1 to operate quickly and assess superficial features, but leaves the investors with a diminutive ability to envision the full potential of a new venture idea. By contrast, the serial processing associated with System 2 allows investors to think about structural considerations and move through logical if-then relationships between a new venture idea and its eventual exploitation (Kahneman, 2011; Lieberman, 2007). These serial comparisons and logical progressions affiliated with System 2 could thus allow an investor to make unobvious comparisons to extant businesses, and even facilitate the imagination of what could potentially come about in a particular technology and market combination. This kind of reasoning is not possible when employing System 1. Even though careful System 2 reasoning would likely yield more insightful considerations of new venture ideas among investors, the ability to engage that system may be possible one day and missing the next. For my purposes, I investigate the roles of both an

entrepreneur's pitch to investors and an investor's sleep habits. This multifaceted approach not only provides an external cue (i.e., first person pronoun use in the executive summary) but also a difference within investors (i.e., sleep problems in the form of insomnia) that both influence investors' initial beliefs about the market opportunity. If belief formations are more efficacious when System 2 is employed, it would behoove entrepreneurship research to identify the conditions in which System 2 is more likely to be used, and those situations where cognitive reasoning tends to be more limited to System 1. I explore a couple of those situations in this paper.

**Table 1 – Dual-process cognition theory and structural alignment theory in entrepreneur opportunity evaluation**

<b>Dual-process Cognition Theory</b> (Kahneman, 2011; Lieberman et al., 2002)	
<i>System 1</i>	<i>System 2</i>
Limbic activation Parallel processing Fast Operating Slow learning Sensitive to subliminal presentations Spontaneous processes Prepotent responses Outputs experienced as reality Relation to behavior unaffected by cognitive load Facilitated by high arousal Representation of symmetric relations Representation of common cases	Prefrontal activation Serial processing Slow operating Fast learning Insensitive to subliminal presentations Intentional processes Regulation of prepotent responses Outputs experienced as self-generated Relation to behavior altered by cognitive load Impaired by high arousal Representation of asymmetric relations Representation of special cases (e.g., exceptions) Representation of abstract concepts (e.g., negation, time)
<b>Structural Alignment Theory</b> (Gentner, 1983; Grégoire et al., 2010)	
<i>Superficial features</i>	<i>Structural relationships</i>
Perception and mapping of superficial elements of mental representation Surface-level characteristics with no more than one-to-one comparisons	Reasoning/processing of structural component of mental representations First-order relationships How and why of technology-market combinations Higher-order relationships Benefits and problems of technology-market combinations

The purpose of this paper is to identify and highlight conditions that lead to cursory decision making in real investment evaluation tasks, where superficial features are relied upon without delving into the more difficult task of assessing structural relationships. Given the consequences that flow to entrepreneurs when investors make go/no-go decisions, it would be fruitful to explain the mechanisms at play that influence investment decisions. I employ entrepreneur communication of the opportunity and an investor’s sleep problems as potential explanations for how investors fall subject to

imprudent initial belief formation in evaluation tasks. When investors are invited to consider an entrepreneur's perspective when evaluating an opportunity, those investors are more likely to evaluate the opportunity favorably. This is because this act of sensemaking allows the investor to step into the shoes of the entrepreneur and assume the role at the helm of the organization.

Murnieks et al. (2011) find that investors who perceive that entrepreneurs think like-mindedly are more likely to commit an investment to those entrepreneurs and their new venture ideas. Yet I suggest that this phenomenon is more universal than just an idiosyncratic investor-entrepreneur dyad. I further submit that these biases are invited when an entrepreneur uses first person language to introduce the new venture idea. Existing theory assumes that humans are more likely to take the perspective of a third-person when extended an invitation to do so (Tversky & Hard, 2009). Sharing language through stories and descriptions is perspective-based, meaning that individuals seek to understand stories by relating them to their own experiences (Beveridge & Pickering, 2013). This means that individuals draw on previous interactions with the world stemming from their own memories in order to understand a story being told (Barsalou, 1999, 2008; Fischer & Zwaan, 2008; Glenberg & Gallese, 2012; Glenberg, Sato, & Cattaneo, 2008; Pulvermüller, 2005). These memories assist a listener or reader to integrate the story's details with their own memories, thereby making sense of the overarching narrative.

I contend that an entrepreneur who introduces her idea using first person pronouns extends such an invitation. Eyal et al. (2018) find that when a person receives instructions to take another person's perspective, the instruction recipient interprets interpersonal

insight better than someone without similar instructions. The use of first person pronouns can be considered a proxy for instructions to take an allocentric perspective. First person pronouns allow the reader to adopt an allocentric view of the new venture idea, the opposite of an egocentric view, defined by a reader placing herself in the storyteller's shoes and interpreting the story from the teller's perspective (Beveridge & Pickering, 2013). Thus an entrepreneur who inserts him/herself or the founder team into investment documents, using first person pronouns, invites the investor to take the perspective of the founder(s). The language a writer chooses can imply both the orientation (Stanfield & Zwaan, 2001) of the new venture (i.e., how the innovation fits with the intended market) and the implied direction (Kaschak et al., 2005) of the new venture idea (i.e., where the new venture is headed in the future). These cues are easier for the reader to perceive when first person pronouns are used because those words invite the reader to envision herself inside the new venture, making steering decisions and shaping the venture's outcomes.

I further assert that the use of such first person language cues the investor to employ fast System 1 thinking and consider superficial features that the entrepreneur highlights from the entrepreneur's perspective. This is because the evaluator is invited to take an allocentric perspective, which makes it easier for investors to quickly think about the venture as though they are the founder at the helm (Eyal et al., 2018). The founder invariably attempts to pitch superficial features of the opportunity in a positive light. The investor who is invited into the founder's shoes during initial belief formation could become comfortable with the notion that the superficial information is sufficient to form an initial belief about the business idea. In the scenario with more first person pronouns,

the investor can superficially comprehend what the entrepreneur intends to do, and may not commit the additional required effort to imagine and assess the potential risks associated with the venture (i.e., the structural alignment or misalignment between a technology and commercial market). Thus an investor who reviews a summary of a startup with more personal interjections would likely give a more positive evaluation of this startup, all else being equal. I formalize these conjectures in the following hypothesis:

*Hypothesis 1: Angel investor initial beliefs about a new venture will be positively related to the proportion of first person pronouns the entrepreneur provides in the executive summary of the venture.*

### ***Sleep and investor belief formation***

The more nascent a venture, the more uncertain its chances for success (Manigart et al., 2002). Various scholars cite typical rational methods to evaluate opportunities, where evaluators tally metrics that have historically been correlated with new venture success (see Franke et al., 2008 for a review of these metrics) and compare the metrics of one opportunity with others to rank the quality of opportunity. In addition to the features associated with the opportunity itself, angels also rely on their own prior experience with a technology, above and beyond their experience investing (Shepherd, Zacharakis, & Baron, 2003; Zacharakis & Shepherd, 2001), to assess the market potential for the opportunity. Yet as I've pointed out above, investors have the potential to vary on a day-to-day basis in their abilities to rationally form beliefs about a new venture's potential for success.

