Survival of the Fittest: Entrepreneurial Longevity and Venture Performance

The role of sleep on decision-making and performance of entrepreneurs: Investigation of sleep- and performance-promoting interventions

Discussion Paper

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Preamble

In longevity research the "health span" - the time we live without any age-induced illnesses – plays a prominent role. Entrepreneurs seem to age faster due to a high-intensive working life. At the same time entrepreneur`s persistence is shown to be a critical factor for venture success. With a cutting-edge in-house research team which collaborates with leading researchers, scientists, entrepreneurs, managers and investors, we strive to disentangle the impact of sleep (and recovery), physical activity, mental health (and resilience), genetics, and healthy eating on entrepreneurial long-term performance. How can we define an entrepreneurial health span and design (digital) interventions to enhance productivity in the life of entrepreneurial leaders in start-ups and corporates? The first study in a series of projects will explain the relationship between physical health and sleep recovery on productivity of high-performing entrepreneurs.

Summary

Entrepreneurship typically has been linked to tremendous amount of working hours, hugely demanding responsibilities for organizing business structure/environment, decision-making under a high-level of ambiguity and uncertainty that results in a feeling of stress and ultimately leads to problems in sleep and health, as well as a decrease in work performance. The general aim of the current project is to particularly investigate the contribution of sleep status on decision-making and entrepreneurial performance and test whether sleep-promoting interventions would lead to differential impacts in these outcomes. We suggest that impairments in sleep severely affect risk perception in decision-making and thus the performance of entrepreneurs. Building on the self-regulatory resource and the effort recovery models, we also contribute to the literature by evaluating the outcomes of interventions that address sleep through pre- and post-tests (within-subject design) across different groups (between subject design). In addition, by integrating sleep and cognitive literature in the context of entrepreneurship, we investigate how cognitive errors, particularly “overconfidence”, mediate the effect of sleep on entrepreneurial decision-making and performance.

Within the scope of the project, two studies will be carried out, one of which is an observationalstudy and the other is a longitudinal intervention study, both carried out in the field. Specifically in Study 1, we seek to determine if entrepreneurs' sleep habits significantly affect their decision-making processes and, consequently, their performance. Furthermore, we will establish whether overconfidence mitigates this effect and how this relates to changes in related biological and physiological mechanisms. In Study 2, we will determine how the implementation of 16 weeks of a sleep promoting intervention affects entrepreneurs' decision-making processes and performance as well as changes in related biomarkers and physiological data.

Considering the interdisciplinary integration of organizational psychology, entrepreneurship, decision-making, and sleep, this project will contribute to different and important streams of research. By including a longitudinal study, combining data from different sources – self-reports, biomarkers and physiological data -, we will be able to draw causal inferences about the effect of sleep in an entrepreneurial context. Completing the project successfully will provide beneficial intervention techniques for entrepreneurs to break the vicious circle of sleep problems and entrepreneurial performance. In addition to these, it is planned that the results obtained from the project will be published in high-ranked journals and the project outputs will be presented at national and international conferences abroad.

Keywords: Entrepreneurship, sleep, self-regulatory resource model, effort recovery model, decision-making

Problem/Background

Entrepreneurs are required to commit a large amount of energy, take on different business roles, make risky decisions while bearing the possibility of a loss of personal and business assets in mind, and regulate the responsibilities of employees. Due to these characteristics of entrepreneurial experience, entrepreneurs have a constant feeling of stress (Cardon & Patel, 2015). As a consequence, most entrepreneurs experience sleep problems and are often sleep deprived which can lead to substantial health problems (Hatak, & Zhou, 2021; Racine, 2021). Indeed, Kollmann, Stöckmann, and Kensbock (2019) have shown that encountering stressors negatively impacts entrepreneurs' ability to detach from work during non-work times increasing their chances of experiencing insomnia. Consistent with these findings, National Center for Health Statistics also reported that entrepreneurs, as well as managers, face the highest risk of suffering from sleep impairments (Luckhaupt et al., 2010). Grandner (2017) describes the complexity of sleep as an outcome influenced by societal, social, as well as individual factors. Insufficient or poor quality of sleep itself leads to several adverse health outcomes, such as general, cariovasular, metabolic, mental, immunologic as well as human performance. Hence sleep should be seen as an antecedent of good health (such as nutrition and sports) but not itself as health. Although a growing research area is interested in the influence of stress on entrepreneurs' health and performance, it is not clear how entrepreneurs' sleep affect their performance.

