



**Feeling, Thinking, Doing:**

**A Time Sensitive Self-Regulation Framework for Exploring Entrepreneur Journeys**

A thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy

**Andrew Paul Brough**

M.Sc. (Space Studies - Cum Laude), International Space University

B.Eng. (Mechanical – 1<sup>st</sup> Class Honours), University of Adelaide

School of Management  
College of Business and Law  
RMIT University

September 2021

## Declaration

*I certify that except where due acknowledgement has been made, this research is that of the author alone; the content of this research submission is the result of work which has been carried out since the official commencement date of the approved research program; any editorial work, paid or unpaid, carried out by a third party is acknowledged; and, ethics procedures and guidelines have been followed.*

*In addition, I certify that this submission contains no material previously submitted for award of any qualification at any other university or institution, unless approved for a joint-award with another institution, and acknowledge that no part of this work will, in the future, be used in a submission in my name, for any other qualification in any university or other tertiary institution without the prior approval of the University, and where applicable, any partner institution responsible for the joint-award of this degree.*

*I acknowledge that copyright of any published works contained within this thesis resides with the copyright holder(s) of those works.*

*I give permission for the digital version of my research submission to be made available on the web, via the University's digital research repository, unless permission has been granted by the University to restrict access for a period of time.*

*I acknowledge the support I have received for my research through the provision of an Australian Government Research Training Program Scholarship.*

*Andrew Brough*

*17 September 2021*

## Acknowledgments

*"One of the things I tend to do is open myself up to a variety of voices. I try to expose myself to the kind of culture shock that occurs when you talk to people who speak a different language." -Pierre Omidyar, founder of eBay*

As with any journey, the PhD journey has been filled with highs and lows, challenges, and victories, along the way. A journey also transpires over time and I am grateful to many people who have supported my journey and given their time and knowledge along the way. Although my work in industry has seen me engage with the university sector previously, the academic world I have been working in as part of my PhD has been eye opening. And having worked with entrepreneurs and been an entrepreneur previously, the focus of academic entrepreneurship research was very different.

Thank you to Professor Pia Arenius for helping guide me through this academic journey both as my supervisor but also as a colleague and friend. You helped and encouraged me to explore the academic world: challenged me to learn new skills; connect and collaborate with the academic community at conferences internationally and in Australia; kept me reading and writing and focusing on thinking in theory and detail; engaged me to apply and share my previous experiences and insights in new ways; and helped navigate the ins and outs of potential academic challenges and opportunities. Thank you for keeping the journey fun and adventurous but also pragmatic and with a purpose.

Thank you also to Associate Professor Afreen Huq, my Associate Supervisor, as well as my fellow PhD Candidates, Imran Ture and Nauman Aslam, who along with Pia and I were the nucleus of our nascent research group using wearable technologies to explore entrepreneurship phenomena. Covid-19 knocked some of our original plans but thank you for your friendship, positivity, and encouragement as we explored together. Thanks also to the RMIT community, including members of the Entrepreneurship and Innovation group in the School of Management, RMIT Behavioural Business Lab and RMIT Activator who helped engage with research participants and facilitate experiments as part of my work while building

and encouraging a community of innovation and entrepreneurship at RMIT. It has been great to meet you and understand your journeys from around the world.

Thanks also to those from various institutions around the world that provided advice, context, or collaboration along the way as I set up and progressed with the challenging task of collecting and analysing long duration physiological data using wearables including Professor Melissa Cardon, Dr Scott Gordon, Professor Roger Maull, Dr Daniel Richards, and others. And thanks to my examiners for recognising the novel and innovative nature of the study and its contributions in the application of a mixed method approach combining quantitative physiological data with qualitative activity and effectiveness data to explore the journeys of entrepreneurs over long durations. I wanted my research to be novel and innovative to shift focus from the static between person approaches I had seen were traditionally used in entrepreneurship research to more dynamic within-person perspectives of the individual entrepreneur.

And finally, a big thanks to my wife, Kelly, and three kids, Leila, Korben and Ilyana, who have been on my PhD journey with me. Thanks for your love, encouragement, and support while I completed my PhD and explored the academic world. I had started this journey with the broad purpose to use wearables to explore emotions in entrepreneurship. Through this journey, global challenges not least the Covid-19 pandemic which disrupted life and work everywhere in 2020 and 2021 continue to show the need for new thinking and approaches in the context of a changing world of work and growing need to support entrepreneurs and innovators of all types to be self-aware and self-manage their performance and wellbeing in a challenging world.

# Table of Contents

Declaration .....	i
Acknowledgments .....	ii
Table of Contents .....	iv
List of Abbreviations.....	vii
List of Figures.....	ix
List of Tables.....	x
 <b>Abstract .....</b>	 <b>1</b>
 <b>1. Introduction .....</b>	 <b>2</b>
1.1. Rationale and Theoretical Basis .....	2
1.2. Research Objective.....	5
1.3. Research Approach .....	7
1.4. Contribution .....	8
1.5. Thesis Structure.....	9
 <b>2. Literature Review .....</b>	 <b>11</b>
2.1. The Entrepreneur and their Journey.....	11
2.1.1. The Entrepreneur as an Individual.....	11
2.1.2. An Uncertain Journey .....	12
2.1.3. Actions and Activities of Entrepreneurs .....	14
2.1.4. Performance of Entrepreneurs .....	16
2.1.5. Wellbeing of Entrepreneurs.....	17
2.1.6. The Effective Entrepreneur.....	20
2.2. Self-Regulation .....	22
2.2.1. Purpose and Importance .....	22
2.2.2. Theoretical Underpinnings .....	23
2.2.3. Self-Regulation Strength and Cycles of Depletion and Recovery .....	27
2.2.4. Self-Regulation and Entrepreneurship .....	30

2.2.5.	Measuring Self-Regulation using HRV .....	32
2.2.6.	Wearable Sensors and HRV Analysis .....	35
<b>3.</b>	<b>Conceptual Development .....</b>	<b>38</b>
3.1.	Dynamic Action Environment Context of the Entrepreneur Journey.....	38
3.2.	Conceptualising the Entrepreneur Bubble.....	40
3.3.	Self-Regulation as Management of the Entrepreneur Bubble .....	43
3.4.	Managing the Bubble for Performance and Wellbeing .....	45
3.5.	Conceptual Framework .....	48
<b>4.</b>	<b>Research Design and Methodology .....</b>	<b>55</b>
4.1.	Research Design .....	55
4.2.	Research Population and Sampling.....	56
4.3.	Data Collection and Analysis .....	57
4.3.1.	Wearable Sensors and HRV Analysis .....	57
4.3.2.	Experience Sampling Methodology .....	60
4.3.3.	Supporting Contextual Information.....	63
4.3.4.	Measurement Variables and Big Data .....	64
4.3.5.	Data Integration and Analysis.....	68
4.3.6.	Biases, Sampling and Error Detection.....	72
4.4.	Ethical Considerations.....	76
<b>5.</b>	<b>Results &amp; Analysis .....</b>	<b>78</b>
5.1.	Case Study - Participant A .....	78
5.2.	Case Study - Participant B .....	89
5.3.	Case Study – Participant C.....	97
5.4.	Case Study – Participant D .....	106
5.5.	Case Study – Participant E.....	117
5.6.	Cross-Case Analysis .....	127
5.6.1.	Interactive Effects .....	127
5.6.2.	Cumulative Effects .....	133
5.6.3.	Causal Configurations .....	135

<b>6. Findings and Conclusion .....</b>	<b>140</b>
6.1. A Time Sensitive Entrepreneurial Framework .....	140
6.2. Contributions.....	145
6.3. Implications .....	147
6.4. Limitations.....	148
6.5. Future Research .....	151
<b>7. References .....</b>	<b>155</b>
<b>8. Appendix.....</b>	<b>180</b>
8.1. E4 Wearable Instructions to Participants.....	181
8.2. ESM Instructions to Participants and Survey Questions .....	184
8.3. Background Survey Protocol for Participants .....	186
8.4. Wearable Accuracy, Errors and Artefact Correction.....	196
8.5. Ethics Approval.....	200
8.6. Participant A – Chart Examples .....	201
8.6.1. Momentary Charts for 30 Days of Period 1 .....	201
8.6.2. Ongoing and Cumulative Charts .....	231
8.7. Conferences and Publications .....	236

## List of Abbreviations

ANS	Autonomic nervous system
BVP	Blood Volume Pulse
CAN	Central autonomic network
CSV	Comma Separated Values
ECG	Electrocardiography
EDA	Electrodermal Activity
ESM	Experience sampling methodology
HF	High frequency
HRV	Heart Rate Variability
IBI	Inter-beat-interval (same as RR interval)
LF	Low frequency
ms	Milliseconds
NN	NN interval represents the RR interval data but with added filtering to remove artefacts and noise present in the data.
PNS	Parasympathetic Nervous System
PPG	Photoplethysmography
PSED	Panel study of entrepreneurial dynamics
RMSSD	Root mean square of successive differences between normal heartbeats



RR	Time interval between successive electrocardiogram R-waves (RR interval, same as IBI)
RSA	Respiratory sinus arrhythmia
SNS	Sympathetic Nervous System
UTC	Coordinated Universal Time
WFH	Work(ing) from Home

## List of Figures

Figure 1-1: Action Environment, Entrepreneur, Performance & Wellbeing .....	6
Figure 3-1: The Entrepreneur Bubble – Indicative Components .....	42
Figure 3-2: Conceptual Framework .....	49
Figure 4-1: Conceptual Model with Measurement Variables .....	66
Figure 5-1: Conceptual Model – Inductive Causal Configurations .....	136
Figure 8-1: Comparison of Automatic vs Medium Artefact Correction.....	198
Figure 8-2: Percentage of Artefacts Corrected .....	199
Figure 8-3: Participant A Period 1 Daily Journey .....	231
Figure 8-4: Participant A Period 2 Daily Journey .....	232
Figure 8-5: Participant A Period 1 & 2 Comparison Subjective Measures vs RMSSD .....	235

## List of Tables

Table 2-1: Potential Categories for a Framework of Self-Regulation Research .....	26
Table 4-1: Data Summary for Integration and Analysis .....	69
Table 5-1: Participant A Activity Comparison .....	80
Table 5-2: Participant A Activity Characteristics Comparison .....	81
Table 5-3: Participant A Daily Comparison .....	85
Table 5-4: Participant B Daily Comparison .....	92
Table 5-5: Participant C Activity Comparison .....	99
Table 5-6: Participant C Activity Characteristics Comparison .....	100
Table 5-7: Participant C Daily Comparison .....	103
Table 5-8: Participant D Activity Comparison .....	109
Table 5-9: Participant D Activity Characteristics Comparison .....	110
Table 5-10: Participant D Daily Comparison .....	112
Table 5-11: Participant E Activity Comparison .....	119
Table 5-12: Participant E Activity Characteristics Comparison.....	120
Table 5-13: Participant E Daily Comparison.....	123
Table 5-14: Comparative Participant RMSSD and Activity Summary .....	128
Table 5-15: Comparative Participant RMSSD and Activity Characteristics Summary .....	129
Table 5-16: Comparative Participant Subjective Responses and Activity Summary .....	131

Table 5-17: Comparative Participant Subjective Responses and Activity Characteristics Summary .....	132
Table 5-18: Inductive Causal Configurations – Interactive Effects .....	137
Table 5-19: Inductive Causal Configurations – Cumulative Effects .....	138

## **Abstract**

The entrepreneurial journey is uncertain where the role of the individual entrepreneur and how they take effective action, make decisions, and manage their motivations and emotions, in the face of this uncertainty is critical to maximising their own potential and turning their entrepreneurial vision into reality. For each individual entrepreneur the way they construct and manage their entrepreneurial journey will be different and influences their individual performance and wellbeing.

This thesis advances a time sensitive self-regulation framework for exploring the idiosyncratic nature of entrepreneur journeys. Entrepreneurship research has often discounted the role of time in the entrepreneurial process by studying entrepreneurship as an act rather than a journey. Using a within-person perspective this study shifts focus from static between-person approaches traditionally used in entrepreneurship research towards more dynamic person-by-situation interactions and processes of within-individual change over time. In order to measure the self-regulation of the entrepreneurs, the thesis builds on research in the computer and health sciences, which has looked at understanding cognitions and behaviours.

The entrepreneurial journey is investigated in moment to moment, daily and ongoing contexts as the action environment changes as part of normal work and life. The time-sensitive self-regulation framework providing opportunities to explore interactive and cumulative effects of the changing action environments on the performance and wellbeing of entrepreneurs. This thesis makes a theoretical, methodological, and practical contribution to entrepreneurship research and literature providing insights into the challenges and limitations of using tools such as wearable sensors and experience sampling methodology to explore entrepreneurs' work life settings and idiosyncratic and dynamic journeys.

*Keywords* – entrepreneurship, self-regulation, heart rate variability, HRV, performance, wellbeing, effectiveness, uncertainty, wearables, experience sampling methodology, within-person, time.

# 1. Introduction

*“Running a start-up is like chewing glass and staring into the abyss. After a while, you stop staring, but the glass chewing never ends”. -Elon Musk, founder of Tesla, SpaceX*

## 1.1. Rationale and Theoretical Basis

Entrepreneurship is defined by the actions of the entrepreneur (Gartner 1988) where the entrepreneurial journey is filled with highs, lows and unexpected challenges over time (Shane 2003; Shepherd & Patzelt 2015). Compared to other organisational settings, entrepreneurs must manage themselves and their ventures with multiple and sometimes conflicting short and long term goals simultaneously, where they feel a need to work harder, better and faster as they are keenly aware that their individual performance is linked to consequences for the venture and therefore themselves, their team, customers and partners (McMullen & Dimov 2013; Nambisan & Baron 2013). The uniqueness of the entrepreneurial journey - acknowledging entrepreneurs' dynamic and fluid work-life setting over time, the centrality of work for their sense of identity, as well as the importance of others and their context can have both positive and negative effects on the individual entrepreneur's performance and wellbeing both in the day to day as well as cumulatively (Shepherd & Patzelt 2015; Stephan 2018; Wach et al. 2018; Wiklund et al. 2019)

Performance and persistence in achieving entrepreneurial goals requires regulating oneself effectively to achieve the best combination of what one has available (skills, money, material, access to market, and other resources) (Frese 2009) and in doing so the entrepreneur actively shapes their environment to achieve success (Dew et al. 2009). Through their thinking, feeling and doing, entrepreneurs themselves integrate human and financial resources to organise, produce, and market products and services that yield value for customers (Baum et al. 2007). Previous research on entrepreneurial goals and motives collectively suggest that entrepreneurs view performance and success broadly and in many dimensions; and are likely to pursue a range of different goals through their work, and will consequently judge their performance against these goals, which become their individual success criteria (Wach, Stephan & Gorgievski 2016); valuing and striving for multiple success criteria simultaneously

(Gorgievski, Ascalon & Stephan 2011; Wach et al. 2018). Independence and autonomy, progress and achievement, self-realisation, learning and personal development, status, social recognition and monetary incentives, work-life balance and wellbeing, personal and family security, social contribution are some of many possible examples of entrepreneurs' individual success criteria proposed in the literature (Jayawarna, Rouse & Kitching 2013; Reynolds & Curtin 2008; Stephan, Hart & Drews 2015). There is also increasing evidence that personal wellbeing of entrepreneurs has a direct link with the entrepreneurial journey and impacts performance (Shir, Nikolaev & Wincent 2019; Stephan 2018) given the long hours, ownership of activities and hard work and work stress that characterise the entrepreneurial journey (Rauch, Fink & Hatak 2018). But it is also clear there is a lack of understanding of this link despite evidence that wellbeing can have a profound effect on entrepreneurs and their ventures (Ho & Singh 2020; Shepherd & Patzelt 2015; Stephan 2018).

Theories of self-regulation processes have emerged as some of the most important psychological processes explaining performance, wellbeing, and success across the entire human lifespan (Forgas, Baumeister & Tice 2009; Vohs & Baumeister 2016). Self-regulation processes and the concepts of self-regulation are central to theories across the breadth of psychological research and more recently applied to work and organisational domains (Karoly 1993; Lord et al. 2010; Vohs & Baumeister 2016). Self-regulation refers to the regulation of the self by the self, and involves bringing thinking, feelings, and behaviour into accord with some consciously desired goal (Forgas, Baumeister & Tice 2009). Broadly self-regulatory processes include acting, thinking, learning and feeling, as well as the links between processes and the context in which they are occurring (Vancouver 2008). As an example, people who can self-regulate tend to think before they act because they are more aware of how they react or feel in most situations and how that impacts others and so as an entrepreneur these qualities can help the entrepreneur adapt to challenges, cope with change, follow through on commitments, work well and build trust with team members, partners, and customers.

While many theories of self-regulation exist, the strength model of self-regulation is one of the most commonly cited and empirically tested models of self-regulation (Baumeister, Tice & Vohs 2018) where over twenty years of research evidence continues to support the validity

and usefulness of the strength model, albeit amid continuing updates and revisions (Baumeister & Vohs 2016; Baumeister 2016; Baumeister, Tice & Vohs 2018). Self-regulation strength is the individual capacity over time to monitor and control the self (Baumeister & Vohs 2016; Baumeister & Alquist 2009; Baumeister & Heatherton 1996; Baumeister & Vohs 2007). The strength model of self-regulation emphasises that a common resource is used for many different tasks and functions, including self-regulation of diverse responses and that acts of self-control tax one's strength or deplete one's resources, and that afterward there is a period of reduced capacity for further self-regulation (Baumeister & Vohs 2016).