To explore the influence of daily variations on rational new venture belief formation, I utilize the measurement of a daily activity that everyone, investor and

otherwise, engages in, namely sleep. In my effort to expose how sleep plays a role in initial belief formation, I draw from structural alignment theory to show how an investor might form superficial initial beliefs about a venture. From an outsider perspective, initial belief formation may appear to rely solely on purely effortful higher-order decision-making criteria. Within the belief formation context, I build from insights contained within structural alignment theory to suggest that biological processes (e.g., sleep problems) often have cognitive effects (e.g., attending to unimportant decision-making criteria) that can influence an investor's initial new venture belief formation.

How might experiencing sleep problems contribute to the cognitive process of forming an initial belief about a new venture idea? Entrepreneurship research has uncovered how low sleep quality can influence self-perceived innovative work behavior (Williamson et al., 2019), and how low sleep quantity is associated with diminished creativity (Weinberger et al., 2018). Sleep is one of several important factors for recovery from exhaustion associated with entrepreneurial work (Murnieks et al., 2019). I show in an earlier chapter that low sleep quantity disrupts an entrepreneur's effective opportunity belief formation (see Chapter III). Chapter III theorizes and tests a specific mechanism, the ability to attend to unobvious but important alignment between prospective markets and technological innovations. The ability to attend to this information mediates the relationship between sleep and initial belief formation. I contend a similar dynamic is at play for investors while they are forming initial beliefs about the new venture idea. These dynamics hold particularly true for early-stage funding evaluations. Initial belief formation happens quickly, and investors are looking for signals of quality. Whereas Chapter III investigates moderation of initial belief formation through idea quality, this

chapter views belief formation through the lens of investors using both a situational variable (i.e., the use of first person pronouns in the executive summary) and a within-individual difference (i.e., experiencing sleep problems in the form of insomnia).

Sleep deprivation has been linked with various changes in brain functioning (Hobson, 2005). However, a growing body of evidence indicates that sleep is especially important for the functioning of System 2. System 2 processing relies heavily on the prefrontal cortex region of the brain (Barrett, Tugade, & Engle, 2004; Gianotti et al., 2009; Hare, Camerer, & Rangel, 2009; Miller & Cohen, 2001). In contrast, System 1 processes occur less centrally in the prefrontal cortex, relying on several other areas such as the amygdala, basal ganglia, cingulate cortex, and temporal cortex (Satpute & Lieberman, 2006).

This difference becomes important in the context of sleep. The prefrontal cortex is the region of the brain most vulnerable to the harmful effects of sleep deprivation (Y. Harrison & Horne, 2000). The body of research supporting this notion includes brain scan results revealing impaired prefrontal cortex functioning under sleep deprivation (Ellemarije Altena et al., 2008; Schnyer et al., 2009). Similarly other research reveals impairments in cognitive functions that utilize the prefrontal cortex when research participants are sleep deprived (Barnes, 2012; Chuah et al., 2010; Nilsson et al., 2005). Overall, this literature indicates that System 2 functioning is especially degraded by sleep deprivation (Barnes, 2012), and that automatic processes are relatively more robust to the effects of sleep (e.g., Y. Harrison & Horne, 1999). This suggests that investors with sleep problems show an increased propensity to form initial beliefs with automatic System 1 cognitive processes, relying more on superficial features than structural alignment, the



latter of which requires System 2 thinking to access. It is simpler to pitch a superficially good new venture idea, and entrepreneurs seeking an investment have an obvious incentive to pitch their idea in a positive light. This is true even if the structural alignments are not as positive as the superficial features, and should lead investors with sleep problems to rate an idea higher on average than an investor without sleep problems.

Entrepreneurs typically frame their new venture in a positive light. So the executive summaries written by entrepreneurs are likely to exhibit superficial alignment between the innovation and commercial market. Yet a deeper analysis of structural alignment, which requires System 2 thinking, reveals the how and why a venture should work and the venture's potential benefits and problems (Grégoire et al., 2010). An investor experiencing sleep problems is less likely to move beyond the superficial considerations to form an initial belief about the new venture's potential for success. After reading an executive summary where an entrepreneur pitches congruent superficial features, investors with sleep problems will form more positive initial beliefs about the venture. This remains true both for new ventures that lack structural alignment (i.e., otherwise ill-conceived new venture ideas) and for those that possess positive structural alignment (i.e., more promising ideas).<sup>13</sup> As an investor with sleep problems reviews an

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<sup>13</sup> Entrepreneurs craft their market problem and commercial solution statements in a decidedly positive light on the online platform investors use for initial belief formation. This means that the real-world data used for the analysis in this paper are different from the manipulated scenarios presented to the entrepreneur sample in Study 2 of Chapter III. Recall in that study, I was able to manipulate the new venture ideas to empirically test whether entrepreneurs formed beliefs using superficial or structural criteria. In this study, there is an overrepresentation of high-superficial, low-structural alignment ideas that did not receive investment. There are also a few ideas in the sample (i.e., those that received an investment from the fund) that exhibit high-superficial, high-structural alignment. Notably missing from the real-world sample in this paper are those business ideas that lack superficial features that match their intended market, both lower- and higher-quality ideas. Thus my analysis assumes that investors form their initial beliefs based on ideas that invariably show superficial alignment (see Appendix A for all four manipulations from Chapter III). The analyses in this paper represent initial beliefs in ideas congruent with Cells II and IV from Appendix A, with most ideas fitting in Cell IV (the high-superficial, low-structural condition in Study 2 from Chapter III).

executive summary with strong superficial alignments between the market and innovation, that investor will form overly positive beliefs about that new venture idea.