Much attention has been paid to the well-being of entrepreneurs as it is linked to the success rate of a venture (Timmons & Spinelli, 2009; Wach et al., 2016). It has been well-documented that entrepreneurs' evaluation of opportunities, innovation, taking risks, and efforts are all greatly influenced by their subjective well-being (Baron & Tang, 2011; Dolan et al., 2008; Foo, 2011; Foo et al., 2009; Nikolaev et al., 2020; Welpe et al., 2012). Although several studies investigated the relationship of entrepreneurial well-being and performance,(Andersson & Johansson, 2008; Binder and Coad, 2016; Fisher, 2010) they largely neglected sleep as a critical antecedent of well-being and health.

By the very nature of entrepreneurship, the majority of the studies in entrepreneurship literature have focused on the impact of stress on the well-being and performance of entrepreneurs. On the one hand, one body of evidence suggests that the stressful nature of entrepreneurial tasks causes negative well-being (Cardon & Patel, 2015; Rauch et al., 2018), increased health problems (Baron, 1998), work-life imbalance (Kollmann, Hensellek et al., 2019) and in turn negatively influence entrepreneurs' performance. On the other hand, another body suggests that favorable characteristics of being an entrepreneur override the negative impact of stress leading to less experience of health problems (Shir et al., 2019; Stephan & Roesler,2010). Based on such mixed results, the importance of recovery, rather than the stressors, on entrepreneurs' well-being and performance has been emphasized (Gunnarson & Josephson, 2011; Weinberger et al., 2018).

Sleep is considered a natural recovery mode that enables psychological and physiological healthy functioning (Grandner, 2017). Thus, if sleep is insufficient or impaired, enough cognitive and emotional energy to manage stress cannot be maintained and physiological impacts of stress accumulate (Orzeł-Gryglewska, 2010). The effects of entrepreneurial stressors such as high pressure of responsibilities, high levels of uncertainty, and long working hours result in sleep disturbances which in turn cause feeling more stressed (for a review see Stephan, 2018). Furthermore, sleep plays a fundamental role in reasoning, problem-solving and analysis, and judgment which are essential to entrepreneurship (Satterfield & Killgore, 2019; Harrison & Horne, 2000). Sleep disturbances in entrepreneurial settings are known to negatively affect alertness (Guiliani, & Torrès, 2018). Although overall findings point out the intertwined relationship between sleep and stress, the influence of sleep in the context of entrepreneurship is largely unexplored.

We argue that leaving sleep rather unnoticed in the research of entrepreneurial decision-making leads to a clear shortcoming. Given that sleep is acknowledged as both cause and consequence of stress, taking the sleep and health literature into the entrepreneurs' performance will

provide better theoretical and practical implications. Thus, the current research specifically aims for a more contextualized understanding of the effect of sleep on entrepreneurial performance. Furthermore, integrating the findings from different fields including psychology, sleep, and neuroeconomics, this research aims to explore the interplay between sleep and cognitive biases, e.g. overconfidence, in the entrepreneurial context.

State of the Art

While creating and running their own venture has several benefits, such as autonomy, a flexible working schedule, and setting own priorities, entrepreneurs are required to commit a large amount of time/energy, play different business roles, make risky decisions bearing a possibility of a loss of personal and business assets in the mind (Morris et al., 2012). Due to these characteristics of entrepreneurial experience, entrepreneurship is considered as one of the most stressful occupations (Cardon & Patel, 2015). The literature on entrepreneurship provides inconsistent conclusions about the consequences of the stressors on entrepreneurs. Some suggest that exposure to stressful conditions interferes with entrepreneurs' well-being and performance (Hunter & Thatcher, 2002) which might in turn reduces their entrepreneurial performance. Others suggest that the favourable characteristics of entrepreneurship – autonomy, and freedom – boost their productivity (Williamson et al., 2019) and motivate entrepreneurs for growth and development while sacrificing their own well-being (Cardon & Patel, 2015; de Mol et al., 2018). Although the latter evidence does not suggest impairments in daily functioning, both lines of evidence emphasize the relation between entrepreneurship and well-being. Indeed, the meta-analysis by Stephan et al. (2022) reported that entrepreneurs experience positive well-being with increased levels of flexibility and autonomy in their entrepreneurial work.