Advances in the strength model state that selective allocation of this limited resource occurs where the brain and associated psychological processes monitor consumption and curtail outlays, not when the resource is gone, but when the current allocations occur at an unsustainable rate (Baumeister & Vohs 2016). Further allocation of depleted resources can occur when current demands are exceptionally high, current tasks have motivational priority, and/or replenishment is imminent, but there may be a natural tendency to resist drawing down energy stores too far or too rapidly (Baumeister & Vohs 2016). It is analogous to muscle capacity, insofar that it depletes with use and requires rest for reuse (Baumeister & Vohs 2016; Baumeister & Alquist 2009; Muraven & Baumeister 2000), and as muscles get tired, the body naturally seeks to conserve energy, long before the point of exhaustion is reached (Baumeister, Tice & Vohs 2018). And much like a muscle it can be strengthened with repeated challenge and so self-regulation capacity can also improve over time with practice (Gailliot & Baumeister 2007). Ineffective self-regulation predicts poor physical and emotional health, and other life problems that would decrease performance and wellbeing (Baumeister, Heatherton & Tice 1994; Tangney, Baumeister & Boone 2004).

This thesis explores the self-regulation changes of entrepreneurs under different action environment conditions as their entrepreneurial journey progresses over time and by doing so makes a theoretical, methodological, and practical contribution to entrepreneurship research and literature. In order to measure the self-regulation of the entrepreneurs, the thesis builds on research in the computer and health sciences, which has looked at understanding cognitions and behaviours. The action environment of entrepreneurs in



moment to moment as well as long duration contexts are investigated, and the resulting time sensitive self-regulation framework enables the exploration of interactive and cumulative effects of the action environment on the performance and wellbeing of entrepreneurs. The thesis shifts focus from the rather static between-person approaches traditionally used in entrepreneurship research towards a more dynamic person-by-situation interactions and processes of within-individual change approach which incorporates the individual development, learning, and adaptation over time (Gorgievski & Stephan 2016; Shepherd 2015). It addresses calls from scholars to explore more deeply the dynamic combination of the entrepreneur, the situation, and impact on performance and wellbeing that is constantly changing over time as the entrepreneur navigates their journey (Byrne & Shepherd 2015; Lévesque & Stephan 2020; Shepherd 2015; Stephan 2018; Wiklund et al. 2019).

## **1.2. Research Objective**

Management researchers have long recognized that time impacts nearly all organisational phenomena, yet even though individuals' changing experiences over time are incredibly important, they are exceedingly difficult to study and assess (Bluedorn & Denhardt 1988). Most phenomena fluctuate over time (Dalal & Hulin 2008), so static research paradigms that do not account for change fail to capture complex and dynamic states, behaviours, and situations (George & Jones 2000). A focus on within-person variability, emphasises that individuals are not static entities but, rather, that their states, behaviours, and environments change over days, hours, or even from one minute to the next providing novel insights about constructs and their relationships with one another that are not possible with a between-person perspective (McCormick et al. 2020).

The objective of this research is to explore the dynamic person-by-situation interactions and processes of within-individual change that make up the entrepreneur's journey over time in their real work and life settings. Where the action environments the entrepreneur is engaging with may change in the moment, daily and ongoing over time. And as self-regulation is linked to individual performance and wellbeing this study explores how the entrepreneur's effectiveness changes on their journey.

**Research Question: How does the changing entrepreneurial journey influence the entrepreneur's self-regulation?**

- a. **Interactively** (in the moment and through the day)
- b. **Cumulatively** (over longer durations of days and weeks)

All entrepreneurs bring their own stable traits, experiences, self-efficacy, and personal and professional circumstances and through their thinking, feeling, and doing entrepreneurs construct their work – the actions they take, when they take them, what interactions they have - and so are in the position that they can create for themselves the conditions or environment where they can be effective which will be constantly changing as the entrepreneurial journey unfolds over time. How the entrepreneur self-regulates their thinking, feeling, and doing in these conditions or environment will influence their individual performance and wellbeing. And how they do something today will be different from tomorrow, indicating their performance and wellbeing could also change. Figure 1-1 outlines this context highlighting the action environment, individual entrepreneur and performance and wellbeing.

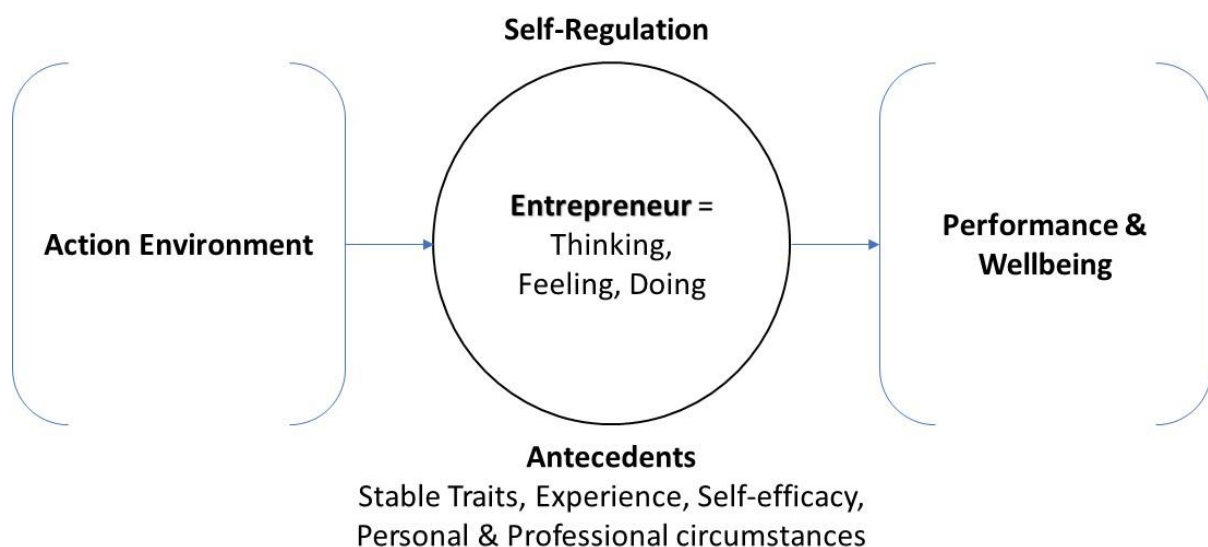


Figure 1-1: Action Environment, Entrepreneur, Performance & Wellbeing

By pursuing this objective, a self-regulation framework for gaining insights into how the action environment influences the performance and wellbeing of entrepreneurs over time is

established that explores interactive and cumulative effects of the entrepreneurial journey. If entrepreneurs could better understand how they self-manage themselves and self-regulate their thinking, feelings, and behaviours through different and changing action environments over time, this could help entrepreneurs understand how and when they are more effective and support sustained performance and wellbeing of entrepreneurs in pursuit of their goals.

### **1.3. Research Approach**

To investigate the entrepreneurial journey over time an exploratory and positivist within-person multiple case study research methodology is used to reveal the kinds of novel insights that are not possible if relying solely on a traditional between-person perspectives (McCormick et al. 2020). For each case mixed qualitative and quantitative methods using a combination of technology approaches capture the self-regulation of the entrepreneur and provide context to the activities that the entrepreneur is experiencing and their subjective effectiveness. Namely wearable sensors and analysis technology to collect physiological data in real-life settings including heart rate variability (HRV) to interpret the self-regulation of participants (Geisler & Schröder-Abé 2015; Holzman & Bridgett 2017; Koval et al. 2013; McCraty & Shaffer 2015; Reynard et al. 2011; Segerstrom & Nes 2007; Zahn et al. 2016) and experience sampling methodology (ESM) via a mobile phone app to repeatedly collect participants responses on activities they are pursuing and their subjective effectiveness (Stone & Shiffman 1994; Stone et al. 2007). This data is further contextualised where possible through discussions with the entrepreneurs and sharing of calendar, to do list, regular routine, and other information from the entrepreneur.

The data used in this thesis focuses on five entrepreneurs from Melbourne, Australia who wore wearables day and night and completed experience sampling surveys on an ongoing basis of between several weeks and several months. This was a small-n exploratory study, where the aim was to strike a balance between managing quantitative study type errors and biases of single-subject research versus the interpretive nature of understanding peoples' subjective experiences of qualitative studies while providing a detailed description of the individual as a case study. Although the small sample size initially may suggest limited generalizability, small-n designs establish external validity by replicating effects across

multiple participants as it is typical that somewhere between two and 10 participants are studied (Gast 2009) and cross-case analysis is used to structure the cases to facilitate synthesis and explore consistency of relationships within and across cases (Eisenhardt 1989; Yin 2014). This data providing the basis to explore theoretical, methodological, and practical implications of changing dynamic person-by-situation interactions and within individual change as part of the entrepreneurs' journey in a real world – “in the wild”- setting over time as well as the potential and challenges of using wearable sensors and analysis in entrepreneurship research.

#### **1.4. Contribution**

In entrepreneurship research there is considerable knowledge on entrepreneurs as people, the environments they work in, and the actions or activities they take to be successful but there is a gap in understanding the dynamic interactions between them and over time (Byrne & Shepherd 2015; Lévesque & Stephan 2020; Shepherd 2015; Stephan 2018; Wiklund et al. 2019). This thesis makes three primary contributions:

Theoretically, it advances a time sensitive self-regulation framework for exploring the idiosyncratic nature of entrepreneur journeys. The framework explores the interactive and cumulative influence of the entrepreneur's journey on the performance and wellbeing of the entrepreneur. It enables investigation of person-by-situation interactions and processes of within-individual change of entrepreneurs over time supporting understanding of how the entrepreneur spends their day and journey. Further it adds to the literature on entrepreneurial actions, cognitions, and behaviours.

Methodologically, it advances understanding of methods to use in studying entrepreneurs in their real work and life settings. The within-person perspective draws attention to more dynamic person-by-situation interactions and processes over time and away from the static between-person approaches traditionally used in entrepreneurship research. It applies novel tools including wearable sensors and HRV analysis for examining self-regulation strength and ESM for exploring and contextualising entrepreneur's actions and subjective effectiveness on an ongoing basis. It provides insights into the use, benefits, and limitations of these tools.

Practically, it advances a framework that can help entrepreneurs understand how and when they are more effective and support sustained performance and wellbeing in pursuit of their goals. It provides practical insights into helping entrepreneurs be more self-aware of their entrepreneurial journey and how the action environment and mediating factors may impact their performance and wellbeing. It provides a framework for lead indicators of performance and wellbeing issues as well as the potential to improve performance and wellbeing.

### **1.5. Thesis Structure**

**Chapter 1** introduces the rationale and theoretical basis for the research. It summarises the research objective as well as methodology used.

**Chapter 2** provides a review of the literature relevant to this research. It outlines core elements of the theoretical basis including entrepreneurs' actions and journey; the context of entrepreneur effectiveness including wellbeing and performance; and self-regulation of feelings, thinking and actions including the link between psychological processes and physiological responses for understanding and measuring self-regulation and its influence on performance and wellbeing.

**Chapter 3** outlines the conceptual development and research propositions for the study. It introduces the entrepreneur bubble construct and the time sensitive self-regulation framework for exploring the idiosyncratic nature of entrepreneurial journeys.

**Chapter 4** provides detail on the research methodology used to meet the objective of the study. It outlines the study, data collection and analysis approach including application of wearable sensors and experience sampling methodology. It highlights the challenges and complexities of the study methods used as well as big data integration and ethical issues.

**Chapter 5** outlines the data collected and provides an analysis of results. It provides a case study of each of the participants and their time-sensitive entrepreneurial journey. It outlines the momentary, daily, and ongoing contexts of these journeys and provides a cross-case analysis.

**Chapter 6** outlines the findings and discusses these findings in exploring the research question. The implications and learnings from the research are discussed including contributions to the current body of knowledge, limitations, and potential future directions for further research.

## 2. Literature Review

*As an entrepreneur, you have to feel like you can jump out of an aeroplane because you're confident that you'll catch a bird flying by. It's an act of stupidity, and most entrepreneurs go splat because the bird doesn't come, but a few times it does."* -Reed Hastings, founder of Netflix

### 2.1. The Entrepreneur and their Journey

#### 2.1.1. The Entrepreneur as an Individual

Entrepreneurs are individuals who recognise opportunities where others see chaos, contradiction, and confusion. They have been compared to Olympic athletes challenging themselves to break new barriers, to long-distance runners dealing with the agony of the miles, to symphony orchestra conductors balancing different skills and sounds into a cohesive whole, and to top-gun pilots continually pushing the envelope of speed and daring (Frederick, O'Connor & Kuratko 2018). The many views of entrepreneurship arguably boil down not to one, but two major perspectives of what entrepreneurship actually is (Davidsson 2004; Gartner 1990). In one entrepreneurship is starting and running one's own venture and so entrepreneurship research studies '*entrepreneurs*', the flesh and blood people who remain entrepreneurs as long as they are running their venture, and any trait, emotion, cognition, behaviour or achievement of such individuals is an issue of interest. In the other entrepreneurship is the creation of new economic activity – where the focus is on the activity '*entrepreneurship*' where different individuals may fulfil different roles as the entrepreneurial process unfolds over time (Davidsson 2008).

Entrepreneurship research has shown that there are multiple personal, organisational, and external causes of successful new venture creation (Baum, Locke & Smith 2001), but it takes human vision, intention, and work to conceive and convert business ideas to successful products and services. And as such entrepreneurship is fundamentally personal where it can be argued that at early stages of a venture's development it is neither possible nor necessary to separate the emerging venture or act of entrepreneurship from the individual entrepreneur (Davidsson & Wiklund 2001; Dimov 2010). It is also known that entrepreneurship can be a very inefficient process where the start-up process is difficult and

uncertain and many new ventures struggle to survive and become sustainable and or valuable (Haswell & Holmes 1989; Nanda & Rhodes-Kropf 2013). In addition, entrepreneurs themselves struggle with their personal wellbeing in areas such as stress and mental health (Cardon & Patel 2015; Rahim 1995; Stephan 2018) which can have consequences for themselves and their ventures.

### 2.1.2. An Uncertain Journey

Entrepreneurship requires making investments (time, effort, money) today without knowing what the distribution of returns will be tomorrow (Venkataraman 1997). There is a fundamental uncertainty that cannot be insured against or diversified away and individuals differ in their awareness and perception of such risks (Katz & Corbett 2019). Through this journey of uncertainty, the nature of entrepreneurial work and the context in which actions take place shapes the relationship between entrepreneurial actions and the emotional and behavioural experiences of the entrepreneur by implication the whole category of emotions, feelings and moods impacting the entrepreneur (Davidson 2003; Fox 2008; Panksepp 2000). According to mood maintenance hypothesis which states that people are motivated to maintain a positive mood state (Isen 1984), entrepreneurs would choose activities that support their attempt to maintain a positive emotional state; and thus may not choose activities that are associated with negative emotions. This has been further reinforced by studies looking at job related affects and behaviours (Warr et al. 2014).

In addition, the broaden and build theory (Fredrickson 2004) suggests that positive emotions (such as enjoyment/happiness/joy, and perhaps interest/anticipation) can broaden one's awareness and encourage novel, varied, and exploratory thoughts and actions. Over time, this broadened behavioural capability builds additional personal skills and resources. Such research suggests that the conscious aspects of planning help founders to make decisions, to balance resource supply and demand, and to turn abstract ideas and goals into concrete operational steps, thereby reducing the likelihood of disbanding and accelerating venture organising activity (Delmar & Shane 2003). Consistent with this research, there is relatively widespread agreement among theorists that planning, whether formal or emergent in nature, generally has a positive influence on a venture's performance (Miller & Cardinal 1994). And



so, it make sense that efforts to develop entrepreneurship education to support emerging entrepreneurs' capabilities for positive intentionality and planning have increased around the world so they can engage more effectively with the entrepreneurial process (Detienne & Chandler 2004; Faggian, Partridge & Malecki 2017; Lüthje & Franke 2003).

However scholars have pointed out that economic information is rarely sufficient for understanding the full nature or potential for entrepreneurial enterprise (Casson 1982) and venture emergence work tends to focus on tacit knowledge or aspects that tend to be context-specific or more challenging to articulate. Therefore, it can't be expected that formal education has the potential to mitigate fully the uncertainty and corresponding risks associated with engaging in the process or journey of new venture creation to exploit entrepreneurial opportunity and accordingly, the distinction between explicit and tacit knowledge helps to explain why some practitioners argue that actual start-up experience is the only way to manage the uncertainty that comes with venturing into the enterprise creation process (Frederick, O'Connor & Kuratko 2018; Gendron 2004). It also supports empirical findings suggesting that such practical experience is what makes real world entrepreneurs different from their respective non-entrepreneurial counterparts (Robinson, Huefner & Hunt 1991).