*Hypothesis 2: Angel investor insomnia will have a positive relationship with initial investor beliefs formed about the market potential of a new venture idea.*

Although I hypothesize on an angel investor's experience of insomnia in this paper, which has an effect on both sleep quantity and quality, there are reasons that both sleep restriction and lower sleep quality might influence initial belief formation in different ways. Namely, sleep quality effects differ from sleep quantity effects when perception is involved (Litwiller et al., 2017). Given my theorizing on the discernment of superficial and structural considerations, a perceptual task at its core, I measure and test insomnia as an antecedent of new venture initial belief formation and capture both investor sleep quality and quantity in one scale.<sup>14</sup> To be clear, I measured sleep quantity in Chapter III and insomnia in Chapter IV due to the data collection procedure. In Chapter III I had the advantage of checking in with entrepreneurs each day to measure their sleep quantity from the previous night. This chapter asks investors about sleep problems retrospectively, and in general. This is because initial belief data were collected over a 14-month period, and information about sleep problems was collected after all initial beliefs were formed, making a specific question about sleep quantity or quality less meaningful than if it were collected, for example, on the day the initial belief was formed.

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<sup>14</sup> I also note that both general sleep quality and sleep quantity were measured separately in this study. Each of these variables is a significant antecedent to initial belief formation, suggesting that insomnia—a measure of both quality and quantity—serves as an effective measure of sleep problems in the investor sample.

The empirical model I construct in this paper couples an investor-specific antecedent with a venture-specific antecedent. This work holds the promise to uncover situations where attempts to form initial beliefs might be colored by environmental factors such as the presence of an entrepreneur or founder team in the business pitch, or an investor's sleep habits (Elsbach, Barr, & Hargadon, 2005; R. K. Mitchell, Randolph-Seng, & Mitchell, 2011; Murnieks et al., 2019; Williamson et al., 2019). These situations cue more automatic and efficient thinking processes to form beliefs about superficial features between an innovation and an intended market, but yield suboptimal investor ratings. The following sections test these speculations in turn and discuss the findings in theoretical and practical contexts.

## **Methods**

I intend to test these hypotheses using data from an online platform that angel investors use to make initial evaluations of startup investment opportunities. This platform is called Gust, and the platform enjoys widespread use among angel investing groups. I follow 14 different angel investor evaluators as they evaluate 137 new venture ideas in two separate investment rounds, eventually investing. My data include 395 individual ratings of new venture ideas. Each investor was only allowed to rate an idea once, and ratings are nested within ideas, with an average of 2.9 ratings per idea. These initial ratings are the screening activities that investors perform before moving forward with more rigorous evaluation tasks. Investors form their initial beliefs about the potential for a new venture idea in about 5-10 minutes. The eventual output is a star-based rating system, where a new venture idea can receive anywhere from 0.5 to 5 stars, in 0.5 star increments. Ideas are rated on the team that's been assembled, the market problem and

potential, the product or service the entrepreneur proposes to solve the market problem, and the supplied financial documents. Structural alignment perspectives focus on the alignment between an innovation and a prospective commercialization market. Evaluators measure alignment between both superficial features and structural components of innovation and market pairings. Since I draw on structural alignment theories of new venture evaluation, I focus on investor ratings of market problem and potential as they form their initial beliefs about the new venture.

### **Measures**

I measured *market opportunity beliefs*, the dependent variable, by directly converting the star-rating in the Gust platform to a number. The numbers range from 0.5 to 5.0, and ascend in increments of 0.5. The higher the number associated with the star-rating, the more positive the perception of the potential market opportunity for this new venture's proposed product or service.

The degree to which an entrepreneur inserted himself or herself into the initial pitch was extrapolated from the executive summary on the Gust platform. Textual data for each of the 137 new venture ideas were scraped from the Gust online platform, organized and stored by company ID within a spreadsheet with other study variables, and then analyzed for *first person pronoun use*. This analysis employed a software tool called Linguistic Inquiry and Word Count (LIWC; Pennebaker, Boyd, Jordan, & Blackburn, 2015). LIWC analyzes textual data by reading one target word at a time. The software compares each word to one of many existing dictionaries. The researcher pre-sets which LIWC dictionary the software will compare with target words. If the software finds a match with the prescribed dictionary, the software notes the match for that portion of text

and analyzes the rest of the passage in a similar fashion. When the software is finished analyzing the passage it calculates the proportion of words used in the passage that match the selected dictionary. Then the software moves on to the next passage and performs the same task until reaching the end of the range of data. The dictionary contains 24 words for singular personal pronouns (e.g., I, me, and mine; accounting for individual founder references) and 12 words for plural personal pronouns (e.g., we, us, our; accounting for team-based founder references). The results for first person pronoun use range from 0.00 (i.e., no first person pronoun use) to 11.94 (i.e., roughly 12% of words in the executive summary were first person pronouns).

*Insomnia* was measured using a scale of insomnia symptoms (Jenkins, Stanton, Niemcryk, & Rose, 1988), an indirect indicator of sleep quality, by asking four questions about the extent to which an angel investor participant experienced trouble falling asleep, trouble staying asleep, waking up throughout the night, and waking up feeling tired (1 = *Very Slightly or Not at All*, to 5 = *Very Much*;  $\alpha = .64$ ). Since the insomnia scale was collected after the angel investors had formed their initial beliefs about the new venture ideas (i.e., after the 14-month study period), the investors were asked the extent to which they experienced these symptoms in general. The four items were averaged together to create an insomnia scale for participating investors.