The majority of studies in the literature are concerned with understanding the impact of stress on entrepreneurs' well-being (Cardon & Patel, 2015; Rauch et al., 2018) and performance (LePine et al., 2005). Focusing on the differentiating effect types of stressors on the well-being and performance of entrepreneurs, Lerman et al. (2021) and LePine et al. (2005) applied the

challenge–hindrance stressor framework to the entrepreneurial context. Findings from these studies suggested that stressors that relate to motivation promote better well-being and performance of entrepreneurs, however, stressors that are perceived as threats lead to negative outcomes. Although this framework advanced the entrepreneurial stress literature, it does not consider the physiological consequences of stress. Exposure to stress leads to long-term chronic increased heart rate, and blood pressure (Patel et al., 2019) which may potentially cause health problems whether its effect on well-being is positive or negative.

While the link between well-being and entrepreneurship is widely established, the concept of health just slowly started to make its way into entrepreneurship literature. The definition of health is not merely the absence of illness. It refers to a state of physical and psychological wellness, as well as a resource that allows to have a sense of purpose and direction in life, good-quality relationships with others, and realize one's own potential (Ryff & Singer1998). In this view, sleep is an essential building block of healthy functioning which provides both psychological and physiological restorative processes (Sejnowski & Destexhe 2000). In examining the phenomenon of sleep, both sleep quality (e.g., the amount of time taken to fall asleep, number of awakenings per night, and the feeling rested after sleeping) and sleep quantity (the amount of sleep) are important components (Pilcher et al., 1997). Studies in sleep research have shown a significant link between sleep and physical health. Sleep-related difficulties have been shown to increase the risk of a suppressed immune system (Besedovsky, Lange, & Born, 2012), impaired cardiovascular functioning (Tobaldini et al., 2017), diabetes, and obesity (Nedeltcheva & Scheer, 2014). In fact, lack of sleep is shown to be a major risk for increased mortality (Vgontzas et al., 2010). In addition, Sleep research has linked inadequate and poor sleep to the risk of depression (Allgower et al., 2001) suggesting a direct relationship between sleep and psychological health. It has also been shown that having adequate sleep reduces sensitivity to stress and helps to enjoy challenging opportunities (Zohar et al., 2005).

In the organizational context, studies have shown that both sleep quality and sleep quantity associated negatively with workload and a number of health, attitudinal, and affective outcomes. (Litwiller et al., 2017) as well as social interaction difficulties in the workplace (Chen & Li, 2019). In the entrepreneurship context, Kollmann, Stöckmann, and Kensbock (2019) have shown that being exposed to workplace stressors impairs people's capacity to disengage from work during non-work hours, which increases their risk of developing insomnia, the most frequent sleep problem. Sleep is not only crucial for mental and physical health but also critical for human functioning including cognitive and emotional processing (Walker, 2009). For instance, loss of sleep (both quality and quantity) results in the inability to maintain attention and alertness, increased reaction time, disturbed emotion processing, and fuzzy thinking (Lim & Dinges, 2010). In the organizational context, these impairments produce problems related to job performance. For example, poor and inadequate sleep leads individuals to focus more on negative events (Pilcher et al., 2015), display aggressive behaviors (Kamphuis et al., 2014), and exhibit poor judgments and decisions (Harrison & Horne, 2000).

Importantly, the literature on neuroeconomics highlights that subjective perceptions are one of the major contributors to decisions made under uncertainty (Kahneman & Tversky, 1991, 1992). The fact that entrepreneurs continuously make decisions under uncertain conditions with a high degree of unpredictability suggests their perceptions as an important determinant of entrepreneurial performance. Considering the importance of rapid decisions in entrepreneurial environments, confidence would appear to be a key to entrepreneurship. Though confidence produces positive impacts such as motivation (Bandura, 1997) and innovation (Simon & Houghton, 2003), overconfidence underpins cognitive errors and thus causes biases in decision-making (Russo & Shoemaker, 1992). For instance, prior research has shown that cognitive errors can potentially hinder effective decision-making (Hermalin & Isen, 2000) and can diminish performance on judgment tasks and logic issues (Melton, 1995). This is especially disadvantageous for an entrepreneur since entrepreneurs, on average, have been found to be confident (Forbes,