Additionally, psychological, and cognitive perspectives suggest the information-based interpretation of experience overlooks the idea that the individuals involved are not only shaped by, but also contribute to the social construction of their respective economic contexts (Aldrich & Zimmer 1986; Davidsson & Honig 2003; Granovetter 2005). In other words they consider information processing efforts to be both motivated and tactical in nature (Sorrentino & Roney 2000). There is also evidence suggesting that entrepreneurs use cognitive mechanisms such as heuristics in order to deal effectively with the open-ended and uncertain nature of pursuing opportunity (Busenitz & Barney 1997; Matthews et al. 2009). Research on uncertainty (Milliken 1987) conceptualised three types of state uncertainty – state, effect and response. With state uncertainty entrepreneurs often confront uncertainty around what is occurring or what is likely to occur in their activity or decision making and reflects an inability to understand or to predict the state of the environment due to

information deficiencies or a lack of understanding of the interrelationships among environmental elements. The relevance of state uncertainty as a construct affecting entrepreneurial activity and decision making is consistent with research on network models of organisational formation (Larson & Starr 1993) whereby new organisations are seen in part as being socially constructed from the actions of individuals embedded in networks of interdependent relationships (Aldrich & Zimmer 1986; Granovetter 2005) as well as evidence suggesting that self-efficacy takes on a context specific dimension given the complex nature of entrepreneurial tasks (Chen, Greene & Crick 1998).

Research has also shown that perceived environmental uncertainty is unidimensional in terms of state uncertainty but multi-dimensional in terms of the sources of uncertainty. A factor analysis (Matthews & Human 2000) found that the eleven activities were influenced by three factors labelled as financial, competitive, and operational uncertainty. These three types of uncertainty and the items within each factor are consistent with Milliken's (1987) notion of state uncertainty in which managers find it difficult to grasp how key components in the environment may be changing. Finally, there may be important variation with respect to the level of control the entrepreneur may perceive over the type of uncertainty depending on the degree to which it occurs in or external to the boundaries of the venture (Bhave 1994) as well as the real world experiences of the entrepreneur (Gendron 2004; Robinson, Huefner & Hunt 1991). To navigate this entrepreneurship journey of uncertainty over time requires human agency (Shane 2003) which highlights the need and opportunity to study the individuals who exercise such agency. And so in order to understand what goes on for entrepreneurs at the micro level, there is every reason to study the emotions, cognitions, behaviours and other characteristics of the individuals involved over time (Davidsson 2008).

### 2.1.3. Actions and Activities of Entrepreneurs

“What do entrepreneurs do?” when starting up a new venture is a research question that has occupied scholars for years (Carter, Gartner & Reynolds 1996; Katz & Gartner 1988; Mueller, Volery & von Siemens 2012). The actions and activities of entrepreneurs have become central to understanding venture emergence in entrepreneurship (Dimov 2010; Klein 2008; McMullen & Shepherd 2006) and a number of large international research projects – including

the panel study of entrepreneurial dynamics (PSED) – have attempted to understand entrepreneurial action through investigations of emergence activities and behaviours of nascent entrepreneurs (Davidsson & Gordon 2012; Gartner et al. 2004; Reynolds 2016). A substantial portion of literature in entrepreneurship research suggests that entrepreneurial activities are conscious, planned, and intentional in nature (Ardichvili, Cardozo & Ray 2003; Brazeal, Schenkel & Azriel 2008; Katz & Gartner 1988) however the relative importance of each individual activity, as well as how complex configurations of gestation activities shape entrepreneurial outcomes is still debatable. Scholars have started to explore certain patterns and timing issues around sets of activities, without clear results emerging across studies (Gordon 2012; Liao & Welsch 2008; Reynolds 2016). And some studies have shown that no particular gestation activities are necessary for start-up and only a low number of gestation activities are needed to reach profitability in 24 months (Arenius, Engel & Klyver 2017). This is not to say that entrepreneurial action is not important but rather that it is challenging to distinguish between what are necessary actions and what are sufficient actions for firm emergence.

Therefore in summary we still don't know what complex combination of actions or activities is likely to explain venture emergence (Gartner & Shaver 2012; Lichtenstein et al. 2007). The entrepreneurial process occurs because people act to pursue opportunities, but people differ in their willingness and abilities to act on these opportunities because they are different from each other. This variation among people in their willingness and ability to act has important effects on the entrepreneurial process and the activities and actions that they prioritise and pursue on their journey. This can include things such as variation across people in how optimistic they are or higher in self-efficacy; their perceptions of risk and opportunity influencing entrepreneurial decisions (Shane & Venkataraman 2000) or how they view the risk of expending resources before knowing the distribution of outcomes (Palich & Ray Bagby 1995). Researchers have also shown that the willingness of people to pursue entrepreneurial opportunities depends on such things as their opportunity cost (Amit, Muller & Cockburn 1995), their reserves of financial capital (Evans & Leighton 1989), their social ties to investors (Aldrich & Zimmer 1986), their career experience (Carroll & Mosakowski 1987), and their motivation (Shane, Locke & Collins 2003). All these factors impact the action environment

that the entrepreneur works in and the actions and activities that they pursue as part of their journey where for this thesis the broad definition of the action environment includes the different and changing complex combination of actions or activities in their context that the entrepreneur is pursuing through their day to day and ongoing journey.

#### 2.1.4. Performance of Entrepreneurs

Performance is the action or process of performing a task or function (McArthur, Lam-McArthur & Fontaine 2018) and talks to how well a person, machine or entity does that activity. In entrepreneurship research, historically venture or firm performance as measured by objective financial indicators has been prominent, however subjective entrepreneurial success, that is the entrepreneur's assessment of how well they perform measured against their own goals and aspirations, has emerged as an area of interest to better understand the behaviour and decisions of entrepreneurs more broadly (Cooper & Artz 1995; Gorgievski, Ascalon & Stephan 2011; Wach et al. 2018). This interest has been driven based on the observation that entrepreneurs' behaviour and decisions cannot be explained solely by reference to financial firm performance indicators as their actions are also driven by goals and values that go well beyond financial returns (Fagenson 1993; Gorgievski, Ascalon & Stephan 2011; Wach, Stephan & Gorgievski 2016). For example, entrepreneurs abandon successful firms when their own personal goals or satisfactions are not met (Bates 2005) but conversely persevere with objectively underperforming firms if they are highly committed to the venture, its purpose and employees (DeTienne, Shepherd & De Castro 2008).

Entrepreneurs view performance and success broadly and in many dimensions where they value outcomes beyond firm performance and financial rewards (Wach et al. 2018). The external objective view of an entrepreneur's performance will therefore be different from the individual subjective view and the satisfaction an entrepreneur has in their own performance. For example, entrepreneurs attach importance to a wide range of performance and success outcomes such as satisfaction as a basic measure of performance (Cooper & Artz 1995); independence and autonomy (Jayawarna, Rouse & Kitching 2013; Reynolds & Curtin 2008); progress and achievement (Edelman et al. 2010; Reynolds & Curtin 2008); self-realisation, learning and personal development (Benzing & Chu Hung 2009; Jayawarna, Rouse & Kitching

2013); status, social recognition and monetary incentives (Benzing & Chu Hung 2009); work-life balance and wellbeing (Jayawarna, Rouse & Kitching 2013); personal and family security (Kuratko, Hornsby & Naffziger 1997; Robichaud, McGraw & Alain 2001); relationships with employees, partners and stakeholders (Gorgievski, Ascalon & Stephan 2011; Jayawarna, Rouse & Kitching 2013); creating social value, making a difference and helping others (Lukes & Stephan 2012; Seelos & Mair 2005; Stephan, Hart & Drews 2015) and spirituality (Kauanui et al. 2010).

Such evidence suggests that entrepreneurs' subjective assessment of their performance and success is important for the ventures future existence and implies that how entrepreneurs assess and measure their own performance is as important to entrepreneurship research as research on objective firm performance itself. And while the focus on firm-related performance indicators is in line with the economic view of entrepreneurs as being individuals who are rewarded with high monetary returns for bearing high levels of risk (Parker 2009), economic research also increasingly acknowledges that entrepreneurs may seek different types of utility, such as independence and satisfaction, over and above monetary returns (van Praag & Versloot 2007; Walker & Brown 2004). There is evidence that entrepreneurs' value and strive for multiple success criteria simultaneously. For example Wach et al (2018) developed a multi-faceted measure that includes entrepreneurs' self-reported achievement of firm performance, workplace relationships, personal fulfilment, community impact, and personal financial rewards. Staniewski and Awruk (2018) developed a Questionnaire of Entrepreneurial Success (QES), which differentiates subjective and objective short and long-term success perspectives. Gorgievski et al (2011) identified the person oriented and business-oriented dimensions that underlie entrepreneurs' perceptions of their success. And Fisher et al (2014) introduced several personal and business performance criteria to capture subjective entrepreneurial success.

#### 2.1.5. Wellbeing of Entrepreneurs

Wellbeing is the overall state of being comfortable, healthy, or happy (McArthur, Lam-McArthur & Fontaine 2018) and it is important to realise that wellbeing is a much broader concept than moment-to-moment happiness. It is also more than the absence of illness and

includes having good mental health for social and emotional wellbeing. Wellbeing is central to effective human functioning (Ryan & Deci 2001; Ryff 2017) and entrepreneurs are no exception. Traditional approaches to studying wellbeing have come from a sociological, economic, and physiological perspective which has resulted in common themes but no one dominating perspective (Sonnentag 2015; Wiklund et al. 2019). Broadly therefore, wellbeing can be understood as a person's hedonic experience of feeling good (such as happiness, satisfaction, or positive affect) and or the eudaimonic experience of fulfillment and purpose (such as personal growth, opportunity and potential)(Ryan & Deci 2001; Ryff 2018; Sonnentag 2015). Wellbeing studies in entrepreneurship have tended to focus primarily on distress and hedonic experiences of wellbeing (Stephan 2018; Wiklund et al. 2019) but the potential of understanding eudaimonic experiences is significant as it focusses on existential flourishing, wellness and potential for growth which are attributes conducive to entrepreneurial qualities (Ho & Singh 2020; Wiklund et al. 2019). There is increasing evidence that personal wellbeing of entrepreneurs has a direct link with the entrepreneurial journey and work (Shir, Nikolaev & Wincent 2019; Stephan 2018) given the long hours, ownership of activities and hard work and work stress that characterise the entrepreneurial journey (Rauch, Fink & Hatak 2018).

Wellbeing in the journey of entrepreneurs is therefore a growing area of interest as there is recognition of its role in entrepreneurs' decision-making, motivations and action that impacts performance (Shepherd & Patzelt 2015; Stephan 2018; Wiklund et al. 2019). It is also clear there is a lack of understanding of entrepreneurial wellbeing despite evidence that wellbeing can have a profound effect on entrepreneurs and their ventures and their ability to sustain performance towards success (Ho & Singh 2020; Shepherd & Patzelt 2015; Stephan 2018). 'Happy' entrepreneurs are more likely to persist and perform better (Wincent, Örtqvist & Drnovsek 2008). Entrepreneurs may make financially costly decisions, such as delaying business failure, to protect their wellbeing (Shepherd, Wiklund & Haynie 2009). They may also value wellbeing as an outcome and see it as an indicator of their performance and success (Wach, Stephan & Gorgievski 2016). Studies have shown entrepreneurs' affect both positive and negative can impact their immediate entrepreneurial tasks (Uy, Foo & Song 2013) and that greater wellbeing allows entrepreneurs to focus more effectively on new venture opportunities (Gielnik, Zacher & Frese 2012). Additionally, the greater the ability of the

entrepreneur to develop and refine their fit in their entrepreneurial role and display distinct entrepreneurial characteristics the higher their wellbeing and performance (Hmieleski & Sheppard 2019).

Compared to paid employees, entrepreneurs' work is more complex and challenging involving high levels of uncertainty, which make it extremely demanding and stressful (Cardon & Patel 2015; Patzelt & Shepherd 2011). The stress and demands are intensified by entrepreneurs' very direct connection to their firm, the work outcomes, employees, stakeholders where they have difficulty distancing themselves emotionally, cognitively, or indeed legally from their accountability and some research has connected entrepreneurs to higher levels of stress and poor wellbeing (Harris, Saltstone & Fraboni 1999; Teoh & Foo 1997; Wincent & Örtqvist 2009) compared to other work settings. For example stress and mental health issues (Cardon & Patel 2015; Rahim 1995; Shir, Nikolaev & Wincent 2019; Wiklund et al. 2019); and burnout are of significant concern for entrepreneurs (Duran-Whitney 2004; Wincent, Örtqvist & Drnovsek 2008) particularly where stress and fatigue can be relentless for an entrepreneur. Issues of wellbeing and health potentially underpin the inter-relationships (between individuals, actions, and opportunities) that are central to the field of entrepreneurship and therefore wellbeing issues (of entrepreneurs and/or others) can facilitate or obstruct entrepreneurial action from delivering value (to the entrepreneur and/or others) (Shepherd & Patzelt 2015).

Individual patterns of entrepreneurial wellbeing can determine the ongoing trajectories of entrepreneurial wellbeing and performance where for example integrating wellbeing into the journey trajectory emphasises consistency and stability in wellbeing while a delaying wellbeing trajectory describes trajectories that move through rises and falls in wellbeing in relation to entrepreneurial activities and actions (Ho & Singh 2020). Wellbeing is key to the very existence of an entrepreneur's firm, increasing their opportunity recognition, persistence (Wincent, Örtqvist & Drnovsek 2008) and firm performance (Stephan 2018) where the relationship between wellbeing and entrepreneurship may have temporal and variable effects throughout the entrepreneurial journey (Ryff 2019). Therefore how entrepreneurs can achieve and or maintain their wellbeing despite their stressful work over

days, weeks, months and years of an entrepreneurial journey is a central question requiring a deeper understanding of the nature of entrepreneurs' work stressors and how such stressors affect wellbeing (Wach et al. 2020). Exploring the links between entrepreneurial actions and context and the wellbeing of the entrepreneur over time can be enhanced through further investigation (Shepherd & Patzelt 2015; Stephan 2018; Wiklund et al. 2019). Wellbeing and entrepreneurship have significant influences on one another which have led several scholars to suggest entrepreneurs and their wellbeing may be uniquely expressed in the entrepreneurship domains (Phan & Wright 2018; Stephan 2018). And such wellbeing, much like entrepreneurship, is a process and explorations of its effects should incorporate a long term and process view (Ho & Singh 2020).

#### 2.1.6. The Effective Entrepreneur

The book "The Effective Entrepreneur" (Swayne & Tucker 1973) was part of extensive early entrepreneurship research done in the 1960's, 70's and 80's that explored entrepreneurial traits that sought to determine why some people become entrepreneurs and others do not (DeCarlo & Lynn 1980; Hornaday & Aboud 1971; Smith 1967; Webster 1977). And while this stream of research produced limited results, these studies showed that no specific entrepreneurial traits exist and thus entrepreneurs are essentially no different than anyone else. But it did shift thinking towards the view that it is not personal traits that are important but the set of personal behaviours that distinguish entrepreneurs' effectiveness (DeCarlo & Lynn 1980; Gartner 1988). By definition effectiveness is the degree to which something is successful in producing an intended or expected result or success (McArthur, Lam-McArthur & Fontaine 2018) and can be applied to how organisations, groups, systems or individuals achieve their desired or predetermined goals and objectives. And so personal effectiveness means to utilise all your individual skills, talent, and energy to reach a goal or set of goals in your life. Some studies (Richard et al. 2009; Thompson & Downing 2006) have linked effectiveness to performance for example arguing that organisational effectiveness captures and indicates organisational performance (Richard et al. 2009) and likewise an entrepreneur's personal effectiveness captures and indicates entrepreneurs' personal performance with regard to their personal objectives and goals which in the long run reflects in their business,



firm, and entrepreneurial activities (Lucky & Minai 2011). Kwantes and Boglarsky (2007) examined perceptions of organisational culture, leadership effectiveness and personal effectiveness across six countries and found that there is a strong relationship between personal effectiveness and organisational performance.

For the individual entrepreneur therefore, effectiveness is essential for success because effectiveness plays a central role to produce desired results. Where entrepreneurs who are more effective may work smarter in reaching their goals. Entrepreneurs' internal representations of desired outcomes differ from attainment of those standards through behaviours and the link between valued and actually achieved success criteria can be quite complex where values find their expression in behaviour varies depending on economic, ecological, and institutional contexts (Fischer 2006; Fischer & Boer 2016). Previous literature (Lucky & Minai 2011) has also connected effectiveness and self-management recognising that entrepreneurs carry out many functions such as planning, organising, coordination and controlling and that those who can manage all these functions effectively pave way to business glory and those who fail face business failure. Effective entrepreneurs' self-management contributes to their personal effectiveness and consequently leads to a better firm performance while entrepreneurs who remain ineffective as a result of their inability to manage themselves can result in worse firm performance (Lucky & Minai 2011).

If an entrepreneur feels better, they are likely to perform better and be more effective both in their moment-to-moment activities as well as their longer journey in creating a product, service, and venture of value (Stephan, Hart & Drews 2015; Wach et al. 2018; Wiklund et al. 2019). Further Identity Theory (Burke & Reitzes 1991; Cardon et al. 2012; Duening & Metzger 2017; Murnieks, Mosakowski & Cardon 2014; Stryker & Burke 2000); Self-Regulation Theory (Carver, Sutton & Scheier 2000; O'Shea, Buckley & Halbesleben 2017; Vohs & Baumeister 2016) and Self-Efficacy Theory (Brännback & Carsrud 2017; Fuller et al. 2018; Gallagher 2012; Maddux 1995; Newman et al. 2018; Piperopoulos & Dimov 2015) applied to entrepreneurship all speak to an entrepreneurs ability to focus thinking, feelings and behaviour to explain progress, performance and success. These theories also take into account the external environment in which the individual operates but acknowledge the power of self in engaging

and directing personal resources in pursuit of goals or specific outcomes central to entrepreneurial progress and therefore individual effectiveness for performance and wellbeing.