I employ a fairly standard set of controls including investor age, gender, and level of formal education (Uy et al., 2017). For investor experience, both general and specific, I include a measure of investing experience, in years, as well as a measure of investor self-assessed competence within the industry being evaluated for each new venture idea on a scale of 1 = *extremely incompetent*, to 7 = *extremely competent*. Investors provided

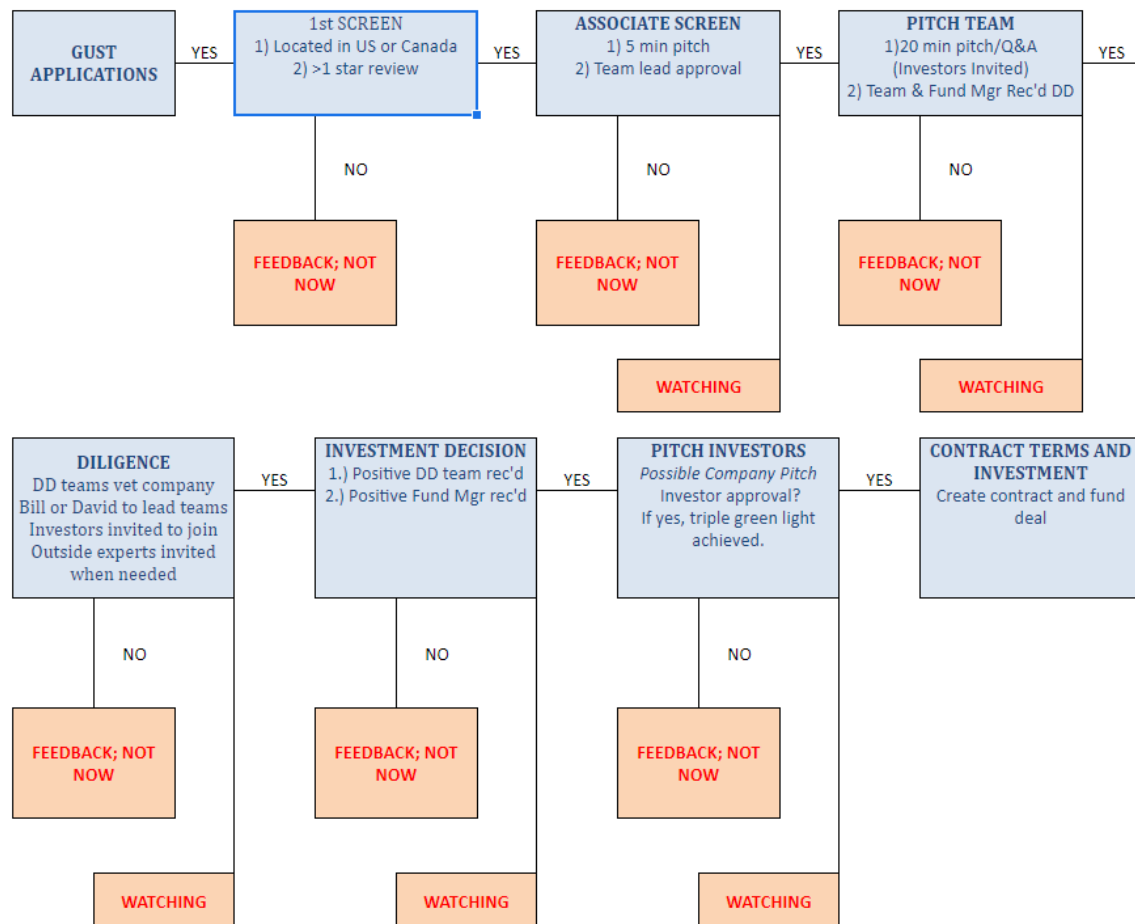
self-assessed competency ratings for 27 separate industry categories, and the category competency was then paired with that investor's rating of the target new venture. These control variables were collected after initial new venture beliefs were formed, in the same survey with the insomnia scale above.

### **Data structure and analysis**

Different angel investing funds review potential investment opportunities employing many different processes. Nevertheless, each angel involved in the investment decision inevitably forms an initial belief about the decision before either dismissing the idea as non-investable, or digging deeper to perform more intensive evaluation activities, usually referred to as due diligence. The data in this paper come from a small angel investing fund on the West Coast of the United States. The fund has 20 member investors, and raises funds for investment about once per year. The data within this paper includes two capital injections from angel investors over a period of about 14 months. Figure 1 shows the process the focal fund uses for evaluating potential investments. During the span of these data, 137 new venture ideas were evaluated using this process, determining desirability for potential investment. The capital invested totaled \$725,000 over the 14-month period. This money was invested in eight separate new ventures after evaluation tasks were completed. The analyses in this paper address the earliest belief formation tasks, the first step in the process model highlighted in Figure 1. Most new venture ideas are discarded at this initial stage. Twenty new ventures made it past the initial step during the focal time period. As stated above, only eight new ventures received an eventual investment. Individual investments range from \$25,000 to 125,000. In these two rounds of funding, 14.6% of applicants moved beyond the first stage and

5.8% of applicants received funding. In other words, 85.4% (117 new venture ideas) were excluded using initial beliefs formed by individual members of the angel investing group. Considering such a low conversion rate from application-to-investment, it would seem that the early-stage belief formation constitutes a critical juncture for most ventures vying for investment funding.

**Figure 1 – Angel fund evaluation process**



*Note.* The initial yes or no decision stage (highlighted in blue above) is based on the investor reviews on the Gust platform. I also note that each of the companies in the study’s sample were in the United States or Canada. New venture ideas founded outside those areas are excluded since the merits of the idea were never evaluated by investors.

During initial belief formation, several angel investors review prospective new ventures, referred to colloquially as “potential investments” or “deals,” on a platform

called Gust. Individual angels review multiple deals on multiple dimensions. Since individual angels review multiple deals, and each new venture receives multiple ratings, there are two nesting structures within these data. Ratings from multiple angel investors are nested within new ventures, and ratings of various new ventures are nested within individual angel investors. To investigate ratings of individual prospective new venture deals, I use the nested structure where multiple investors form initial beliefs within one new venture deal on the Gust platform. By adopting this structure, and since one user can only rate a new venture once, I observe within-venture variation among individual raters. Research within organizations routinely reports that one-third to two-thirds of variation at the lowest level of analysis lends itself to multilevel analysis (e.g., Butts et al., 2015; S. H. Harrison & Wagner, 2016; Schilpzand et al., 2018). The outcome variable in this study, market opportunity rating, has an intraclass correlation coefficient ( $ICC_1$ ) of 0.431. This suggests that approximately 43% percent of the variance in market opportunity ratings is due to the grouping variable (the new venture idea), and supports the use of hierarchical linear modelling to test my hypotheses.