2005) and have low-risk perception (Simon et al., 2000). In fact, Koellinger et al. (2007) found a significant negative correlation between the level of entrepreneurial confidence and the approximate survival chances of entrepreneurial ventures. In addition, given the above-mentioned evidence that sleep has a crucial impact on cognitive functioning, it is not surprising that sleep impairments are associated with alterations in confidence. Harrison and Horne (2000) found that sleep-deprived people reported higher levels of confidence about their responses than non-sleep-deprived people. Impairments in sleep have also been linked to cognitive biases. A study with medical assistants who suffer from lack of sleep showed that they rely on cognitive biases by making a decision based on previous cases without using analytical reasoning to process new information (Mamede et al., 2010). Finally, as sufficient self-control of entrepreneurs is necessary for realistic goal creation and pursuit, it is important to note that in a broad body of research it has been shown that sleeping less or poorly inhibits the individuals' ability to exert self-control and thereby can have negative impact on the decision-making of entrepreneurs (Baron, Mueller, & Wolfe, 2016; Guarana, Ryu, O'Boyle, Lee, & Barnes, 2021).

Given the role of sleep both in thinking and feeling processes and these processes are integral to any decision-making, the need to understand the influence of sleep on the performance of entrepreneurs is apparent. Utilizing self-regulatory resource theories, we argue that sleep disturbances in entrepreneurs lead to disruption in optimal decision-making which in turn negatively affecting their performance while causing health problems. Moreover, we suggest that sleep disturbances increase the susceptibility of entrepreneurs to cognitive biases such as overconfidence which may negatively impact their performance. As overconfidence is shown to have also positive effects on some performance dimensions such as innovation (Burkhard, Sirén, van Essen, Grichnik, & Shepherd 2022) to counterbalance positive and negative effects might be essential for entrepreneurs.

Research Questions

How do sleep of entrepreneurs affect decision-making and performance? Is this effect moderated by overconfidence?

How does sleep-promotion impact decision-making, performance indicators, and (over)confidence level of entrepreneurs?

Conceptual Bases and Research Methodology

According to **self-regulatory resource models**, people have resources that enable them to control ideas, behaviors, and emotions (Baumeister et al., 1998; Muraven & Baumeister, 2000). The resources, however, have a limited capacity and tend to become depleted resulting in a decrease in self-control (DeWall et al., 2007). Regulation of thoughts, emotions, inhibition of impulsiveness, engaging in complex cognitive tasks, being successful, and being healthy require a great number of self-control strategies for sustaining motivation to achieve them. In this regard, reduced self-control is known to cause impulsive behaviors and risky decisions (Leith & Baumeister, 1996). Lack of self-control has also been linked to failure in emotion regulation which makes it difficult to inhibit impulsivity (Beal et al., 2005; Tice et al., 2001). In this context, sleep is the vital resource recovery process that regenerates mental and physical energy (Sonnentag, 2018) and thus is considered as a key for self-control resources (Barber, 2014; Guarana, Ryu, O'Boyle, Lee, & Barnes, 2021). For example, insufficient sleep has been linked to increased stress (Cruess et al., 2003) and greater health problems (Steptoe et al., 2006), disruption in cognitive capacity (Walker, 2009), and poor self-regulatory capacity (Altena et al., 2008). Given the role of sleep both in cognition and emotional control processes and these processes are integral to any decision making which is the essence of entrepreneurship, the self-regulatory resource theory provides a useful framework to highlight the relationship between sleep and entrepreneurship.

In an entrepreneurial context, competing demands of regulating various processes in work, and stress due to worrying about work are more likely to prevent detachment from work resulting in the depletion of resources. **The effort recovery model** states that workload challenges psychological and physiological resources reducing performance efficiency and thus recharge of one's resources is necessary to maintain work performance (Meijman & Mulder, 1998). The excessive working hours, work effort, responsibility, and uncertain business environments in entrepreneurship make it difficult to maintain sufficient sleep (Sonnentag et al., 2010; Sonnentag & Fritz, 2015). Therefore, it is likely that entrepreneurs might have a high risk of facing inadequate recovery processes, both physiologically and psychologically. In fact, entrepreneurs' tendency to overestimate their potential for success may even result in an overestimation of their ability to deal with stress (Koellinger et al., 2007) which will consequently prevent recovery to occur and deplete their resources. The effort recovery model proposes two recovery pathways. One pathway is detaching from workload whereas the second pathway is by building up additional psychological resources. Drawing from both models, given the homeostatic underlying of sleep that restores psychological and physiological resources at the same time, we argue that an understanding of the effect of sleep loss and sleep interventions is of primary concern for entrepreneurs.