## **2.2. Self-Regulation**

### **2.2.1. Purpose and Importance**

People's ability to self-regulate may be their most essential asset (Vohs & Baumeister 2016). It is defined by one's capacity to change thoughts, inhibit impulses, alter emotions or emotional responses, and/or change behaviour in line with a desired objective (Karoly 1993; Vohs & Baumeister 2016). Self-regulation is frequently referred to interchangeably as self-control and in non-academic texts is referred to as 'willpower' or 'self-discipline' (Gailliot & Baumeister 2007). Self-control is the process by which individuals bring themselves into line with their goals and standards, while self-regulation describes all forms of monitored adaptation by the self, including non-conscious regulation (Baumeister & Alquist 2009). Hence, self-control is a narrower concept, only relating to the conscious, effortful form of self-regulation and so the broader term self-regulation is used throughout this thesis.

Forgas, Baumeister and Tice (2009) noted that the ability to control and regulate our actions is perhaps the quintessential characteristic of human beings and that people with good self-control do better than others. Numerous studies have shown that self-regulation has important implications for success in life as well as health and wellbeing (Baumeister, Heatherton & Tice 1994; Duckworth & Seligman 2005; Forgas, Baumeister & Tice 2009; Tangney, Baumeister & Boone 2004; Vohs & Baumeister 2016). There has also been growing recognition, that goal directed behaviour is central to the wellbeing of individuals, that goal-guided self-regulation can be improved, and that the impact of factors that threaten self-regulation can be reduced (Boekaerts, Maes & Karoly 2005). Research has shown the existence of a strong relationship between individuals' self-regulation strategies and various indices of adaptive success (Boekaerts, Maes & Karoly 2005).

Theories of self-regulation processes have been studied across the breadth of psychological research helping to explain performance and success (Forgas, Baumeister & Tice 2009; Karoly

1993; Neal, Ballard & Vancouver 2017; Vohs & Baumeister 2016) and more recently have been applied to work and organisational domains. Developments in industrial and organisation (I/O) psychology and organisational behaviour (OB) research have converged on a self-regulation perspective to understand the complexity of human behaviour and work motivation where self-regulation is the capacity of individuals to guide their activities over time and across changing circumstances (Diefendorff & Lord 2008; Kanfer 1990). In organisations, managers want people to achieve high performance levels; and so psychologists accordingly are interested in individuals' regulation of their own levels of job performance (Boekaerts, Pintrich & Zeidner 2005; Porath & Bateman 2006).

Self-regulation research has highlighted the importance of goals, but typically has focused narrowly on a single task goal and has neglected the mediating tactics between goals and overall job performance (Karoly 1993). But people's goals at work are not composed merely of single task goals and involve other factors or broad goal orientations. People can have and act on at least three different types of broad goal orientations which hold important implications for people's work behaviours and ultimately job performance including learning, performance-prove, and performance-avoid (Elliot & McGregor 1999; Vandewalle & Cummings 1997). Work on managerial effectiveness has also highlighted the processes for adaptive self-regulation. They involve the active management of constituencies' role expectations and performance opinions through standard-setting, discrepancy-detection, and discrepancy-reduction in order to enhance manager's effectiveness (Tsui & Ashford 1994). There is also much work focussed on positive psychology, to develop and maximise peoples strengths and psychological capabilities (Cameron & Dutton 2003; Seligman 2004) to realise the potential of positive approaches on performance to identify the best ways to help people recognize both their own behavioural patterns and how they can think and behave differently to attain desired goals (Mischel & Mendoza-Denton 2003).

### 2.2.2. Theoretical Underpinnings

There have been numerous scientists, researchers and psychologists that have studied self-regulation processes and the concepts of self-regulation are central to a range of theories across human behaviour, management, and entrepreneurship. This includes for example

goal-setting theory (Latham & Locke 1991); action theory (Baum et al. 2007; Frese 2009) and control theory (Carver & Scheier 1982, 1990, 1998) where each theory has its strengths but they are not always compatible (Zeidner, Boekaerts & Pintrich 2000). The origins of self-regulation however come from motivation theories and research including significant contributions from Albert Bandura focusing on the acquisition of behaviours that led to the social cognitive theory (Bandura 1986). This research suggested that instead of being just shaped by environments or inner forces, individuals are self-developing, self-regulating, self-reflecting and proactive in working towards goals. Bandura brought together behavioural and cognitive components in which he concluded that humans are able to control their behaviour through a process known as self-regulation (Bandura 1986). He studied self-regulation before, after and during the response and created the triangle of reciprocal determinism that states behaviour, environment, and the person (cognitive, emotional, and physical factors) both influence and are influenced by one another (Bandura 1986, 2012). Bandura concluded that the processes of goal attainment and motivation stem from an equal interaction of self-observation, self-reaction, self-evaluation, and self-efficacy (Bandura 1991).

Other major contributions have come from Roy Baumeister who alongside colleagues conducted research on the self, related to how people perceive, act and relate to themselves including studying self-control as a limited resource and establishing concepts of ego depletion and self-regulatory failure (Baumeister 2003; Baumeister & Alquist 2009; Baumeister & Heatherton 1996; Baumeister, Heatherton & Tice 1994; Baumeister & Vohs 2007; Forgas, Baumeister & Tice 2009; Muraven & Baumeister 2000; Muraven, Tice & Baumeister 1998; Vohs & Baumeister 2016; Vohs, Baumeister & Schmeichel 2012). His research explored self-regulation from a number of different perspectives including self-regulation as an information processing ability, as a way to direct appropriate responses, and self-regulation as a skill or ability, which one could practice in order to control the self. However his most prominent theory, the strength model, stated that self-regulation is a limited resource analogous to muscle capacity because it depletes with use and requires rest for re-use (Baumeister & Alquist 2009).

Some researchers have called for a need to integrate diverse theories of self-regulation and Wood (2005) presents a table highlighting theoretical underpinnings and depicts potential categories that may be used in the development of a general framework of self-regulation research in the domain of work and organisational psychology (see Table 2.1). Karoly, Boekaerts and Maes (2005) suggest that the following components of self-regulation may serve as functional universals: goal-selection, goal-setting, feedback sensitivity, error monitoring, self-evaluative judgements, self-corrective instrumental action, and the emergence of self-efficacy beliefs; and can be used in all fields to pursue, in parallel, studies that attempt to examine the interactive nature of these universal component functions along with the moderating role of boundary conditions, such as schematic knowledge structures, and automaticity. What is common across all models is the broad definition of self-regulation as the capacity of the self to alter dominant responses and to regulate behaviour, thoughts, and emotions (de Ridder et al. 2012).

As such self-regulatory processes broadly include acting, thinking, learning and feeling as well as the links between processes and the context in which they are occurring (Vancouver 2008). Further, models of self-regulatory processes building on previous research and theory are integrating cognitive, motivational and behavioural approaches to self-regulation research and also integrating distal and proximal concepts within each of these three domains (Forgas, Baumeister & Tice 2009). Psychological mechanisms that are involved in goal pursuit and self-regulation are so closely related that the best strategy appears to be to treat them as an integrated whole and examination of the cognitive aspects of the model aimed to establish the core elements of the self-regulation process and build upon past research and theory (Forgas, Baumeister & Tice 2009). A systems approach is also important, where self-regulation is viewed broadly as the process by which a person interacts with their environment (Bandura 1997). The person and the environment form a closed loop where the behaviour of the system as a whole emerges from the interactions among its elements, and is critically dependent upon the structure of the loop and the internal dynamics of the elements within that loop (Neal, Ballard & Vancouver 2017). Self-regulation can also be viewed as a choice problem, the choice that people face is what to do, when to do it and how to it. Environmental constraints

determine the choices that are available, while the individual's needs, desires, fears, and concerns determine the choices that they make (Locke & Latham 1991).

*Table 2-1: Potential Categories for a Framework of Self-Regulation Research*

<b>Theoretical frameworks</b>
Social cognitive theory
Control theory
Self-determination theory
Action theory
Action-state theory
<b>Categories of key processes or sub-functions in self-regulation</b>
Goal establishment; planning; striving; goal revision
Self-observation; judgments; self-reactive influences
Goal setting; self-monitoring; activation of standards; discrepancy detection
<b>Self-regulatory mechanisms (cognitive and affective mediators of outcomes)</b>
Standards and goals
Affective self-evaluations
Self-efficacy
Intrinsic interest
Perceived instrumentality
<b>Self-regulatory skills</b>
Memory
Emotional discrimination; impulse control
Attention capacity and control
Feedback seeking
Planning and goal setting
<b>Personal determinants of self-regulatory processes</b>
Conscientiousness
Extraversion
Neuroticism
Self-monitoring
<b>Self-regulation interventions</b>
Attention management; distraction activities
Behavioural recording; performance monitoring
Goal setting; task planning; scheduling
Verbal self-guidance; self-talk; thought suppression
Stimulus control; task selection; context management
Self-rewards; values clarification
<b>Organisational events that stimulate self-regulatory processes</b>
Accountability (planning, budget reviews, performance appraisals, etc.)
Organisational change (technology change, job redesign, etc.)
Personal challenges (failures, task setbacks, promotions, new jobs, etc.)
Disrupting of routines (equipment failure, poor performance, criticism, etc.)
Dysfunctional work cultures (anxiety, perceived inequities, threat, etc.)
<b>Organisational and work arrangements that facilitate self-regulation</b>
Error tolerance
Autonomy and flexibility in allocation of effort
Task support
Guided mastery approach to novel and challenging tasks
Goal setting and feedback systems

### 2.2.3. Self-Regulation Strength and Cycles of Depletion and Recovery

Self-regulation strength or capacity is the ability over time to continue the process of monitoring and controlling the self and when it becomes depleted, this is termed self-regulatory failure or ego depletion (Baumeister & Vohs 2016; Baumeister & Alquist 2009; Baumeister & Heatherton 1996; Baumeister & Vohs 2007). Self-regulation strength can be depleted by a range of factors including emotional, cognitive, or behavioural (Baumeister & Vohs 2007; Gailliot & Baumeister 2007) and in particular, many patterns of self-regulation break down when people are challenged, under stress or fatigued, because the stress or fatigue depletes their self-regulatory capacities (Baumeister & Heatherton 1996). Our capacity for self-regulation can be replenished or restored by a range of factors including rest, glucose, and/or positive emotions (Gailliot & Baumeister 2007). The implication is that learning how to maintain, increase and replenish this resource has health and performance benefits (Baumeister 2003; Forgas, Baumeister & Tice 2009).

The strength model of self-regulation is one of the most commonly cited and empirically tested models of self-regulation (Baumeister, Tice & Vohs 2018) where over the last twenty years researchers have put forward rival theoretical accounts and others have questioned the phenomena but the weight of evidence continues to support the validity and usefulness of the strength model, albeit amid continuing updates and revisions (Baumeister & Vohs 2016; Baumeister 2016; Baumeister, Tice & Vohs 2018). The model continues to be researched and updated to understand the nature of self-regulation strength as a resource and its depletion and replenishment given the ability of the brain for selective allocation of this precious, limited resource and the adaptive long-term benefits of good management and the ability with practice that self-regulation can be improved and trained (Baumeister & Vohs 2016).

Ego depletion does not mean that the self has run out of energy; rather, it reflects the cutting back of exertion to conserve its remaining energy (as it does with physical exertion). Strength meant, first and foremost, that after exerting self-control, subsequent acts of self-control, even in different contexts, would suffer. People therefore have only a limited capacity to control and alter their behaviour, and this capacity appears to be vulnerable to depletion in the aftermath of strenuous use (Muraven & Baumeister 2000). When people find themselves

in circumstances that make strong, challenging demands for self-control or when people squander their self-regulatory strength in unproductive endeavours, they may find that their self-regulation breaks down in other, unrelated spheres (Muraven & Baumeister 2000). Furthermore, acts of self-regulation may impair subsequent self-regulation due to temporary exhaustion of self-regulatory strength. A key feature of self-regulatory strength is inhibitory capacity (Muraven & Baumeister, 2000) and more generally the effective operation and management of limited strength may be one valuable key to understanding how the self functions.

The basic cycles of self-regulation strength depletion and recovery have been well replicated across hundreds of studies in many fields using different procedures as confirmed by various meta-analysis reviews (Carter et al. 2015; Hagger et al. 2010; Holzman & Bridgett 2017; Zahn et al. 2016). It has been found that people with multiple demands on their self-regulatory processes tended to fare poorly at all of them (Baumeister, Tice & Vohs 2018) where put simply depletion inhibits inhibition. Assorted findings indicate that depleted persons fail to inhibit a broad range of actions and responses that indicate lower performance or wellbeing than they would otherwise (i.e. if not depleted) inhibit successfully (Baumeister 2014) including for example aggression (DeWall et al. 2007), prejudice (Muraven 2008), overeating of unhealthy food (Vohs & Heatherton 2000), alcohol consumption (Muraven, Collins & Neinhaus 2002), impulsive spending (Vohs & Faber 2007) and compliance to social norms where for example depleted persons were more likely to take social and ethical risks, use curse words and ignore or disobey specific instructions (Gailliot et al. 2012).

Because ego depletion is typically a matter of conserving a slightly depleted resource, its effects can be overcome with a variety of cognitive and motivational stimulants (Baumeister 2014). However, as ego depletion becomes increasingly severe, or there are multiple demands on self-regulatory processes these other procedures become less effective at counteracting the behavioural decrements of ego depletion (Vohs, Baumeister & Schmeichel 2012). And although automatic processes continue to operate in the depleted state it would be rash to argue that no automatic processes deplete (Baumeister & Vohs 2016). For example Schmeichel, Vohs and Baumeister (2003) showed that intellectual performance deteriorated



unevenly where depletion impaired effortful and high-level processes such as logical reasoning, extrapolation and making inferences based on reading comprehension but had little or no significant effects on simpler intellectual processes such as rote memorisation and accessing general knowledge. Depletion may make people more passive or reluctant where they rely or fall back on default responses or low-effort styles of making decisions (Pocheptsova et al. 2009) or on the other hand during a depleted state, impulsive behaviour may be increased (Baumeister & Vohs 2016; Baumeister 2016) which in either case can result in less effective performance and wellbeing outcomes where the depletion has weakened central control, allowing automatic or unconscious processes to influence thinking, feelings and behaviour.

This self-regulatory failure or ego depletion phenomenon has traditionally been studied using a between-subject, sequential task paradigm where one group of participants completes a difficult self-control task, while the other group of participants completes an easy version of a similar task; afterwards, both groups complete an unrelated self-control task and the performance of the two groups is compared. This design has been used with a vast variety of depleting tasks to induce fatigue, and an equally vast variety of second tasks to measure the impact of fatigue (Hagger et al. 2010). However, although hundreds of studies have found differences between these groups, some failures to replicate the effect and evidence of publication bias and questionable research practices in previous studies did shake confidence in the very existence of the phenomenon (Carter et al. 2015; Hagger et al. 2016; Lurquin et al. 2016). Many of these design, publication and methodological issues have since been answered (Baumeister 2016; Baumeister, Tice & Vohs 2018; Francis et al. 2018).

With current advances the strength model of self-regulation emphasises that selective allocation of this limited resource occurs where the brain and associated psychological processes monitor consumption and curtail outlays, not when the resource is gone, but when the current allocations occur at an unsustainable rate (Baumeister & Vohs 2016). Further allocation of depleted resources can occur when current demands are exceptionally high, current tasks have motivational priority, and/or replenishment is imminent, but there may be a natural tendency to resist drawing down energy stores too far or too rapidly (Baumeister &

Vohs 2016). Therefore for previous self-regulation research the affect size may be not as large as original studies indicated and the ego depletion effect is also likely moderated by individual differences such as trait self-control (Gailliot, Schmeichel & Baumeister 2006) and task characteristics, contributing to heterogeneity in the effect size (Judd, Kenny & McClelland 2001). For these reasons within-subject designs, particularly repeated-measures designs have been highlighted for the increased statistical power that enables researchers to be more confident in their results because an increasing proportion of significant results will reflect true effects instead of false positives (Francis et al. 2018).

#### 2.2.4. Self-Regulation and Entrepreneurship

Research at the level of the individual in management and organisational sciences has started to move towards a more contextualised and nuanced examination of the person in action and has been applied to a range of behavioural domains (de Ridder et al. 2012). Self-regulatory processes and their importance for entrepreneurs has been acknowledged in numerous studies (Baron & Henry 2010; Frese 2009; Haynie & Shepherd 2009; Mitchell et al. 2007; Nambisan & Baron 2013; Trevelyan 2011; Wartiovaara, Lahti & Wincent 2019). For example, Nambisan and Baron (2013) focussed on three self-regulatory processes - self-control, grit, and metacognition – as not only important aspects of self-regulation for entrepreneurs working towards their goals but also particularly relevant to the ecosystem context that their research focussed namely enabling strong interfirm dependencies, pursuit of common goals, and evolution of shared complementary capabilities. Similarly research by Haynie and Shepherd (2009) used a metacognitive lens to highlight adaptive cognition of entrepreneurs to be dynamic, flexible and self-regulating in the dynamic and uncertain task environments of entrepreneurship.