Table 1 displays the descriptive statistics, minimum and maximum values, and correlations among the study variables, and Figure 2 is a visual display of the same information. Since individual new venture market opportunity ratings are nested within new venture ideas, and a sufficient amount of variance in ratings was due to this grouping variable, I use a multilevel analysis to test my hypotheses. This approach helps account for variations in idea quality since the multilevel model compares market opportunity ratings within one new venture idea to other ratings within the same new venture idea. I



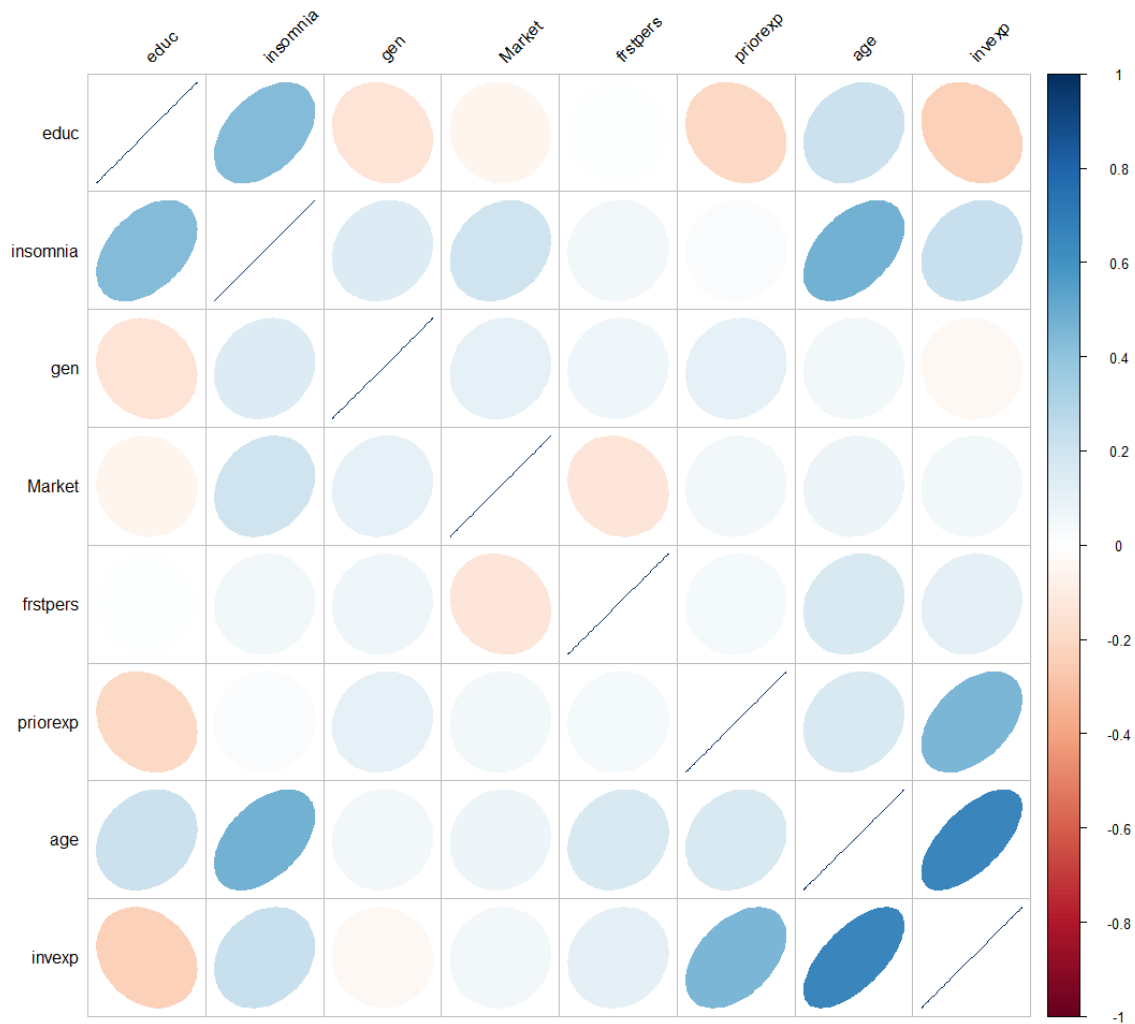
analyzed the data with the lme4 package in R, using restricted maximum likelihood estimation (lmer; Bates et al., 2015).

**Table 2** – *Descriptive statistics and correlations among study variables*

<i>Variables</i>	<i>Mean</i>	<i>SD</i>	<i>Min</i>	<i>Max</i>	(1)	(2)	(3)	(4)	(5)	(6)	(7)
1. Age	42.19	17.68	21	68	—						
2. Gender	1.02	.14	1	2	.06	—					
3. Education	5.61	.62	4	7	.21***	-.14**	—				
4. Investing experience	7.83	10.91	1	35	.65***	-.04	-.24***	—			
5. Prior domain competence	4.83	1.25	1	7	.17***	.11*	-.20***	.46***	—		
6. Insomnia	2.12	.64	1	4.25	.48***	.14**	.44***	.23***	.03	—	
7. First person pronoun use	2.60	2.41	0	11.94	.16**	.06	.00	.11*	.05	.05	—
8. Market opportunity ratings	2.61	1.20	0.5	5	.07	.11*	-.05	.06	.05	.21***	-.14**

*Note.* Market opportunity ratings (n = 395). First person pronoun use (n = 137). All other study variables are repeated across individuals (n = 14), who rated a new venture ideas only once. \*\*\* =  $p < .001$ , \*\* =  $p < .01$ , \* =  $p < .05$

**Figure 2 – Visual correlation table**



*Note.* N = 395. The shape of the ellipse corresponds to the strength of the correlation. As a correlation approaches zero, the ellipse approaches the shape of a circle. As the correlation approaches one, the ellipse approaches the shape of a line. Shades of blue represent a positive correlation. Shades of red represent a negative correlation.

## Results

Hypothesis 1 predicted that more references to the entrepreneur’s role within the venture would be associated with more positive initial beliefs about the new venture idea. Table 3 shows the results from my hypothesis tests. In both Models 2 and 4, the data do not support the conjecture proposed in Hypothesis 1. Curiously, the use of more first person pronouns was associated with a lower market opportunity rating for that new

venture idea (Model 4;  $\gamma = -.07$ ,  $p = .031$ , 95% CI [-.13, -.01]), suggesting that there is a modest penalty in market opportunity ratings when an entrepreneur uses first person pronouns to pitch the idea. Hypothesis 2 predicted that higher sleep problems would be associated with more positive initial beliefs about the promise of the new venture idea. Greater insomnia symptoms were associated with a significantly higher initial belief about the market opportunities presented in the executive summaries (Model 4;  $\gamma = .39$ ,  $p < .001$ , 95% CI [.17, .60]), supporting Hypothesis 2. I discuss these results in the following section, but I mention here that there is a one-star-point threshold for a new venture to move beyond the initial belief formation stage and to get through to the next round, a five-minute pitch to investors (see Figure 1). Recall that the lowest star-rating available is 0.5. These results suggest that one unit increase on the seven-point in insomnia symptoms scale for evaluators corresponds with 0.39 additional star-points during initial belief formation, almost enough to push an otherwise ill-conceived idea through to the next evaluation round.