Study 1: Measuring sleep and its relation to decision-making and performance indicators of entrepreneurs

Poor and inadequate sleep has been known to relate to an increased feeling of stress (Sonnentag & Fritz, 2015; Syrek et al., 2017) and physical health problems (Majde & Krueger, 2005; Walker, 2009; Besedovsky, Lange, & Born, 2012), as well as the exhibition of poor judgments and risky decisions (Harrison & Horne, 2000), suffering from fuzzy thinking and decreased alertness (Lim & Dinges, 2010). Of interest here, decision-making under uncertain conditions is especially susceptible to degradation from sleep deprivation (Killgore et al., 2006). For instance, lack of sleep is known to lead to biases in the valuation of inputs resulting in a

tendency to take risks (Venkatraman et al., 2011). It has been shown that people who have poor sleep quality (Castro and de Almondes, 2018) and individuals that were sleep-deprived for 49 hours (Killgore et al., 2006) perform worse in the complex decision-making paradigm (Iowa Gambling Task) by making irrational decisions. A possible explanation for such decisions is that sleep-deprived individuals are more likely to favor pursuing gain rather than avoiding loss (Venkatraman et al, 2011). This highlights the influence of sleep loss on cognitive bias, namely overconfidence which refers to the overestimation of one's abilities or judgments to make accurate forecasts. Because sleep deprivation leads to overconfidence, entrepreneurs who have sleep disruption may prefer to take high-risk decisions. On this basis, entrepreneurs are known to be overconfident about their chances of success (Cassar, 2010; Forbes, 2005; Koellinger et al., 2007) and have lower perceptions of risk (Simon et al., 2000). Indeed, a significant negative correlation was found between the level of entrepreneurial confidence and the approximate survival chances of entrepreneurs (Koellinger et al., 2007) suggesting the negative impact of overconfidence in entrepreneurship. While studies mentioned previously have shown the influence of sleep and confidence on decision-making, how these factors interact with each other in an entrepreneurial context remains yet unknown.

In Study 1, we aim to explore whether sleep of entrepreneurs has an significant impact on their decision-making strategies, hence their performance, and whether overconfidence moderates this effect. We suggest that entrepreneurs' decisions may be more influenced by overconfidence with poor sleep conditions, which would have fundamental consequences for entrepreneurs' real-world performance. To this aim, we are planning to recruit around 150 entrepreneurs who established their businesses at least 1 year ago. Potential participants will be contacted via Linkedin, mail or phone, and given a brief overview of the study. After informed consent is obtained, they will receive an experimental package including information about the study procedure, saliva sample kit, and an Oura ring to measure digital biomarkers. The package includes clear instructions for the usage of all materials, the study

procedure, and login details for the participants to complete questionnaires, and computerized tasks. Participants will wear the Oura ring for two days. On the second day, participants will be asked to participate in the online tasks (Iowa Gambling Task, Ellsberg Urn Task, Attention Tasks, and Stroop Task) and answer several questionnaires. Thereafter, participants will be asked to collect a hair and saliva sample for the analysis of of cortison and cortisol as a physical biomarkers of stress (see details in "Biomarker of stress"). All participants will be asked to conduct the experiment between 2-5pm to control for diurnal rhythms in hormone release (Kudielka et al., 2004). All the measurement tools and related procedural information are explained below:

Overconfidence in business decision-making*:* The 8-statements scale which was developed by Souza Silva et al. (2021) to assess overconfidence in managers will be used as a measure of entrepreneurial overconfidence. The statements will aim at identifying whether entrepreneurs overestimate their capacity for making decisions at a given time resulting in the perception of having competitive advantages for their venture and whether entrepreneurs believe they can forecast the future more accurately than what is now possible. Each statement will be rated using 10-point scale ranging from "1= strongly disagree" to "10= strongly agree". The higher scores will indicate overconfidence bias in entrepreneurs' abilities in managing their ventures and making entrepreneurial decisions.

The Iowa Gambling Task (IGT): Computerized IGT will be used to assess risk-taking as a function of recognition of potential gains and losses (Bechara et al., 1994). Participants are asked to select one card at a time - a total of 100 cards- from four decks that are designed as two advantageous and two disadvantageous decks. The advantageous decks yield small gains with small losses resulting in overall net gains whereas the disadvantageous decks yield high gains but even higher losses resulting in overall net losses. Following card selection, feedback on a win or a loss is given. At the beginning of the task, participants will be instructed to maximize the money they gain and, they will also be informed whoever accumulated the largest amount

of money will get a real monetary bonus of 50CHF in order to ensure incentive compatibility. Participants will complete 100 trials divided into 5 blocks.