Further, Wartiovaara et al (2019) stated an entrepreneur's ability to control his or her true self and behaviour is beneficial for the evaluation and elaboration of an entrepreneurial opportunity. And Mitchell et al. (2007) noted that metacognitive thinking leads to the creation of entrepreneurial expertise which facilitates the self-reflection, understanding, and control of one's own entrepreneurial cognitions working towards goals. There is also emerging research on impulsivity, ADHD (attention deficit hyperactivity disorder) and entrepreneurship

that explores the harmony and discord between benefits of impulsivity and negatives of inattention as an example (Lerner, Hunt & Verheul 2018; Wiklund et al. 2017). Individuals with ADHD symptoms may be more likely to harness advantages associated with ADHD rather than suffer from associated disadvantages in highly uncertain and dynamic environments such as entrepreneurship (Wiklund et al. 2017). The influence of ADHD on entrepreneurship is complex and multifaceted, mediated by multiple dimensions of impulsivity implicating that the application of self-regulation research could provide additional context to this emerging research (Lerner, Hunt & Verheul 2018). For example, understanding how cycles of depletion and recovery influence the performance and wellbeing of entrepreneurs with ADHD and how depletion may impact impulsivity control and associated benefits and negatives.

And while it is clear that there is considerable research in cognitive, motivation and behavioural aspects of entrepreneurship that are components of self-regulation there has been limited research on the effects of the entrepreneur journey on self-regulation over time that have been empirically studied and what impact this has on an entrepreneurs' effectiveness and outcomes such as performance and wellbeing. How individuals sense, perceive, acquire knowledge, think, and reason is governed by cognition (Brännback & Carsrud 2017; Shepherd & Patzelt 2018) and research has shown the existence of a strong relationship between individuals' self-regulation strategies and various indices of adaptive success (Boekaerts, Maes & Karoly 2005). Entrepreneurship researchers are using cognitive theories to help explain how individuals perceive and understand the world and in combination with individuals' characteristics, show how over time, their interactions with their environments influence their thinking, feeling, behaviours and their subsequent outcomes (Baron 1998; Baum, Frese & Baron 2007; Krueger Jr 2005; Sadler-Smith & Badger 1998). Self-regulation constructs integrate the cognitive, motivational, social and behavioural strands of theory and research while also taking into account cultural, organisational and contextual variables that influence self-regulation (Boekaerts, Pintrich & Zeidner 2005). This makes models that explore self-regulation highly relevant for entrepreneurs and theories on the entrepreneurship process.

Taking a dynamic process perspective regarding the ways in which entrepreneurs manage themselves, as well as their thoughts, emotions, social interactions, time and so on; an advantage of self-regulation to researchers and practitioners is that it is amenable to development offering potential for improving entrepreneur performance, in contrast to cognitive ability which is largely regarded as stable and hence, not amenable to change (O'Shea 2011). Compared to other organisational settings entrepreneurs tend to operate in environments characterised by ambiguity and low levels of feedback, in which the entrepreneur has responsibility for managing both themselves and their venture, in order to achieve success and sustainability. Entrepreneurs operate in a highly autonomous environment, and they frequently manage multiple potentially conflicting goals simultaneously (Nambisan & Baron 2013). Entrepreneurship takes several months or years to realize the potential of a venture, and therefore it is a long-term goal to achieve where in particular long-term goals require self-regulation (Bateman & Barry 2012). As such, one can postulate that the need for well developed self-regulatory strength or capacity in all domains of functioning is likely more important for entrepreneurs than in most other contexts in which people work.

#### 2.2.5. Measuring Self-Regulation using HRV

HRV indices which can reflect the capacity for individuals to modulate cognitive activity, emotions as well as behaviours to be able to adaptively respond to changing environmental demands, are often considered to be indicators of top-down self-regulation based on assertions from two prominent theoretical perspectives: Porges's Polyvagal Theory (Porges 2001, 2007, 2011) and Thayer's Neurovisceral Integration Perspective (Thayer et al. 2009; Thayer & Lane 2000). Both theories use evidence that pre-frontal cortical substrates of top-down self-regulation influence cardiac activity primarily through the parasympathetic section of the nervous system. Given these theories, there is considerable interest in examining HRV indices and aspects of top-down self-regulation such as emotion regulation, executive functioning, and self-control. Hundreds of studies using a range of approaches have used HRV as a biomarker of self-regulatory capacity (Geisler & Schröder-Abé 2015; Holzman & Bridgett

2017; Koval et al. 2013; McCraty & Shaffer 2015; Reynard et al. 2011; Segerstrom & Nes 2007; Zahn et al. 2016).

At the conceptual level, there has been growing recognition that many constructs invoked as being self-regulatory in nature share considerable overlap in regard to their definitions and their underlying neural, physiological, and genetic origins (Bridgett et al. 2015; Schmeichel & Tang 2015; Zhou, Chen & Main 2012). And as such top-down self-regulation is generally agreed as the combination of behavioural and emotion regulation, that when adequate, allow individuals to flexibly engage in adaptive responses, as evidenced by self-regulated behaviour, emotion, and cognition, to environmental demands (Bandura 1991; Bridgett et al. 2015). A key basis for conceptualising HRV as a biomarker of top-down self-regulation are connections between top-down neural structures and cardiac activity. Cardiac activity is dually innervated by the parasympathetic nervous system (PNS) and the sympathetic nervous system (SNS), both components of the autonomic nervous system (ANS) which itself is primarily influenced by the central autonomic network (CAN) which consists of prefrontal cortical, limbic and brainstem structures. Bidirectional activity across these neural systems produces input to the cardiac sinoatrial node through the ANS allowing for variability in heart rate (Porges 2007; Thayer et al. 2009). Although both components of the ANS influence heart rate, the PNS is considered to have a faster and more predominant effect on resting HRV (Berntson et al. 1997).

The polyvagal theory (Porges 2001, 2007, 2011) argues that the vagal tone is part of a social engagement system that had been originally developed to regulate flight/fight reactions triggered by the SNS. Due to functional connections between vagal outflow and structures related to emotion processing, attention, and communication, the social engagement system enables behavioural responses such as social communication, self-soothing, and the inhibition of physiological arousal. Respiratory sinus arrhythmia (RSA), which is closely related to trait HRV, serves an index of tonic vagal tone and according to Porges, RSA indicates an individual's ability to maintain homeostasis and responsiveness to changing demands. The Neurovisceral integration perspective (Thayer et al. 2009; Thayer & Lane 2000) posit that HRV is a proxy for the "inhibitory capacity" of the CAN that regulates behavioural, cognitive, and

emotional responses. The CAN comprises brain regions related to inhibition and executive functions such as the prefrontal cortex and is reciprocally connected with the heart as well as the periphery via PNS and SNS neural pathways. Through this neural network, the prefrontal cortex can exert inhibitory control on subcortical structures, thereby enabling the individual to flexibly and adaptively respond to situational demands.

In summary, both theories posit that higher HRV should reflect a better ability to inhibit dominant impulses and behaviours, which can be considered a key component of automatic regulatory processes (i.e. self-regulation) as well as deliberate regulation (i.e. self-control). The (excitatory) sympathetic (SNS) and (inhibitory) parasympathetic (PNS) subsystems interact to produce variation in physiological arousal. During periods of physical or psychological stress the SNS becomes dominant, increasing physiological arousal and heart rate (fight-flight reactions). During periods of stability and low stress the PNS is dominant and maintains lower physiological arousal and heart rate. HRV indexes moment by moment regulation of physiological arousal, via inhibition of the timing and intensity of a response to environmental stimuli (Appelhans & Luecken 2006; Geisler & Kubiak 2009; Holzman & Bridgett 2017; McCraty & Shaffer 2015; Zahn et al. 2016). PNS activity is known to decrease heart rate and increase HRV while SNS activity has the opposite effect, increasing heart rate and decreasing HRV. Therefore, heart rate is lowest and HRV is highest when we are in rest and fully recovered. During stressful situations when SNS activity is increased, resting heart rate is elevated and HRV is decreased. Hence, higher HRV can be considered as a biomarker of a better capability for top-down-self regulation and be an indicative measure of improved performance and wellbeing. While lower HRV, can be considered as a biomarker of decreasing capability for top-down self-regulation and be an indicative measure of poorer performance and wellbeing.

Applied research has also provided additional viewpoints on the use of HRV as an indicator of self-regulatory strength versus stress in ambulatory workplace research (Baethge, Vahle-Hinz & Rigotti 2020; Kim et al. 2018). Where during chronic stress, the SNS is hyperactivated, causing physical, psychological, and behavioural abnormalities. At present, there is no accepted standard for stress evaluation, however current neurobiological evidence from

numerous studies suggests that HRV is impacted by stress induced by various methods and supports its use for the objective assessment of psychological health and stress (Kim et al. 2018). It has also been shown HRV can be a measure of allostasis through the changing workday, where for example it has been shown that employees with higher co-worker support, on average, had a high, stable PNS and low, stable SNS level during work compared to workers with less support (Baethge, Vahle-Hinz & Rigotti 2020). The most frequently reported factor associated with variation in HRV variables was low PNS activity where HRV may be associated with the activity of a flexible network of neural structures, which are dynamically organized in response to environmental challenges (Kim et al. 2018). Therefore, HRV can be considered a tool that reflects heart activity and overall autonomic health, rather than specific stress states. Since the concept of stress includes biological and psychological factors, objective and physiological evaluations as well as self-reporting should be integrated when evaluating stress, using HRV in clinical practice (Kim et al. 2018).

#### 2.2.6. Wearable Sensors and HRV Analysis

The advent of mobile communication devices and lightweight notebooks/laptops has freed the user from the desktop but not from the ubiquity of the keyboard or touchpad but the development of unobtrusive, wearable sensors offers an opportunity for users to communicate with ubiquitous technology without any overt input device (Picard & Healey 1997). A psychophysiological representation of the user state could be collected unobtrusively and relayed to personal devices located on the person or elsewhere. These systems may be used to monitor emotional changes (Picard & Healey 1997) or health-related variables (Milenković, Otto & Jovanov 2006). Wearables have advanced to a point where off the shelf devices have been validated for use in research and scientific purposes (Garbarino et al. 2014; Ollander et al. 2016; Ragot et al. 2017). Previous research into self-regulation or emotions used primarily observational or self-report methods that have the possibility of retrospective or interpretive bias and do not capture the full picture (Davidson 2003; Mauss & Robinson 2009) or laboratory-based methods that didn't allow for real life and work measurements. The use of wearables enables the real time capture of physiological measures that can address these limitations and provide a more ecologically valid way of capturing data

on self-regulation and emotions that individuals are actually experiencing and are particularly applicable in work/life settings (Peterson et al. 2015; Poh, Swenson & Picard 2010). The challenge is that they measure physiological responses which need to be interpreted cautiously and responsibly (Malhi et al. 2017; Westerink, Krans & Ouwerkerk 2011).

As research and theory support the utility of HRV as a non-invasive, objective index of the brain's ability to organise regulated responses through the ANS and as such are a marker of individual differences in self-regulatory capability (Appelhans & Luecken 2006), this data can be collected with wearable devices over long durations and in real work and life settings. HRV is measured using electrocardiography (ECG) or photoplethysmography (PPG) to obtain interbeat intervals (IBIs) which reflect the temporal distance between R-spikes (R–R intervals) marking contractions of the heart's ventricles caused by depolarisations of the sinoatrial node. Analysis used to compute HRV are separated into three main classes: statistically derived indices, frequency-derived indices, and geometrically derived indices (Appelhans & Luecken 2006; Berntson et al. 1997). Statistically-derived indices, also referred to as time-domain indices, are computed directly from the R–R intervals through application of statistical computations in order to yield information pertaining to variance of the IBIs. The most common measure is the root mean square of successive differences between normal heartbeats (RMSSD) which is obtained by first calculating each successive time difference between heartbeats in milliseconds (ms). Then, each of the values is squared and the result is averaged before the square root of the total is obtained. In contrast to statistically derived indices, frequency-derived indices partition heart rate variance at different frequencies within the power spectral density band and provide estimates of HRV within specified frequency bands. The high frequency component (HF HRV) occurs between 0.15 HZ and 0.40 HZ for adults and primarily reflects the activity of the PNS while the low frequency band (LF HRV) occurs between 0.04 Hz and 0,15 Hz and indexes a combination of SNS and PNS activity. As HF HRV indexes moment by moment regulation of response to stimuli a higher HF HRV is associated with greater moment by moment self-regulation (Appelhans & Luecken 2006; Sütterlin et al. 2011).



The time domain measure of RMSSD and the frequency domain HF HRV power measure are considered to be highly correlated time and spectral measures of HRV (Kleiger, Stein & Bigger 2005; Shaffer & Ginsberg 2017; Task Force 1996) and while frequency-derived indices are considered to provide a relatively more “pure” estimate of vagally-mediated PNS functioning (Berntson et al. 1997) than time based measures the influence of respiration rate on frequency based measures such as HF HRV is uncertain (Penttila et al. 2001). RSA is the naturally occurring variation in heart rate that occurs during the breathing cycle and is directly proportional to HRV where RMSSD is less affected by respiration across several tasks (Hill et al. 2009) and typically provides a better assessment of RSA than other measures including other time based measures such as standard deviation of NN intervals (SDNN). The HRV Task Force (Task Force 1996) provides recommendations on HRV measurement periods used in studies. More recently research has shown correlation between shorter measurement periods - ideally 60 seconds – and typical 5 min readings in the trend of RMSSD measures and may further increase the potential use of HRV in field settings, for example with athletes in response to stress in performance settings (Esco & Flatt 2014; Shaffer & Ginsberg 2017) which could be in future applied to entrepreneurship research.

### 3. Conceptual Development

*“Timing, perseverance, and ten years of trying will eventually make you look like an overnight success.” -Biz Stone, founder of Twitter*

#### 3.1. Dynamic Action Environment Context of the Entrepreneur Journey

Entrepreneurship can be a long and lonely journey with ups, downs and unexpected challenges, sacrifices, and rewards from the inception of an idea through to the day the entrepreneur exits from the venture (Shane 2003; Shepherd & Patzelt 2015). The nature of the entrepreneurial journey and the dynamic context in which actions take place shapes the relationship between entrepreneurial actions and the experiences of the entrepreneur over time. These dynamic person-by-situation interactions and processes of within-individual change incorporate the individual development, learning, and adaptation of the entrepreneur through their journey (Gorgievski & Stephan 2016; Shepherd 2015). McMullen and Dimov (2013) described the journey in terms of information, highlighting how and when information is acquired is likely to affect the ideas that are generated, the goals that are selected, the behaviours engaged in, and ultimately the outcomes attained. And therefore consequently, entrepreneurs and other agents in the system strive to reach their motives and goals by integrating new information they acquire during the journey. As such entrepreneurs need to manage and optimise their work environment proactively.

The activities and actions of entrepreneurs are critical in the emergence of new ventures and a number of large international research projects including the PSED have attempted to understand entrepreneurial action (Davidsson & Gordon 2012; Gartner et al. 2004; Reynolds 2016). Numerous studies demonstrate that although there is a range of activities and actions that entrepreneurs do, there is no specific sequence or order in which these are taken (Arenius, Engel & Klyver 2017; Gartner & Shaver 2012; Lichtenstein et al. 2007). And the characteristics of the activities or actions are an important determinant of performance at the individual level (Shanteau 1992). For example, when deciding on the amount of effort to exert on a particular activity the entrepreneur makes judgments, based on his/her perceptions, of the fit between the likely completion of that activity and achieving desired

end-states or goals. The individual will also have highly individualised approaches to whether they find the particular activity or action environment to be challenging, uncertain or routine. Different activities, will result in different effort allocation decisions because the characteristics such as whether they are exploratory, exploitative, judgment or action oriented will vary, and consequently perceptions of likely activity completion and fit with goals vary (Trevelyan 2011). Recent conceptualisations suggest job crafting as a process by which individuals initiate and create change in their work over time (Bruning & Campion 2018). And it is argued that the very essence of entrepreneurship is the ability of entrepreneurs to craft and create their own jobs, tasks and roles in the development and running of their ventures where how entrepreneurs manage and organize themselves can shed light on their motivations and entrepreneurial outcomes (Baron 2010).

A characteristic of entrepreneurs' work is high uncertainty (McMullen & Shepherd 2006; Rauch, Fink & Hatak 2018) which makes it unclear at the beginning of an entrepreneur's workday which tasks they will do and how and when their action environment will change. For example, some days might involve intense coordination and direction of team members or partners including managing challenging interpersonal relationships where others may be more focussed on deep cognitively demanding analysis and conceptual problem-solving. As each entrepreneur's skills, experiences and preferences are different such uncertainty results in high variability in the levels of entrepreneurs' work stressors for that individual from one day to the next. The implication is that for entrepreneurs, conscious self-regulation decisions are needed based on entrepreneurs' understanding of and attitudes to the activity characteristics and their goals. As an example, based on individual preferences self-regulatory compensation may involve consciously putting more effort into uncertain and challenging tasks, or asking others to engage in supporting these challenging or uncertain tasks. The entrepreneur may also approach or compensate differently for tasks that are normal or routine or where an activity involves interaction with other people and/or may be flustered or inexperienced in tackling different types of setbacks or receiving negative feedback. As the demands of the action environment are constantly changing through the day and along the journey the challenge for the entrepreneur is to be self-aware of their biases and preferences so they are able to use self-regulation to compensate for them (Russo & Schoemaker 1992;

Trevelyan 2011) making some entrepreneurs better at managing their work environment than others.