**Table 3 – Multilevel model results – within-new-venture analysis**

<i>Dependent variable</i>	Market opportunity rating							
	(1)		(2)		(3)		(4)	
<i>Model number</i>	<i>est.</i>	<i>SE</i>	<i>est.</i>	<i>SE</i>	<i>est.</i>	<i>SE</i>	<i>est.</i>	<i>SE</i>
Intercept	2.15**	(.71)	2.30**	(.71)	2.82***	(.73)	2.96***	(.73)
Insomnia					.39***	(.11)	.39***	(.11)
First person pronoun use			-.07*	(.03)			-.07*	(.03)
Education	-.15	(.09)	-.16 <sup>†</sup>	(.09)	-.33**	(.11)	-.33**	(.11)
Prior domain experience	.05	(.05)	.05	(.05)	.06	(.05)	.06	(.05)
Age	.01*	(.00)	.01*	(.00)	.01	(.00)	.01	(.00)
Investing experience	-.01	(.01)	-.01	(.01)	-.01	(.01)	-.01	(.01)
Gender	.68 <sup>†</sup>	(.39)	.70 <sup>†</sup>	(.39)	.34	(.40)	.37	(.40)

*Note.* These models include 395 market opportunity ratings of 137 new venture ideas. Individual ratings are nested within new venture ideas. \*\*\* =  $p < .001$ , \*\* =  $p < .01$ , \* =  $p < .05$ , <sup>†</sup> =  $p < .10$

## **Additional analysis**

Considering the results from Hypothesis 2, showing that initial new venture beliefs about market potential were higher when an investor reports sleep problems, I decided to investigate whether these effects hold across new venture ideas of both high- and low-quality. Though it is normatively impossible to establish the “true” quality of an investment opportunity idea *ex ante* (Knight, 1921; Townsend et al., 2018), all of the new venture ideas in this sample have been through the entire evaluation process at the focal angel investing fund. This means that the ideas that made it through the initial screening stage received a more in-depth look than the others, potentially diminishing the effect of biases addressed in this paper, when initial beliefs are rapidly formed. Recall that eight ideas received funding, and I use this as a proxy for new venture idea quality to test whether the effects I observe are only true of a particular level of idea quality, and answer what may be an obvious question: Is it bad that the ideas are rated higher than normal when experiencing insomnia symptoms? After all, it may not be a negative phenomenon if the high-quality new ventures are driving this effect.

To test whether this may be the case, I partitioned the data into two separate datasets, one with new venture ideas that did not receive an investment ( $n = 371$ ), and one with only those new venture ideas that received an eventual investment ( $n = 24$ ). Although the latter test may suffer from a small sampling frame, with only 24 total evaluations for the 8 ideas that received an eventual investment, the results are not different from the main analysis. Specifically, and using the same multilevel model specified in Table 2, Model 4, the alternate sample that did not receive investment showed a positive and significant effect of insomnia on initial belief formation ( $\gamma = .34, p$

= .002). In the smaller sample that received investment, the coefficient remained positive, but did not achieve statistical significance ( $\gamma = 1.45$ ,  $p = .053$ ), likely due to the much smaller sample size in this test. Thus it appears that an investor who suffers from insomnia forms more positive initial beliefs about lower quality ideas than a well-rested investor. This may also be the case for higher-quality ideas, but the test of only 24 evaluations is far from conclusive.

## **Discussion**

The findings in this study suggest that angel investors do indeed utilize superficial schema when forming initial beliefs about a new venture idea. Both situational and within-individual cues influenced investor initial belief formation about new venture ideas. The majority of the ideas on the Gust platform did not receive investment, meaning that after deliberations beyond initial belief formation revealed that these new venture ideas would not move forward to receive an investment. Both external cues presented by the entrepreneurs (first person pronoun use) and within-investor differences (the experience of insomnia) influenced initial belief formation. However, there were some unexpected outcomes from my analysis, which I discuss with other implications below.

My results show that an angel investor who experiences insomnia will form more positive initial beliefs about a new venture idea than an angel investor who sleeps well. Relatedly, recent research into sleep and entrepreneurship suggests that creative pursuits suffer when sleep is disrupted (Weinberger et al., 2018; Williamson et al., 2019). Although the results contained in this paper do not measure within-person differences in belief formation, these results combined with existing research suggest that angel investors should not form initial beliefs about a new venture idea when symptoms of

insomnia are particularly acute. In other words, angel investors are more likely to employ System 1 schema to form initial beliefs about a new venture when the investor is not well-rested.

Recent research on language and perspective-taking offers some potential reasons for my findings between first person pronoun use and initial belief formation in the opposite direction. Evaluators may be inclined to adopt a more allocentric perspective when the referent sufficiently signals relevant expertise (B. T. Mitchell et al., 2017; Samuel, Roehr-Brackin, Jelbert, & Clayton, 2019), and in these scenarios, initial evaluation from the executive summaries rarely addressed founder expertise. Angel investors may not have had sufficient expertise information about the founder (or team) to rely on the expertise of the entrepreneur and defer to their judgement of the market promise, thereby leading to a deeper evaluation and lower overall market opportunity ratings, most of which were of poor quality and never received an investment. This means that the more-negative beliefs they formed were slightly more accurate when first person pronouns were more prominent in the executive summary. Raters may have also read first person pronouns and felt unable to normally-used shortcuts in evaluation tasks, cuing more complex System 2 evaluation (Galati, Dale, & Duran, 2019). In sum, even though the results indicate a relatively small effect on belief formation in the opposite direction from what I hypothesized, it is still plausible that System 1 processing—more superficial thinking that is subject to subliminal presentations—drives this effect.