Ellsberg Urn Task: To quantify attitudes more precisely towards uncertainty, computerized Ellsberg Urn Task (Ellsberg, 1961) will be employed. Participants are confronted with two urns: one containing 50 red and 50 black balls and the other containing a total of 100 red and black balls, the latter in unknown proportion. Participants are asked to first choose one of the urns and then bet on the color of the ball that would be drawn from the urn. Most people prefer to avoid the ambiguous urn which is termed as ambiguity aversion. In the present design, participants will be asked to make choices in 20 trials. To infer ambiguity attitude, we will calculate the number of trials in which participants choose the ambiguous urn.

Attention Tasks: To test the ability to focus attention, a Simple Reaction Task will be used. In this task, participants are asked to press "1" on the keyboard as soon as the target "1" appeared on the computer screen. The task will consist of 20 trials and the reaction times will be measured in milliseconds. To test ability to update information actively requiring sustained attention, the Vigilance Test will be used. Target letters which are "Y, L, M" will be presented with non-target letters in the middle of the screen, one at a time. Participants will be asked to press the space bar when a target letter appeared through 20 trials. Both reaction times and the number of errors will be calculated as a measure of speed and accuracy, respectively.

The Pittsburgh Sleep Quality Index (PSQI): To assess sleep quality, Pittsburg sleep quality index which is composed of 19 items will be used (Buysse et al., 1989). The PSQI comprises questions about subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbance, use of sleep medication, and daytime dysfunction during the past month. High values represent low levels of sleep quality (Guiliani & Torrès, 2018) thus enabling to reveal of sleep disturbances and grouping people as good and bad sleepers.

Healthy Life-Style Behaviors: The 36-items Healthy Life-Style Screening Tool will be used to assess sunlight exposure, water intake, air quality, rest, exercise, nutrition, temperance, trust, and physical condition in the last month (Kim & Kang, 2019). Participants will rate the items on a 4-point scale ranging from 1= strongly disagree to 4= strongly agree with high scores representing a healthy lifestyle. Additionally, waist circumfence and waist-hip raito will be used as a proxy of fat distribution and health (World Health Organization, 2011).

Self-Control Capacity: To assess the availability of self-control as a self-regulatory resource, the 25-items State Self-Control Capacity Scale will be used (Twenge et al., 2004). Participants will rate the items on a 5-point scale ranging from "1= not at all" to "5= very much". Higher scores represent higher capacity for self-control. Additionally, the Stroop task (Stroop, 1935) that requires inhibiting an automatic response will be used as another measure of self-control. In the Stroop task, color words will appear either in the same or different ink color (e.g. the word BLUE printed in blue or green ink). In cases where the word and the ink color of the word are mismatched, it becomes difficult to say the ink color of the word. In the present study, an online version of Stroop task will be used, and participants will be asked to indicate ink color of the word by pressing the associated buttons which are "r", "g", "b", "y" for red, green, blue, yellow, respectively. The reaction times and the number of errors of participants will be measured for Stroop performance. Higher number of errors and longer response times will indicate weak/reduced self-control.

Self-Reported Entrepreneurial Performance: As an objective measure of performance, entrepreneurs will be asked to rate their venture performance on growth in the number of employees, growth in sales, growth in profitability, return on equity, return on assets, the profit margin on sales, and the ability to fund growth from profit using a 7-point scale (ranging from 1 = much worse than competitors to 7 = much better than competitors) (Van Praag & Versloot, 2007; Powell & Eddleston, 2013). As a subjective measure of performance, the Subjective Entrepreneurial Success–Achievement Scale will be employed (Wach et al. 2016; Dijkhuizen et al.,

2018). Entrepreneurs will be asked to rate their achievements on a 5-point scale (1 = totally not achieved to 5 = totally achieved) with subscales of personal finance, business finance, social factors, good relationship with clients, personal goals, and personal development.

Biomarkers of stress: Given the strong relations among sleep, stress and even risk-taking behavior, the cortisol levels of participants will be measured. To assess long-term stress exposure reactivity, hair cortisol concentrations will be analyzed (Dettenborn et al., 2010; Schermuly et al., 2020). Given that one centimeter of hair is known to serve as a marker of accumulated stress for approximately 3 month, 3 cm long hair strand will be cut as close to the scalp in the present research. To assess short-term stress exposure reactivity, a salivary cortisol sample will be analyzed using Salicaps from IBL-International (Maina et al., 2008; Holland et al., 2012). All samples will be sent to the lab for analysis within 28 days to prevent significant degradation of testosterone or cortisol levels (Toone et al., 2013).