As the entrepreneur engages with their action environment; what they are thinking, feeling, and doing will change, and how they manage themselves and their environment will change, and it continues to change as the entrepreneur navigates their day-to-day journey. The dynamic nature of the entrepreneur journey means there is a need to understand the changing person-by-situation interactions and broader action environment in which the entrepreneur is navigating. This is particularly relevant to entrepreneurship research because of the heterogeneity of entrepreneurs and the entrepreneurial start-up process as concluded by Gartner and Shaver (2012) “generalizable findings (main effects) that encompass ‘all entrepreneurs’ across all ‘kinds of firms’ in all ‘kinds of environments’ have been scarce—if not non-existent”. This is supported by Reynolds’s (2016) conclusion that there is “considerable variation in the nature and sequence of start-up activities that are initiated” by entrepreneurs. To avoid the mistake of drawing inferences of intraindividual differences from interindividual differences, repeated measurements of the same individual are needed (McCormick et al. 2020). With repeated measurements of the single individual drawing insights of behavioural change and processes is possible where the drawback is that generalisability to a population of subjects is not possible until replications have been conducted across multiple subjects (McCormick et al. 2020).

### **3.2. Conceptualising the Entrepreneur Bubble**

The word bubble has many meanings but for this purpose is a popularised way of describing an environment or sphere of context in a range of different ways. Applied to people, a bubble is sometimes an enclosed or isolated sphere of experience or activity. The saying “living in a bubble” implies that you are living in your own world or environment – your very own reality. Bubbles for the most part are translucent, so someone who lives in a bubble can see what goes on around them but is somehow sheltered and in their own world. Another saying “to burst someone’s bubble” can be to cause someone to suddenly realize that something believed, trusted, or admired is not really true or good. Conceptually therefore the word bubble can apply to any person and everything in their cognitive reality, including

the context and environment, in which the individual sees themselves. It is not a fixed construct and can change as the individual changes as they go about their lives.

Social cognitive theory (Bandura 1986, 2012) introduced the interaction of personal, behavioural and environmental triadic processes where people's development is a life-long process (Baltes & Baltes 1986). In this model of reciprocal causation, behaviour; cognition, affect and other personal factors; and environmental influences all operate as interacting determinants that influence each other bidirectionally. This concept of interactionism does not mean that the different sources of influence are of equal strength, occur simultaneously or are stronger than others. People are also agents of experiences rather than simply undergoers of experiences (Bandura 2001). The sensory, motor, and cerebral systems are tools people use to accomplish the tasks and goals that give meaning, direction, and satisfaction to their lives (Bandura 1997; Harré & Gillett 1994). By regulating their motivation and activities, people produce the experiences that form the functional neurobiological substrate of symbolic, social, psychomotor, and other skills where the nature of these experiences is, of course, heavily dependent on the types of social and physical environments people select and construct (Bandura 2001).

Therefore, the entrepreneur bubble represents everything in the entrepreneur's cognitive reality in pursuit of their goals. The bubble is purely a conceptual construct as a descriptor of the environment of the entrepreneur and the dynamic interactions between people (personal factors), their behaviour, and their environment. Bandura's concept of interactionism has not been used itself because the bubble construct is meant to be both descriptive and philosophical in relation to how the entrepreneur sees and works within their own individually constructed environment. Descriptively the word bubble helps represent the challenges of the entrepreneur is managing in their own context and that these challenges can impact or burst the bubble of the entrepreneur influencing performance and wellbeing.

As a conceptual construct it can apply to any entrepreneur and represent the spectrum of different approaches to how they construct and go about achieving their goals on their entrepreneurial journey. Existing theories of entrepreneurship can collectively explain much of the bubble construct for the entrepreneur and be positioned within it conceptually. Prior

work on social capital, social skills and social competence, self-determination theory, socially-situated cognition, entrepreneurial decision making, entrepreneurship as experience, theory of planned behaviour, can explain the cognitive reality of the entrepreneur in different parts and for example the theory of planned behaviour (Krueger & Carsrud 1993) speaks to entrepreneurial behaviours and intentions but does not explicitly discuss the environment and uncertainty in the environment, where socially-situated cognition (Mitchell, Randolph-Seng & Mitchell 2011) does, enabling entrepreneurs to construct the image of the venture, while acting in their physical and social environment.

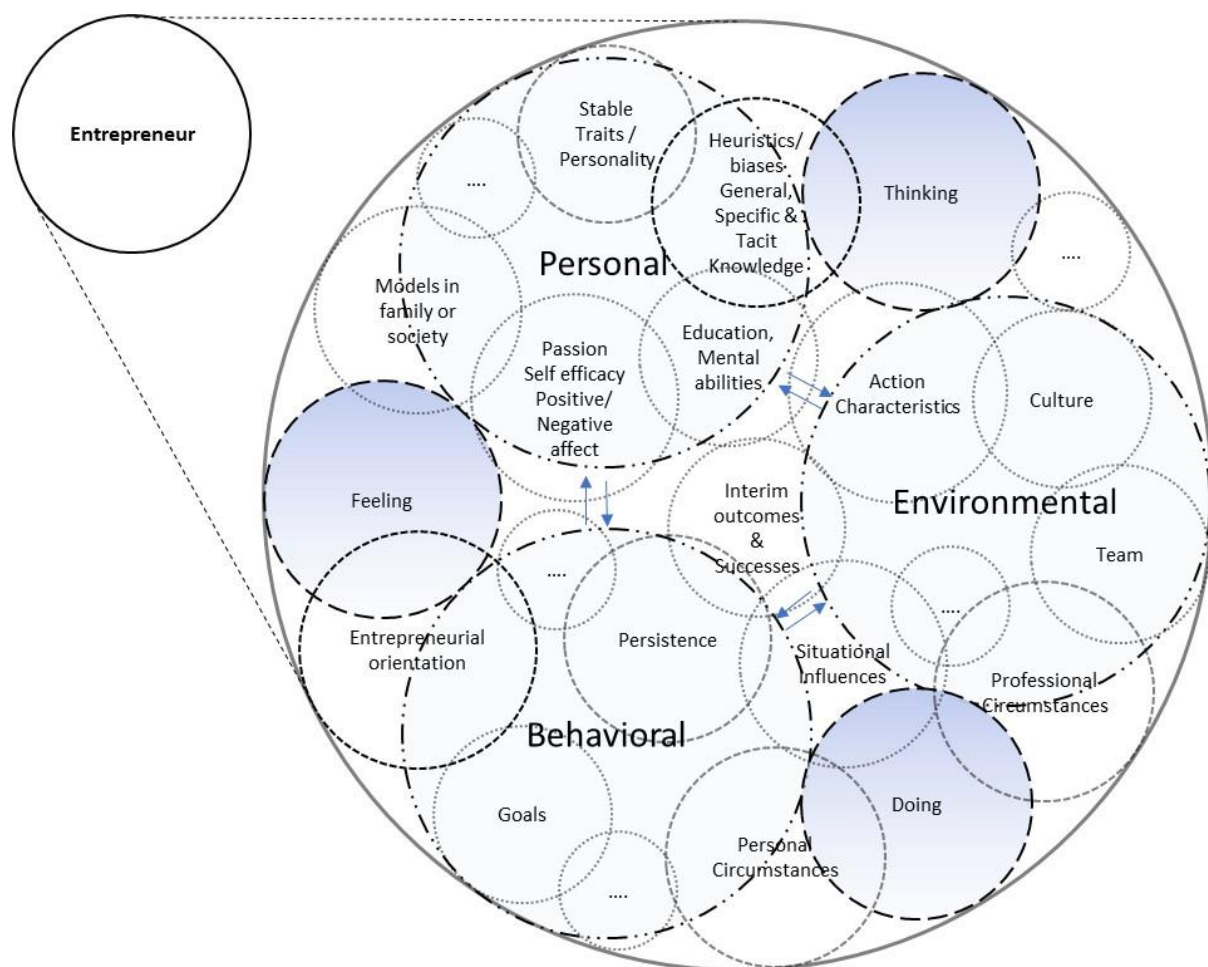


Figure 3-1: The Entrepreneur Bubble – Indicative Components

In conceptualising the entrepreneur bubble, the three components of social cognitive theory (Bandura 1986, 2012), personal, behavioural and environmental, are used as the broad categories of determinants that are interacting and shape the thinking, feeling and doing of the individual entrepreneur. Figure 3-1 shows this conceptualisation and details an indicative

list of the type of sub-components that are involved but is not intended to be an exhaustive or complete list as the bubble is a conceptual representation of the sphere of context of the individual entrepreneur.

### **3.3. Self-Regulation as Management of the Entrepreneur Bubble**

Understanding the nature of human selfhood and personal identity has been a preoccupation of multiple fields of inquiry. Regulating itself is not just one more thing that the self does, it is often a basic part of almost everything the self does (Baumeister 2016). In other words, how the self regulates itself is key to understanding the self. In this research we use self-regulation as the mechanisms of entrepreneurs to self-manage and constantly shape and reshape their entrepreneur bubble in pursuit of their individual and venture goals. Each entrepreneur's journey and relationship to their ability to self-manage their bubble for their performance and wellbeing is different and individually unique. Self-regulation strength is the capacity of individuals to guide their activities over time and across changing circumstances (Diefendorff & Lord 2008; Kanfer 1990) and the individual capacity to self-regulate is a limited resource, which can temporarily become depleted (Baumeister & Vohs 2007; Gailliot & Baumeister 2007) where the state of reduced self-regulatory strength or capacity stemming from prior exertion of self-control is dubbed ego depletion (Baumeister et al. 1998).

The original depletion theory was that some limited resource is used for self-regulation and thereby becomes depleted, leaving less available for subsequent tasks and demands. The well-replicated decline in performance caused by initial self-regulatory exertion (the basic depletion effect) was assumed to reflect lack of energy needed for self-regulatory processes but this has since been amended to indicate that significant resources remain but were being conserved (Baumeister 2016; Baumeister, Tice & Vohs 2018; Muraven, Shmueli & Burkley 2006). The strength model bears some resemblance to folk notions of "willpower," a presumptive source of energy that can be devoted to some undertaking or withheld according to conscious decisions by the individual (Baumeister 2016). The power aspect of willpower may derive from the subjective impression that some temptations are stronger than others, so that the self requires equal or greater strength in order to resist or manage successfully. The assumption is that acts of self-control tax one's strength or deplete one's resources, and

that afterward there is a period of reduced capacity for further self-regulation (Baumeister & Vohs 2016) much like a muscle that gets tired (Baumeister, Tice & Vohs 2018) reflecting the cutting back of exertion to conserve its remaining energy (as it does with physical exertion). Strength meant, first and foremost, that after exerting self-control, subsequent acts of self-control, even in different contexts, would suffer but just as muscles become stronger with exercise, self-control could be improved by frequent exertions, as studies found (Baumeister et al. 2006).

Self-regulation strength can be depleted by emotional, cognitive, or behavioural factors caused by different activities and manifested by challenge in others. For example, an entrepreneur may struggle with prioritisation or communication of necessary actions for themselves and their team; face pressures relating to cash flow and paying of bills; and be challenged in their attempt to convince potential customers of the benefits of their product or service when they are a new entrant in a market. Stress, fatigue, intrusive negative feelings, and self-doubt deplete self-regulatory capacities (Baumeister & Heatherton 1996; Maranges, Schmeichel & Baumeister 2017). While our capacity for self-regulation can recover and be restored with glucose, rest, and/or positive emotions and purpose (Gailliot & Baumeister 2007). For example, an entrepreneur who has clear purpose, works in a supportive, well balanced and high performing team that is meeting or exceeding their objectives, while balancing work and life to ensure they get the required nutrition, exercise, and sleep for themselves. Improving self-awareness and self-management of the individual cycles of depletion and recovery of self-regulation strength implies opportunities for entrepreneurs to improve their individual performance and wellbeing.

Self-regulation is thus costly in the short run and subject to fluctuations in capacity, which would underpin within-person variations in self-regulatory performance (Baumeister & Vohs 2016; Baumeister 2016). Researchers across many fields have recognized the power and utility of these ideas for explaining an immense diversity of human behaviour patterns even when the exact explanations of the processes have been challenged (Baumeister, Tice & Vohs 2018). And while the strength model characterises a person's capacity for self-regulation as a fluctuating state there are also trait aspects to self-control, in the sense that some people are



habitually better than others at self-control. These differences may reflect different quantities of self-regulatory energy, different strategies for using it effectively, more effective monitoring of behaviours that one seeks to regulate, higher motivation to conform to self-regulatory standards, or other possible factors which are all very specific to the individual (Baumeister 2016). The importance of self-regulatory processes in the entrepreneurship domain has been recognised in numerous studies and an entrepreneur's self-management towards their goals in the context of their performance and wellbeing is particularly important (Baron 2012; Bateman & Barry 2012; Frese & Gielnik 2014; Haynie & Shepherd 2009; Nambisan & Baron 2013). Therefore, by exercising self-regulation entrepreneurs can operate generatively and proactively, not just reactively, to shape the character of their goals and the context they work in. In other words, shaping and reshaping their entrepreneur bubble to improve their performance and wellbeing.

### **3.4. Managing the Bubble for Performance and Wellbeing**

Entrepreneurs feel the pressure to perform based on the belief that striving for performance excellence is needed and that performance efforts will be scrutinised and tied to significant consequences (Gardner 2012; Gutnick et al. 2012). For the entrepreneur, the mix of expectations of higher performance and relevant consequences creates a tension or urgency to perform well (Baumeister 1984; Lazarus 2000) where the subjective experience of performance pressure is internalised, creating arousal and is an activator of the stress process (Gutnick et al. 2012; Lazarus 2000). Performance pressure is ongoing through the journey of the entrepreneur as they grow their venture and on a daily basis may be appraised as a threat, which promotes self-regulation depletion that explains dysfunctional behaviour; or may also be appraised as a challenge, which elicits engagement that explains enhanced task proficiency and citizenship (Mitchell et al. 2019). Because performance pressure can produce paradoxical reactions, how entrepreneurs handle this pressure influences their performance and wellbeing. Stress reactions are influenced by individuals' stable characteristics where trait resilience influences how individuals appraise and cope with stressors across time (Glantz & Johnson 2002; Lazarus 1966) and adaptive self-regulation enables individuals to manage stress (Muraven & Baumeister 2000; Muraven, Tice & Baumeister 1998). Under these

changing and challenging conditions, the entrepreneur needs to manage their bubble to be effective.

Self-regulation research has shown its utility as an indicative physiological measure of performance and wellbeing (Baumeister 2003; Forgas, Baumeister & Tice 2009). As a measure of self-regulation capacity; theory and studies (Hagger et al. 2010; Holzman & Bridgett 2017; Zahn et al. 2016) have linked greater HRV to the use of adaptive regulation and coping strategies for better performance and wellbeing and reduced HRV with various outcomes indicative of poor performance and wellbeing such as anxiety, depression, and rigid attentional processing of threats or challenges. Each individual regulates their thinking, feelings, and actions differently so HRV analysis has great potential to illuminate the role of individual differences in self-regulation and consequently performance and wellbeing in the pursuit of their entrepreneurial journey. And as self-regulation can improve over time with practice, (Gailliot & Baumeister 2007; Hofmann, Schmeichel & Baddeley 2012; Muraven, Baumeister & Tice 1999; Tice et al. 2007) it implies that through education and support that the self-regulation of entrepreneurs and therefore their effectiveness can be improved (Brockner, Higgins & Low 2004; Bryant 2006, 2007; Pihie & Bagheri 2013; Tumasjan & Braun 2012). It follows that each entrepreneur could learn to practice and maintain their self-regulation strength based on their individual understanding of their bubble and how they interact with their action environment. For example, it may be the case that serial entrepreneurs because of their experience are better at managing their bubble than inexperienced nascent entrepreneurs who have no or limited experience of the required self-regulation through challenging action environments they will encounter. That is experienced entrepreneurs may react differently to organisational, industry, or institutional cues than novices, for example, being less susceptible to recency bias and other forms of irrational behaviour (Foss, Klein & Bjørnskov 2019).

Research on entrepreneur performance and wellbeing is predominantly conducted cross-sectionally and from a between-person perspective (considering differences in averages across entrepreneurs) which neglects the change over time which this study explores through a within-person approach. As an example, of the 144 studies in a review of entrepreneurs'

mental health and wellbeing (Stephan 2018), only three adopted a within-person perspective that can identify short-term changes in wellbeing (Foo, Uy & Baron 2009; Totterdell, Wood & Wall 2006; Uy, Sun & Foo 2017). But as we know the link between the feelings, thinking and behaviours of entrepreneurs and their performance and wellbeing can be complex and the extent to which contextual factors such as economic, cultural, and social resources impact these links is not clearly understood. Thus, even though prior research (Stephan 2018; Wach et al. 2018) offers insights on valued success criteria and wellbeing outcomes for entrepreneurs, it is not clear whether individual entrepreneurs measure outcomes with the same metrics and how these expressions of effectiveness change through the entrepreneurial journey over time.