My findings may also contribute to a larger conversation about how humans interact with inanimate sources of information, such as the language presented in the executive summaries on the Gust platform. Recent research suggests that humans find it

difficult to personally relate to inanimate information sources (Wiese, Metta, & Wykowska, 2017). This has led to a lively discussion on how humans might begin to interact more intimately with artificial intelligence and robots, an idea that has been met in the past with widespread skepticism. In the context of this paper, it may be plausible that the investors forming beliefs in this study had trouble sufficiently relating to the new venture idea in the absence of first person pronouns. When the founder teams introduced this language, it could have cued the investor to more-closely relate to the inanimate language about the business idea, and subsequently delve deeper into understanding the merits and pitfalls associated with the market potential of the idea. Since very few of the ideas were high quality, this deeper cognitive engagement led to lower overall market opportunity ratings.

The additional analysis in the methods section splits the type of opportunity into two categories that are ostensibly lower and higher in quality (Cells II and IV from Appendix A) for analysis. I expected to see a positive effect of insomnia on beliefs for the majority of the ideas presented (high-superficial and low-structural alignments,  $n = 371$ ) and no effect of insomnia on belief formation for the small minority of ideas presented (high-superficial and low-structural alignments,  $n = 24$ ). In the scenarios where high superficial alignments are backed up with similarly high structural alignments, I had no theoretical reason to believe that an investor should need to go beyond superficial assessments to accurately form a belief about a more promising new venture idea. I did not expect to observe an effect in these scenarios because investors with insomnia were not required to move beyond superficial assessments to form congruent beliefs with their well-rested counterparts. As expected, I observed a statistically significant and positive

effect for insomnia on belief formation in the additional analysis of ideas with less promising prospects. Curiously, I also observed higher beliefs for investors who suffered from insomnia in the higher quality ideas, albeit with a very small sample size and a *p*-value slightly outside the normal range for statistical significance. The larger coefficient for those ideas that received investment lends further impetus to follow-on work that investigates superficial alignment in conjunction with structural alignment. This finding contrasts the null finding from Cell II in Study 2 of Chapter III. That study had the advantage of a larger sample, however. Future research could explore this effect using many more than 24 initial belief formations, which would offer a more definitive conclusion to the apparent contradiction I outline above.

A robust addition to this research could be a randomized laboratory test of angel investor initial belief formation with System 1 and System 2 indicator tasks, much like the lab investigation in Study 3 of Chapter III. It would also be useful to know whether these effects replicate with other angel investing funds, and whether individual vary their approach on days when insomnia symptoms and outcomes are particularly salient. The tests I've outlined in this chapter could be replicated with other angel investing funds that perform initial belief formation using the Gust platform. Perhaps using a larger sample of investors, new venture opportunities, and investments would offer greater statistical power and provide results that are more congruent with the findings from Chapter III, and consistent with my theorizing. Nevertheless, the results in this paper indicate that not only are investors influenced by their individual sleep hygiene, they are also influenced by the language the entrepreneur chooses when pitching the idea. In situations of investor



insomnia and greater use of first person pronouns in the pitch, investors appear to lean heavily on more superficial criteria to form their initial beliefs about a new venture.

## **Conclusion**

I combine dual process cognition theory with structural alignment theory to hypothesize that investors form initial beliefs in a dynamic fashion. Investors are subject to biased decision-making based on their sleep hygiene and the language the entrepreneur uses when pitching the idea. This work represents a constructive replication of the theory and empirical findings in Chapter III, using a real-world observation of early belief formation by angel investors thereby extending the findings from Chapter III in a new context and with alternative methods. My results indicate that both investor sleep problems and entrepreneur language, in the form of first person pronoun use, change the way that investors form their initial beliefs. This chapter holds theoretical implications for the integration of two analogous theoretical perspectives, and has relevant practical implications for both entrepreneurs seeking funding and investors seeking to place their assets in winning new ventures.

## CHAPTER V: CONCLUSION

I began this three-paper dissertation with the goal of highlighting conditions under which entrepreneurs experience daily-varying performance when faced with uncertain situations. The new venture contexts represents a salient and uncertain context to study these entrepreneurial decision making. I exploit the process of sleep as a variable that influences each entrepreneur's life on a daily basis. Sleep proved to be a suitable variable in this context. Sleep exhibits sufficient variability between- and within-individuals, for example. This gave me the opportunity to provide a concentrated description of processes at play in uncertain contexts, measure differences between individuals, and highlight how one individual can vary over multiple days. Sleep also has known cognitive and affective implications that were underexplored in the management field, and in the entrepreneurship literature specifically. This gap in knowledge supplied the opportunity to reveal the theoretical and practical implications of sleep rhythms, sleep quality, and sleep restriction among individuals participating in the new venture context.

Each chapter in this dissertation represents a stand-alone paper. The first chapter combines literature on sleep processes with decision making in uncertain contexts to create a process model of sleep and uncertainty management. I highlight many mechanisms between sleep and uncertainty management, and explore the recursive relationship between these activities and subsequent sleep. The underexplored mechanisms in Chapter II provide the empirical impetus for Chapters 2 and 3. The second chapter investigates entrepreneurs in new venture settings, providing causal evidence for the effect of sleep restriction on new venture ideation and belief formation. The third and final chapter provides a constructive replication of the second chapter in an

angel investing context, where beliefs about new venture potential are formed more frequently and more formally by investors.

The combination of these three papers represents an in-depth investigation of decision making without knowledge of decidedly uncertain outcomes such as new venture efficacy and performance. The evidence collected in this dissertation informs our collective knowledge of decision making in uncertain situations. Yet the questions asked and answers provided demand additional, follow-on queries. Future research can use this work as stimulation to continue a more comprehensive line of inquiry into dynamic processes germane to the new venture context and decision making in uncertain situations.

## APPENDICES

### APPENDIX A – SAMPLE MANIPULATION OF A PROSPECTIVE OPPORTUNITY

#### Technology explanation

“True” new technology	Formula one racing teams develop a one-piece cockpit for drivers to decrease the probability of disintegration in a high-speed collision. In a high-speed collision, the rest of the vehicle is allowed to disintegrate, but the cockpit maintains its integrity.
“True” target market	Military vehicles are the frequent target of roadside bombs, leading to devastating consequences for the passengers in these vehicles. The cockpit is adapted and designed for passengers in these military vehicles, diminishing the likelihood for injury or death in roadside bombing events.
	From the perspective of our model, this technology-market pair is characterized as: Low levels of superficial similarity (e.g., Formula 1 racing ≠ military transportation) High levels of structural similarity (e.g., capability to protect passenger in a high-speed collision = need for maintained cockpit integration during an explosive event (i.e., a roadside bomb)).