Digital markers of sleep: Previous works have shown that the use of wearable devices are valid and reliable tools to track sleep and heart rate (Pereira & Elfering, 2014b; Pakhomov et al., 2020; Leeder et al., 2012; for a review see Eatough et al., 2016). Recently, Oura Ring which is a photoplethysmography-based smart ring drew attention for remote health monitoring (https://ouraring.com). The use of Oura Ring has been validated in terms of heart rate and sleep parameters by a number of studies (Altini & Kinnunen, 202; Cao et al., 2022; Koskimäki et al., 2018). Thus, in the current study Oura Ring will be used to objectively infer sleep quantity and quality (sleep onset, sleep latency, amount of time spent sleeping between onset and last wakening, number of awakenings), heart rate, and physical activity. Participants will wear the device continuously during daytime and sleep.

Study 2: Intervention to improve sleep of entrepreneurs to thereby improve decisions and performances of entrepreneurs

Given the strong association between sleep and entrepreneurship, we still do not know what interventions would help entrepreneurs' sleep and how these interventions affect entrepreneurs' decision-making and entrepreneurial performances. In organizational research, sleep interventions – such as using consistent bedtimes, relaxation exercises, and avoiding sleep inhibiting substances - have been shown to improve sleep quality and affective states as well as positively influence work-relevant outcomes (Barnes et al., 2017; Valshtein et al., 2020). For instance, workplace programs promoting engagement in physical activity, having a balanced diet, maintenance of healthy weight improved both sleep quality and quantity, as well as increased work performance (Bruno et al., 2011; Silberman et al., 2011; Merrill et al., 2011). Furthermore, few studies provided preliminary evidence on the promise of interventions in the field of entrepreneurship focusing on recovery from stressors via coaching and mindfulness techniques (Engel, Noordijk et al., 2020; Engel, Ramesh, & Steiner, 2020; Schermuly et al., 2020). These intervention techniques provide individuals with an opportunity to evaluate possible stressors, the effect of these stressors, and how to prevent them through awareness of the cognitive process. On the other hand, sleep allows the brain to rest and recover from stress. However, we still do not know what interventions would help entrepreneurs' sleep and how these interventions affect entrepreneurs' decision-making and entrepreneurial performances.

The purpose of Study 2 is to assess changes in entrepreneurs' decision-making strategies and performance, as well as changes in stress-related biomarkers, observed after the implementation of 12 weeks of sleep-promoting intervention. To do so, all the measurements used in Study 1 will be taken both at baseline (at the beginning) and 4-months follow-up (after the interventions). We are planning an experiment with around 300 entrepreneurs who established their businesses at least 1 year ago randomly assigned to either a sleep intervention or a control group resulting in groups of each 150 entrepreneurs. The first phase of the Study 2

will be the same as in Study 1 and will serve as a baseline test. Following the completion, 12 weeks intervention programs will begin. Sleep intervention will be designed to help in the management of sleep patterns. In particular, cognitive behavioral therapy for insomnia (CBT-I) will be used (Edinger, Wohlgemuth, Radtke, Marsh, & Quillian, 2001). This involves the systematic restructuring of cognitions and behavioral patterns to promote higher quality sleep—such as using consistent bedtimes, relaxation exercises, and avoiding sleep inhibiting substances. Previous data from studies on sleep promotion in the workplace showed that 3-months of interventions foster the increase in productivity (Silberman et al., 2011), decrease in weight /body fat, cholesterol (Bruno et al., 2011), and increase in total sleep time and the awareness of sleep insufficiency (Olson et al., 2015). The sleep intervention group will get clear education about either sleep in the first month based on the CBT-I protocol. Following that, participants will be instructed to apply sleep hygiene practices in their daily life. Based on recommendations by Posner and Gehrman (2010), the participants will also be asked to not take naps during the day, avoid liquids before bedtime, avoid caffeinated products within 6 hours before bedtime, avoid alcohol, avoid nicotine late in the night, use ear plugs or white noise to block out disruptive noises, make the sleep environment comfortable and conducive to sleep (bedding, temperature, and light), keep a regular sleep schedule, sleep 7 or more hours, avoid stressful tasks before bedtime and blue light before bedtime. The control group will receive no education. For both groups, we will again collect digital and physical biomarkers as in study one. On day 1 as well as every four weeks, the participants will have to complete the online questionnaires and tasks as for study 1 to control the effects of the intervention.