As the individual goals that entrepreneurs set for themselves can vary widely (Jayawarna, Rouse & Kitching 2013; Reynolds & Curtin 2008; Stephan, Hart & Drews 2015), individual level study offers many possible dependent variables for effectiveness that incorporate performance and wellbeing outcomes and provide opportunities for future research studies that relate the characteristics of the individual to individual level outcomes (Davidsson 2008). Relevant examples could include personal financial success, specific goal achievement, learning, achieving a particular lifestyle or wellbeing objective, satisfaction in many dimensions, and changes in values, motivations and attitudes (Van Gelderen, Kautonen & Fink 2015). Entrepreneurial satisfaction might be viewed as a basic measure of entrepreneur performance (Cooper & Artz 1995) as it may influence decisions by individual entrepreneurs about whether to invest more time and money, whether to cut back, or whether to close down a venture. It may also influence whether entrepreneurs work effectively towards their goals and how they engage with their customers, partners, and employees. Determinants of satisfaction are very individualised based on the individual's goals and expectations. Progress towards an entrepreneur's goals and more broadly goal achievement is also a subjective and individualised concept referring to the realisation of desired outcomes and the avoidance of undesired outcomes (Schulz & Heckhausen 1996).

As values are motivational goals that guide individual attitudes and behaviours (Fischer & Boer 2016), it can be argued that the success criteria valued by entrepreneurs are equivalent

to those they use in assessing their actual achievements. In the context of the entrepreneur journey an understanding of the entrepreneurs' subjective assessment of their effectiveness including satisfaction and excitement in being an entrepreneur, effort and progress towards their goals as an entrepreneur and how stressful and rested they are each day as entrepreneurs provides a useful comparison to the indicative physiological self-regulation measure of performance and wellbeing and to provide further insights into the journey and the attitudes and behaviours of the entrepreneur over time. Wellbeing may be both a determinant of and outcome of the entrepreneur's performance and therefore the subjective effectiveness measures can have both a positive and negative framing in their impact on wellbeing. Positively it could help to stimulate creativity, a growth mindset, and flourishing (Fredrickson 2001; Keyes 2013; Ryff 2019; Wiklund et al. 2019) which are all important outcomes for entrepreneurs. Yet it is known that entrepreneurs' work settings also entail many stressors that suppress positive wellbeing and therefore how stressful the day of work has been for the entrepreneur can be a broad indicator of this.

### **3.5. Conceptual Framework**

Prior entrepreneurship research has tended to diminish the role of time in the entrepreneurial process by studying entrepreneurship as an act, as opposed to a journey that explicitly transpires over time (McMullen & Dimov 2013). To explore the interaction of the action environment on the self-regulation of the individual entrepreneur and influence on their effectiveness in a time sensitive way a conceptual framework is outlined in Figure 3-2 which builds on the literature reviewed. Time can be moment to moment or day to day in order to explore the interactive and cumulative changes as the framework allows for a wide-ranging exploration of the entrepreneurial journey in order to answer the research question: How does the changing entrepreneurial journey influence the entrepreneur's self-regulation?

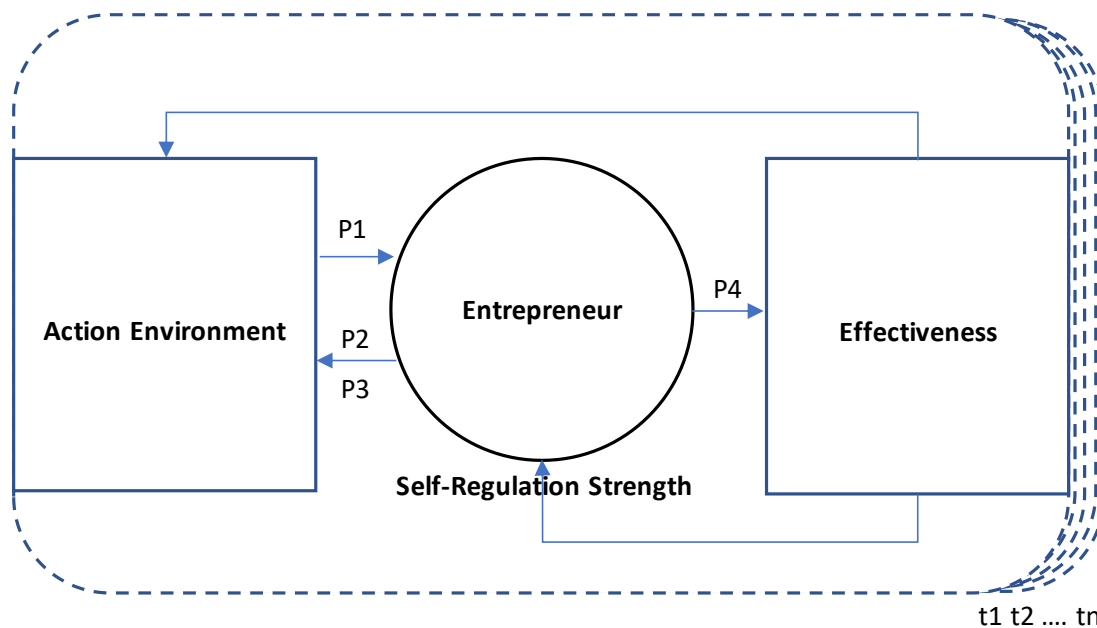


Figure 3-2: Conceptual Framework

Entrepreneurship cannot be explained solely by reference to a characteristic of certain people independent of the situations in which they find themselves (Shane & Venkataraman 2000). Entrepreneurs therefore must respond to constantly changing situational and contextual cues as they navigate their entrepreneurial journey. This constantly changing action environment being the situations that the entrepreneurs find themselves in during their day-to-day journey. Entrepreneurs navigate their day-to-day journey where choice and change of actions is constantly taking place in an attempt to balance potentially conflicting short-term and long-term goals. The entrepreneur bubble is constantly changing and represents the entrepreneur and what they are feeling, thinking, and doing in pursuit of their goals, the environment in which they work and the experience, capabilities, personal and professional circumstances they bring with them. And how effective they feel in pursuit of their goals will also change.

Self-regulation strength as the ability over time to monitor and control the self (Baumeister & Vohs 2016; Baumeister & Alquist 2009; Baumeister & Heatherton 1996; Baumeister & Vohs 2007) is a representation of how well the entrepreneur is managing themselves and their entrepreneur bubble and is an indicative physiological measure of their performance and wellbeing. The entrepreneur bubble as measured by self-regulation strength is in a constant state of change, shaped and reshaped by the changes in the action environment.

***Proposition 1: The action environment has an effect on the entrepreneur's self-regulation strength.***

Self-regulation research has shown that the many and varied actions and activities that are part of the entrepreneur journey can be depleting of self-regulation strength. The entrepreneurial action environment and activities of entrepreneurs are such that they are prone to deplete self-regulation strength. Alquist, Baumeister and Tice (2016) found that going through uncertain situations is depleting of self-regulation strength. Uncertainty is a central element of the entrepreneurial journey and individuals vary in their perception of such uncertainty, and in their aptitudes and capacities to deal with and manage it (Katz & Corbett 2019; Kirzner 1973; Markman 2007; McMullen & Shepherd 2006). Entrepreneurs' planning is an advanced form of volition that depends on deliberate control of actions and use of ideas to guide behaviour and meaningful integration of acts and events across time (Van Gelderen, Kautonen & Fink 2015; van Gelderen et al. 2018). Planning, making decisions and choices is part of the daily fabric of entrepreneurs and is depleting of self-regulation strength (Baumeister et al. 1998; Baumeister, Tice & Vohs 2018; Bruyneel et al. 2006). Entrepreneurs must make multiple and varied decisions under the condition of uncertainty, with limited information where the consequences of the decisions are unknown and have a significant impact on themselves and their ventures. And so, in each and every decision-making process, being effective plays a central role to produce desired results where it is safe to conclude that performing entrepreneurship is an activity which depletes self-regulation strength.

Managing emotions is depleting of self-regulation strength where even nonconscious, nondeliberate processes that alter emotional states, such as damping negative affect can be depleting (Pu, Schmeichel & Demaree 2010). Entrepreneurs ride an emotional rollercoaster as part of their journey where regulating emotions to bounce back from setbacks and disappointments is important for success (De Cock, Denoo & Clarysse 2020). Research has linked entrepreneurial action with positive emotional outcomes (Baum & Locke 2004; Cardon et al. 2009; Cardon et al. 2005), negative emotions (Patzelt & Shepherd 2011), and the co-existence of high positive and high negative emotions (Fong 2006). As an example, performing activities as part of the entrepreneurial journey can lead to experiences of passion "a

consciously accessible, intense positive feeling” (Cardon et al. 2009); excitement, happiness and flow (Schindehutte, Morris & Allen 2006); and job satisfaction (Thompson, Kopelman & Schriesheim 1992) as well as through the risk and uncertainties cause fear and anxiety (Boyd & Gumpert 1983); loneliness and social isolation (Akande 1994); frustrations (Du Toit 1980); and grief (Byrne & Shepherd 2015). Hence performing entrepreneurship is emotionally laden and can consume self-regulation strength.

***Proposition 2: Periods of depleted self-regulation indicate entrepreneurs are performing more challenging or demanding activities.***

By exerting self-regulation entrepreneurs can manage their thinking, feeling, and doing in a variety of ways in order to be effective in their performance and wellbeing (Baron 2012; Bateman & Barry 2012; Frese & Gielnik 2014; Haynie & Shepherd 2009; Nambisan & Baron 2013). People who can self-regulate tend to think before they act and in an entrepreneurial context these qualities can help entrepreneurs consider challenges as opportunities to learn and improve their future efforts, allow entrepreneurs to adapt their responses and emotions according to different situations and adapt to change. It follows that entrepreneurs use self-regulation to be able to navigate their entrepreneurial journey effectively. And as entrepreneurship actions matter, how effective the entrepreneur is in each and every action plays a role in producing desired results.

These interactions with the action environment in the moment can indicate which actions or activities an entrepreneur is positive or negative about and when they are more or less effective, both perceived and actual. Mood maintenance hypothesis (Isen 1984) states that entrepreneurs would choose activities that support their attempt to maintain a positive state; and thus may not choose activities that are associated negatively. This has been further reinforced by studies looking at job related affects and behaviours (Warr et al. 2014). For example, entrepreneurs may choose to spend more time on their product design and development, searching for minor improvements, to maintain a positive state rather than calling or engaging with potential customers or partners to drive sales or get feedback on their product which has the potential to be negative. This could have implications for the performance of the individual entrepreneur as well as the start-up venture, as start-up

activities in general matter and some activities might be more important than others at the various stages of start-up development (Delmar & Shane 2003).

***Proposition 3: Periods of self-regulation recovery indicate entrepreneurs are performing more routine or comfortable activities.***

Self-regulation is also described as cyclical because the feedback from prior performance is used to make adjustments during current efforts (Zimmerman 2000). Such adjustments are necessary because personal, behavioural and environmental factors are constantly changing (Carver & Scheier 1981; Zimmerman 2000). Entrepreneurs have different individual ability to regulate their entrepreneurial thinking, feeling, doing because of different levels of their own self-awareness of their entrepreneur bubble and its changing nature. The entrepreneur has the potential to be more effective if they self-manage their bubble well and as such the individual entrepreneur navigates a continuum of their own individual effectiveness as they navigate the changing action environments along their entrepreneurial journey. It also follows that entrepreneurs who are more effective may work smarter in reaching their goals, eliminating unnecessary effort, and wasted time. The ability of the entrepreneur to self-manage their bubble and the cycles of depletion and recovery of self-regulation strength that occur has an influence on their effectiveness.

When people are not depleted and they remain in more or less full possession of their powers to self-regulate, their actions are guided by their conscious, explicit attitudes rather than unconscious ones (Baumeister & Vohs 2016; Baumeister 2016; Baumeister, Tice & Vohs 2018). The impact of depleted self-regulation strength can be varied in the moment as well as over time. One general effect of depletion is to increase a range of impulsive, disinhibited behaviours. Self-regulation depletion weakens control over thinking, feeling and behaviours, allowing automatic or unconscious processes to influence behaviour. For example, depletion makes people more passive and so they rely on default responses. It is also linked to intensification of subjective feelings where depleted persons report their emotions as stronger than otherwise (Vohs et al. 2014). And after exerting self-control, decision-making is impaired, in the sense that people shift to low-effort styles of deciding (Pocheptsova et al.



2009). Therefore during depletion, impulsive behaviour is increased and inhibition of poor behaviour is decreased risking effectiveness (Baumeister 2016).

Entrepreneurs that do not self-regulate well may enter an ongoing cycle of self-regulation strength depletion as they are less effective and must waste effort and time to keep up with goals which has the potential to cause further negative health, wellbeing, and performance impacts (Baumeister 2003; Forgas, Baumeister & Tice 2009). Depletion exists on a continuum from mild to extreme (Baumeister, Tice & Vohs 2018) where the more intense depletion should yield more intense effects. This for example could include increased stress or ultimately burnout as broadly ineffective self-regulation predicts poor physical and emotional health, and other life problems (Baumeister, Heatherton & Tice 1994; Tangney, Baumeister & Boone 2004).

***Proposition 4: Overtime, cumulatively, if there is more depletion and not enough recovery of self-regulation the entrepreneur's effectiveness is negatively impacted.***

There has been some research connecting entrepreneurs to higher levels of stress and poor wellbeing (Harris, Saltstone & Fraboni 1999; Teoh & Foo 1997; Wincent & Örtqvist 2009) than other work settings; caused by high business risk (Douglas & Shepherd 2002) and high workload (Eden 1975; Harris, Saltstone & Fraboni 1999) faced by entrepreneurs. There has also been some research suggesting that burnout is a significant concern for entrepreneurs (Duran-Whitney 2004; Wincent, Örtqvist & Drnovsek 2008), where stress and fatigue when unrelenting, as it can be for the entrepreneur, can lead to a host of negative physical and psychological outcomes, including hypertension, arteriosclerosis, and job burnout (Boyd & Gumpert 1983). Cumulative effects involving prolonged, strenuous exertion of self-regulation is much more difficult for entrepreneurs to overcome, where entrepreneur's performance and wellbeing may be diminished impacting their effectiveness despite interventions to restore self-regulation.

Performing entrepreneurship is a prolonged activity and as such the cumulative or ongoing effects are of particular importance to entrepreneurs because the entrepreneur journey unfolds over time where information overload, high uncertainty, high novelty, strong

emotional involvement, high time pressure and fatigue are all conditions that entrepreneurs face more regularly than non-entrepreneurs (Baron 1998). The entrepreneurial journey has sometimes been described as an emotional rollercoaster or a grind like running a marathon where changes in the entrepreneur's performance and wellbeing can have significant impacts on the venture itself, as well as the team and personal contexts of the entrepreneur.

## 4. Research Design and Methodology

*“All humans are entrepreneurs not because they should start companies but because the will to create is encoded in human DNA.” -Reid Hoffman, founder of LinkedIn*

### 4.1. Research Design

In this study an exploratory approach to the research design and methodology is taken utilising a positivism research philosophy in order to investigate the dynamic person-by-situation interactions of entrepreneurs over time. Research can be designed to fulfil either an exploratory, descriptive, explanatory or evaluative purpose, or some combination of these (Saunders, Lewis & Thornhill 2016). This study is primarily exploratory to discover what is happening and gain insights into how the action environment is influencing an entrepreneur's self-regulation. Positivism relates to the philosophical stance of the natural scientist and entails working with an observable social reality to produce descriptive and predictive principles and rules for a reality that exists independently of an observer or participant (Saunders, Lewis & Thornhill 2016).

A within-person multiple case study design is used which emphasises that individuals' states, behaviours, and environments change over time. Individuals are not static entities but change from one moment to the next revealing how management phenomena unfold over time that are not possible with a between-person perspective (McCormick et al. 2020). The study of within-person fluctuations also provides insight into the dynamics of work and wellbeing and furthers the understanding of performance on a day-to-day basis (Xanthopoulou, Bakker & Ilies 2012) which should be applied to entrepreneurship (Stephan 2018; Wach et al. 2020; Wiklund et al. 2019). In order to investigate within-individual processes, a minimum of three measurement moments is required to model individual growth curves (Liu et al. 2016) but the benefit of technologies such as wearable sensors is that real time data collection provides for ongoing analysis.

A multiple case-study approach is used to provide detailed analysis of each of the individual entrepreneurs and their journey over time enabling intense exploration so that knowledge

about individual processes and behaviours can be investigated, which are sacrificed in group designs (Price et al. 2017). Case studies can accommodate a rich variety of data sources both qualitative and quantitative (Eisenhardt & Graebner 2007; Price et al. 2017; Yin 2014) and multiple case studies provide a stronger base for broader exploration of research questions and theory building enabling comparisons that clarify whether emerging findings can be replicated by several cases (Eisenhardt & Graebner 2007; Yin 2014). Cross-case analysis is used to structure the cases to facilitate synthesis and explore consistency of relationships within and across cases (Eisenhardt 1989; Yin 2014).