#### Experimental manipulations of similarity (technology only)

Manipulation 1: Increasing superficial similarity with target market	Instead of being developed by a Formula 1 racing team, the technology is developed by the Defense Advanced Research Projects Agency (DARPA). The founder of the new company is a former combat-active soldier.
Manipulation 2: Decreasing structural similarity with target market	Instead of being used to keep a race car driver safe in a collision, the one-piece cockpit technology is portrayed as a rigid element of the vehicle that promotes greater stability during acceleration, braking, and cornering.

#### Technology-market pairs with different similarity characteristics

		<i>Superficial similarity</i>	
		Low	High
<i>Structural similarity</i>	High	Cell I <i>Superficial</i> elements of technology <b>mismatch</b> superficial elements of market: race car ≠ military transport Formula 1 ≠ military research and development  <i>Structural</i> capabilities of technology <b>match</b> structural causes of latent demand in market: protecting drivers in high-impact collisions ≈ protecting combat drivers/passengers in the event of a roadside bomb	Cell II <i>Superficial</i> elements of technology <b>match</b> superficial elements of market: military research ≈ protecting soldiers DARPA ≈ military vehicle protection  <i>Structural</i> capabilities of technology <b>match</b> structural causes of latent demand in market: protecting drivers in high-impact collisions ≈ protecting combat drivers/passengers in the event of a roadside bomb
	Low	Cell III <i>Superficial</i> elements of technology <b>mismatch</b> superficial elements of market: race car ≠ military transport Formula 1 ≠ military research and development  <i>Structural</i> elements of technology <b>mismatch</b> causes of latent demand in market: rigid cockpit body for stability ≠ protecting soldiers in roadside bomb event improved performance in acceleration and cornering ≠ improved passenger safety	Cell IV <i>Superficial</i> elements of technology <b>match</b> superficial elements of market: military research ≈ protecting soldiers DARPA ≈ military vehicle protection  <i>Structural</i> elements of technology <b>mismatch</b> causes of latent demand in market: rigid cockpit body for stability ≠ protecting soldiers in roadside bomb event improved performance in acceleration and cornering ≠ improved passenger safety

## APPENDIX B – TECHNOLOGY ASSESSMENT PROMPT

Top-Tier University has just announced the development of new software that analyzes multiple video recordings to track the movement of multiple people across different locations. The All View Information Software (AVIS) does this through a unique face-recognition algorithm developed by a team of graduate students from Top-Tier University’s advanced informatics laboratory. “In many ways, our software works like a google search engine for faces,” says Lonny Granston, one of the students from the team. “By using our software on the videos recorded every day by the closed-circuit television cameras installed in most public places, we are able to track the movements of individuals from camera to camera.” The ability to do this is hardly new. Surveillance agencies have used movement-tracking technologies for a while now. “The power of our innovation rests in the analytics we have automated,” says Granston. “We can generate reports on the speed with which people moved from one place to the other, identifying where they have slowed, stopped or sped up. By combining this with detailed maps of the spaces where they were moving, we can then tell what people were looking at, for how long, whether they lingered or returned, and tie all that to where they were before or where they were rushing to afterwards. In short, we can tell a lot about what ‘moves’ people!” Initial tests have shown that the AVIS technology is easy to deploy on the most common video monitoring platforms available, and can be rapidly adapted for different purposes.

Building on these successful results, Top-Tier University’s Transfer Center is actively seeking partnerships and collaborations to commercialize the AVIS software.

Considering the above:

**What business opportunities could you pursue with this technology?**

Please list and explain all of the ideas that come to mind.

## APPENDIX C – CODING SCHEMES

Categories	Subcategories	Operationalization
<i>Attention focus</i>		
Technology		The statement consists primarily of comments, observations, questions, issues (etc.) about the technology presented
Market		The statement consists primarily of comments, observations, questions, issues (etc.) about a market context
Neither/other		The statement refers to neither the technology presented, nor to a particular market context
Categories	Subcategories	Operationalization: The statement consists primarily of comments, observations, questions, issues (etc.) about...
<i>Level of structural reasoning</i>		
Superficial, technology	Technological characteristics	...the “objects” of a technology, such as the parts of the technology, its elements, the materials/inputs it uses, the objects/output it produces, the individuals who developed that technology, the general field of origin of that technology, along with all the characteristics of these objects, individuals, etc.
	Market characteristics	...the objects in a context, and/or their attributes/characteristics/features. This includes individuals in that market context, their characteristics, the products/services they use, the characteristics of these products/services, the characteristics of the market context as a whole, etc.
First-order relationships, technology	T-how: How technology operates	...the operation of a technology, how it works, what it does, what it does with what, and how.
	T-why: Aims and purposes of technology	...the current aims and purposes of the technology in the specific context of its development, e.g., why its developers have the technology do what it does (in the lab), with what effects.
First-order relationships, market	M-how: How a market “works”	...the activities in a context, i.e. what individuals in that context do with current products/services they use, how they interact with these products/services, how the products/services themselves function, etc.
	M-why: Aims and purposes of market actors	...the current and immediate purposes of individuals in that market context, i.e., why they do the things they do.
Higher-order relationships, technology	T-ben: Ultimate benefits of technology and their causes	...the potential benefits/advantages/implications of the technology, e.g., the ultimate capabilities/effects of the technology, along with the causes/reasons why it has such capabilities.
	T-prob: Problems of technology and causes	...the particular problems/limitations of the technology, along with the reasons/causes of such capabilities.
Higher-order relationships, market	M-ben: Benefits of market activities and causes	...the larger implications/advantages/implications that actions and activities in a market may have—such as using products/services for a particular purpose.
	M-prob: Problems of market activities and causes	...the problems individuals have in a market context, the limitations of an activity and/or product/service they use in that market. This also extends to the goals, motives and needs that individuals have that are poorly satisfied under current conditions, and/or the reasons why these problems and limitations exist.

Superficial features

Structural relationships

*Note.* Coding schemes adopted from Grégoire et al. (2010).

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