Significance of the research work

The proposed research project will have benefits for the involved researchers, the research field in general, entrepreneurial practice, as well as the University of St. Gallen. The proposed project shall be the initial start of a series of projects. For this we were already able to win the ETH Sleep Lab and the company Biolytica – a leading health startup using the

possibilities data offers to improve the health of humanity – as strong research partners to explain the relationship between physical health and sleep recovery on productivity of high-performing entrepreneurs. With Biolytica we want to use these insights not not only to create impact in the academic community, but also to improve the health of humanity. With a cutting-edge in-house research team which collaborates with leading researchers, scientists, entrepreneurs, managers and investors, our long-term vision is to expand the field of research to the direction of longevity to increase the time we live without any age-induced illnesses. In particular we want to disentangle the impact of sleep (and recovery), physical activity, mental health (and resilience), genetics, and healthy eating not only on entrepreneurial long-term performance, but also on humanity to create social impact.

This project will be highly beneficial to the profiling of HSG in a new area and the career advancement of the involved scholars. Prof. Grichnik has been exploring this line of research since 2008 and has a deep interest to develop the field of healthy aging of entrepeneneurs and managers. This study will be the starting point for a research center around healthy aging at HSG and beyond in collaboration with the School of Medicine and practitioners tackling the question How can we define an entrepreneurial health span and design (digital) interventions to enhance productivity in the life of entrepreneurial leaders in start-ups and corporates? Moreover, this project will fund the position of Robert Schreiber as a postdoctorial fellow as well as a PhD Student for two years and will be an important part for their future academic career.

The given project is relevant to management and entrepreneurship research in several ways. First, the research topic of entrepreneurial health has been fairly unrecognized and has only emerged over the past decade through the field of well-being and is rapidly gaining momentum (Stephan, & Roesler, 2010 ; Stephan, 2018; Hatak, & Zhou, 2021; Stephan, Rauch, & Hatak, 2022). As a result, some of the most reputable researchers (e.g. Johan Wiklund, 2019) have called health as a hot topic in entrepreneurship. With this project we seize the opportunity to explore their link further. Second, we expand existing research by introducing sophisticated

state-of-the-arts methods from neuroscience to measure biomarkers of health. Several researchers have called for an adpoption of new methods in order to bring entrepreneurship research to a new level (Gartner, 2001; Shepherd et al., 2015). To our knowledge, we will be the first to combine digital and physical biomarkers with an experimental approach to investigate the affect of sleep on entrepreneurial performance. The prevailing dearth of empirical studies amplifies the importance of contributions like this one further.

Apart from the relevance in the field of research, the present study provides a number of strong practical insights for entrepreneurs as well as for humanity. Not only is the aim to understand the health of entrepreneurs on venture performance, but shall contribute to understanding how general health can be improved with non-invasive methods. This study in a series of projects will explain the relationship between physical health and sleep recovery on productivity of high-performing entrepreneurs. In longevity research the "health span" - the time we live without any age-induced illnesses – plays a prominent role. Entrepreneurs seem to age faster due to a high-intensive working life. At the same time entrepreneur`s persistence is shown to be a critical factor for venture success. With a cutting-edge in-house research team which collaborates with leading researchers, scientists, entrepreneurs, managers and investors, we strive to disentangle the impact of sleep (and recovery), physical activity, mental health (and resilience), genetics, and healthy eating on entrepreneurial long-term performance. How can we define an entrepreneurial health span and design (digital) interventions to enhance productivity in the life of entrepreneurial leaders in start-ups and corporates?

The project will benefit the University of St. Gallen by improving its impact, reputation, and visibility. With regard to impact, the study will produce peer-reviewed publications and citations of HSG in the field of entrepreneurship research. Moreover, it will increase the number of presentations given by HSG researchers at scientific conferences in the field of management and entrepreneurship and explore avenues for future research. For both publications and conference presentations, the cooperation with ETH Zurich and Biolytica will provide additional exposure and impact. The participation of such strong research partners will substantially increase our chances of acceptance in one of the previously mentioned A+ journals. Similarly, the cooperative nature of this project will

benefit the overall reputation of the University of St. Gallen. ETH Zürich is ranked in the top 10 in the world by both Times Higher Education (2015) and QS Top Universities (2015). The proposed cooperation with ETH Zürich and Biolytica will reflect positively on the University of St. Gallen, deepen the ties between the schools as well as to industry, and pave the way for future research project.

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