Wearable sensors are used to collect quantitative physiological data in real-life settings and HRV software is used to interpret the self-regulation of participants (Geisler & Schröder-Abé 2015; Holzman & Bridgett 2017; Koval et al. 2013; McCraty & Shaffer 2015; Reynard et al. 2011; Segerstrom & Nes 2007; Zahn et al. 2016). ESM via a mobile phone app is used to repeatedly collect participants qualitative responses on activities they are pursuing and their subjective effectiveness as they go about their day (Stone & Shiffman 1994; Stone et al. 2007). This data is contextualised further through discussions with the entrepreneurs and sharing of calendar, to do list, regular routine, and other information from the entrepreneur. This mixed qualitative and quantitative method supports broad exploration of the research question to gain insights and context into what the entrepreneurs are doing, thinking and feeling where patterns, resemblances and regularities in the data collected and analysed from a variety of sources is used in order to reach conclusions (Eisenhardt & Graebner 2007; Hallebone & Priest 2009; Price et al. 2017).

#### **4.2. Research Population and Sampling**

The idea of observing entrepreneurs' daily actions and experiences to understand the entrepreneur's thinking, feeling, and doing throughout their entrepreneurial journey cannot be easily and readily executed without access to their daily thoughts and records of their activities. It would be ideal to observe multiple entrepreneurs during their journeys but doing so every moment, every day and over weeks or months on end is not feasible. In 2018, data was collected in repeated two-to-four-day measurement periods (excluding nighttime recordings) from over 30 participants across two groups as part of a 12-week early-stage

incubator program. The challenges in engaging entrepreneurs for long duration data collection and the resulting learnings and refinements in data collection helped inform the direction of this thesis starting with one of the entrepreneurs from the incubator program requesting to use the wearable and provide data on an ongoing basis. This entrepreneur participated in two one-month data collection periods in August and then December 2018 that were 24 hours a day including sleep and he was interviewed before and after each period while also sharing detailed information on schedule, routine, and key activities during this period. The learnings from this participant in the breadth and depth of the data collected at a number of levels focused growing interest and emphasis on understanding the idiosyncratic journey of entrepreneurs and helped inform the development of a number of propositions and a renewed focus on exploring the dynamic person-by-situation interactions and processes of within-individual change in a time sensitive way.

With this focus the recruitment of participants willing and able to participate in long duration study of greater than a week and ideally up to a month or more was prioritised in the first half of 2019. It is a far more significant sacrifice of time for busy entrepreneurs to commit to an ongoing 24-hour study for weeks or months on end while wearing a wearable device and completing regular surveys than laboratory or short duration studies. Another four participants were recruited in Melbourne and data was collected between September 2019 and January 2020 giving a total of five participants to be included in the study. Additional long term participants had started to be identified and recruited in early 2020 before the Covid-19 pandemic in March 2020 created lockdown conditions in Melbourne, Australia which changed the day to day nature of entrepreneurial work life and participation availability or willingness with unknown Covid-19 effects resulting in the decision to exclude any further data collection from this current study and to focus on data analysis of the five participants that had been already collected.

### **4.3. Data Collection and Analysis**

#### **4.3.1. Wearable Sensors and HRV Analysis**

The E4 wearable sensor by Empatica used in this study is worn on the participant's wrist on their non-dominant hand and is similar in size to a wristwatch and relatively unobtrusive,

compact, and comfortable to wear for continuous use. The device has been validated for scientific and medical purposes (Garbarino et al. 2014; Ollander et al. 2016; van Lier et al. 2020) and has been shown to be as accurate as laboratory sensors (McCarthy et al. 2016; Ragot et al. 2017). The E4 has been used in studies as diverse as an urban planning analysis where E4s were used to measure emotional arousal while visiting different parts of a city (Shoval, Schvimer & Tamir 2018) and evaluate driver's emotions and physiology in real time to mitigate the risk of human error in manual or semi-autonomous driving (Melnicuk et al. 2017). An E4 was provided to each participant involved in long duration collection and the participant was provided instructions on how to wear the device, upload data and recharge the device as indicated in Appendix 8.1.

The participant was asked to wear the E4 on a continuous basis only removing it for recharge and data upload purposes. The E4 has the capability for wireless and USB data uploads and has an internal memory that allows up to 60 hours of data to be recorded. Participants used regular USB uploads and charging cycles that fit their individual routines as recommended by the E4's manufacturer Empatica for longitudinal studies as the wireless connection through Bluetooth to the participant phone have greater possibility for data loss for a variety of circumstances. To view the data collected over time from the E4, the manufacturer Empatica provides a data visualisation tool or data can be exported from the E4 connect platform as Comma Separated Values (CSV) files for each recording period.

The E4 collects a number of physiological variables namely Electrodermal Activity (EDA), Blood Volume Pulse (BVP), Movement (Accelerometer), Heart Rate, Interbeat Intervals (IBI) and Temperature that can be used for analysis. The E4 has a PPG sensor for monitoring blood volume changes in the micro vascular bed of tissue which can be used to verify beat locations and exclude noisy segments extracted from the BVP data to calculate HRV (Tarvainen et al. 2019). The BVP signal is obtained from the PPG sensor by an algorithm and has a fixed sampling rate of 64 Hz (64 times per second) which can be exported as a CSV file for the full period of each recording and then used for HRV analysis. A unit of measurement for BVP is not provided as it is derived from the combination of two different measures of the amount of light that is reflected and goes back to the PPG sensor (Tarvainen et al. 2019). Theoretical

perspectives including Porges's Polyvagal theory (Porges 2001, 2007, 2011) and Thayer's Neurovisceral Integration Perspective (Thayer et al. 2009; Thayer & Lane 2000) posit that HRV reflects self-regulatory capacity and therefore can be employed as a biomarker of top down self-regulation to reflect the capacity for individuals to modulate their cognitive activity, emotions and behaviour to adaptively respond to changing environmental demands (Holzman & Bridgett 2017; Zahn et al. 2016).

HRV is analysed using Kubios HRV which is a commonly used scientifically validated software package and its early versions were developed as part of academic research work carried out at the Department of Applied Physics, University of Eastern Finland, Kuopio, Finland (Tarvainen et al. 2019; Tarvainen et al. 2014). Kubios bases its calculations on the standards defined by the HRV Task Force (Task Force 1996) and is outlined in its user guide (Tarvainen et al. 2019). Every individual CSV file is imported into Kubios which uses the PPG/BVP input signal to compute inter-beat-interval (IBI) timings, heart rate and HRV as outputs over time. Artefacts in the inter beat interval time series can cause significant distortion to HRV analysis results, and thus, all artefacts should be either corrected or excluded from analysis. Typical artefacts include missing, extra, or misaligned beat detections as well as ectopic beats such as premature ventricular contractions (PVC) or other arrhythmias. Kubios HRV includes two methods for correcting artefacts and ectopic beats present in the data – automatic correction and threshold-based correction. The automatic artefact correction method is applied in this study where artefacts are detected from a time series consisting of differences between successive RR intervals providing a robust way to separate ectopic and misplaced beats from the normal sinus rhythm.

Kubios analysis provides time based, frequency based, linear based and time varying results views of the HRV calculations (Tarvainen et al. 2019). A time-based measure of HRV, namely RMSSD measured in ms which reflects parasympathetic activity, is used as the dependent variable in this study to reflect self-regulation strength (Shaffer & Ginsberg 2017; Task Force 1996). Kubios automatically provides other HRV calculations that reflect PNS tone (e.g. high frequency HRV power) and SNS tone (e.g. Baevsky's stress index or low frequency HRV power). The RMSSD and high frequency HRV calculations are the two most frequently used

HRV indices and have been used to measure self-regulation in numerous studies (Holzman & Bridgett 2017; Zahn et al. 2016). The time domain measure of RMSSD and the frequency domain high frequency power measure are highly correlated measures of HRV (Kleiger, Stein & Bigger 2005; Shaffer & Ginsberg 2017; Task Force 1996) but RMSSD is less affected by respiration (Hill et al. 2009) and typically provides a better assessment of RSA than other HRV measures.

For calculation of HRV the recommendations of the HRV Task Force (Task Force 1996) were used. HRV is analysed in 5-minute intervals throughout the period of measurement to allow for time-based analysis of interactive effects. HRV is then calculated at rest each night in order to compare cumulative and ongoing effects of the entrepreneur journey. The resting period was calculated for a 4-hour period while asleep from 1am-5am or 12am-4am each night based on the typical sleeping patterns of the entrepreneur but was adjusted on occasion if the participant was awake late or woke up early necessitating a shift in time to ensure a clean resting measurement. The resting RMSSD value measuring the body's parasympathetic activity captures the baseline physiological stress in response to acute and chronic stressors impacting the participant (Shaffer & Ginsberg 2017; Task Force 1996). For each individual, it is important to identify the normal average HRV over a period of time, and then to explore the magnitude and direction of RMSSD as an indicator of change. In that way each case explores the individual RMSSD changes from the average specific to the individual and follows the approach used in numerous studies applying HRV analysis (Geisler & Schröder-Abé 2015; Holzman & Bridgett 2017; Koval et al. 2013; McCraty & Shaffer 2015; Reynard et al. 2011; Segerstrom & Nes 2007; Zahn et al. 2016).

#### 4.3.2. Experience Sampling Methodology

ESM also known as Ecological Momentary Assessment (EMA) can be used to repeatedly collect real-time data on participant's momentary states in the natural environment and is characterised by four qualities: 1) assessment of phenomena at the moment of occurrence, 2) data sampling at relevant moments, not at the convenience of researchers or participants, 3) repeated observations, and 4) data collection in the natural environment (Stone & Shiffman 1994; Stone et al. 2007). Using ESM allows for collecting data on what a participant is currently



thinking, feeling and doing as they perceive them in real time and in their natural environment thus “maximizing ecological validity while avoiding retrospective recall” (Stone & Shiffman 1994). The method can advance entrepreneurial theory and research by allowing researchers to capture dynamic person by situation interactions as well as between and within person processes, improving the ecological validity of results, and minimising retrospective biases (Uy, Foo & Aguinis 2010).

Participants completed ESM surveys using a mobile app called Expimetrics (recently changed name to Expiwell) which was designed for academic research and were provided with instructions for how to install and use the app, and how to use and complete the surveys which is provided in Appendix 8.2. Participants were asked to complete an ESM activity survey frequently where possible throughout their day and ideally every hour which captured rapidly activity information from a summary list, perceived feelings of happiness, stress, and alertness and if an activity was routine, a challenge, had an uncertain outcome, suffered a setback and whether they were alone or interacting with others. They were also asked to indicate once a day when they were at the end of their workday and to complete additional end of day ESM survey questions reflecting on and summarising the day and their subjective effectiveness.

This included a daily diary question asking them to comment on “how was your day” including timing and detail of significant positive or negative experiences from the day, how they felt about those experiences and overall progress for the day. It also included a number of effectiveness measures reflecting on the day where participants used a 100-point sliding scale to rate for the day their effort, satisfaction, and excitement of being an entrepreneur, how stressful their work was as an entrepreneur, how much progress they made, and how well rested they had felt starting the day as well as how many hours of sleep they had had last night. A video diary was used to supplement information in early versions of the data collection procedure but difficulties with participants data upload speeds or connection and the Expimetrics app for video capture resulted in the ongoing change to free text-based responses in all cases. These end of day measures and daily diary comments provide a basis for evaluating the change or trend in individual subjective effectiveness.

The measures captured in the ESM survey were developed based on both use in prior research as well as an understanding of the environment in which entrepreneurs operate in their daily lives. Data on the action environment includes the activities as well as characteristics of the activity and is based on research done by Mueller, Volery and von Siemens (2012) whose study on what do entrepreneurs actually do used structured observation to investigate the everyday behaviour of six entrepreneurs in the start-up stage and six entrepreneurs in the growth stage to explore both commonalities and differences between these two stages with regard to activities, functions, exploration vs. exploitation, and communication. The categories and subcategories of work content were used to define the activities that were captured in the ESM survey and inform the characteristics that were captured. Entrepreneurship is considered uncertain (Davidson 2003; Fox 2008; Panksepp 2000) so it was important to capture whether the activity had an uncertain outcome or not alongside if there was a setback or not to provide context on the participant's emotional response. Asking if the participant was alone or not was included to explore the nature of social support which when added to contextual data captured in the daily diary could be used to inform understanding of the type of interactions and with who they might be happening. Whether an activity was routine or not or a challenge or not could show if the entrepreneur was comfortable in their own self-efficacy or not for a particular activity.

The daily subjective effectiveness measures were not collected in the same way in the activity survey in the moment as the activity survey was intended to be completed quickly by the participants in order to limit disruption in their workday and facilitate frequent collection of activity information as their activities changed throughout the day. Its purpose was to primarily collect information about the activity and context of the action environment with the completion time of each activity survey being 30 seconds or less. The end of day survey questions on the other hand were intended to only be collected once a day and be given some time and reflection by the participant to consider the impact of the day as well as provide free form contextual information to the question "how was your day" requiring at minimum several minutes to complete. In retrospect the effectiveness measures could have also been collected in the activity surveys (but excluding the daily diary question) to provide greater consistency and detail in understanding the change in subjective effectiveness over time on

a moment-to-moment basis. However, in designing the surveys priority was given to ensuring the activity surveys could be completed quickly and with as little disruption as possible to the entrepreneur in the moment.

The ESM data collected could be viewed and tracked for each participant as separate projects within the Expimetrics web platform so the frequency and completeness of survey data collected could be reviewed periodically. The Expimetrics platform also provides tools to message and encourage participants to complete surveys or provide other updates. At completion of the long duration data collection all the survey data collected for the participant is downloaded as CSV files. The data is referenced by a unique participant identifier and each survey includes the start and end time it was completed alongside the survey responses for each question. By using a data filter and statistical formula in excel it can be sorted and organised to identify change and trends in the responses or sorted to enable easier integration with other data collected using unique identifiers including participant and time.

#### 4.3.3. Supporting Contextual Information

The data collected by ESM is potentially extensive and detailed however to provide further supporting contextual information entrepreneurs were asked to share other information where possible on their typical daily schedule or routine as well as calendar or task information that could be easily shared as an export of calendar-based software (such as Outlook or Google Calendars). Each participant also completed an in-depth background survey using Qualtrics taking 30-45 minutes to complete to elicit a series of demographics as well as particular individual-level personality and attitude measures. The background survey covered individual entrepreneurial identity and self-efficacy, current emotions over the past week, competitiveness, and trust, risk-taking, details of current business and intent, entrepreneurial experiences, demographics, and personality. Appendix 8.3 outlines the background survey protocol, instruments used and references for use. The protocol for participant sign up included the completion of a participant information and consent form that explained the purpose of the study and requirements of data collection before the background survey was completed.

In the recruitment, onboarding, and data collection process there were numerous formal and informal opportunities to gain additional contextual information about the entrepreneur, their venture(s) and their journey. For each participant there were several in person meetings both to provide detail about the study and its purpose and instruct participants in how to use the E4 wearable and complete ESM surveys as well as learn about their normal behaviours and routines, the nature of their business and plans as well as current issues and challenges. Throughout the data collection period regular contact was maintained to check in on any issues, progress, and challenges both with the study and also as entrepreneurs using email, phone calls or messaging (via the expimetrics app) alongside occasional face to face meetings where needed. Participants were also asked both during or after data collection to provide further explanation or clarification of information provided in their ESM surveys and to clarify timing of event or schedule information that may have been shared to further augment the detail collected through ESM surveys.

The contextual information collected is different and varied specific to each individual participant and their journey. Through ongoing contact with the participants, the participants also started to think about, ask about and volunteer other information relevant to their journeys showing willingness to share information specific to themselves, as an example such as dietary intake and exercise activity. Some were also open to sharing medical and other health history which was declined. However, it shows the potential for integration of numerous data collection techniques and sources of participant information as big data analysis capabilities are enhanced in the future both for individual analysis and research purposes.

#### 4.3.4. Measurement Variables and Big Data

In this study activity information is collected throughout the day alongside how the changing action environment impacts the self-regulation of the participant measured as HRV (RMSSD). The activity information includes the type of activity selected from a list and characteristics of the activity such as whether it is routine or not, a challenge or not, has an uncertain outcome or not, includes a setback or not, and whether they are working alone or with others. Subjective self-reported effectiveness measures of the entrepreneur participants in broad

terms are collected at the end of each day and can be framed in both a positive and negative view in relation to their own perception of their performance and wellbeing. This includes words used by the entrepreneur themselves in their daily diary of positive and negative moments from the day, as well as measures of satisfaction, excitement and progress as an entrepreneur, excitement, and stress of being an entrepreneur, and how well rested they are from a daily point of view.

The daily effectiveness measures were intended to be reflective and broader than the variables that were collected in the moment in the activity survey which was done quickly to primarily capture activity information. However, the activity survey did collect subjective responses on happiness, stress, and alertness in order to quickly capture an impression of their momentary state alongside the activity information in that moment while being able to be completed in 30 seconds or less. All the subjective measures collected used a 100-point scale and in the results are all expressed as a percentage of the maximum value recorded for that participant during their collection period in order to establish a range specific to the individual participant. Supporting contextual information collected from the participants in the daily diary or elsewhere adds further insights on their changing experiences through the day and over their journey both in terms of the action environment as well as how they perceive their effectiveness.

The conceptual framework incorporating the measurement variables summarising the mixed method qualitative and quantitative data collected is shown in Figure 4-1 enabling the time sensitive exploration of the entrepreneurs' journey.

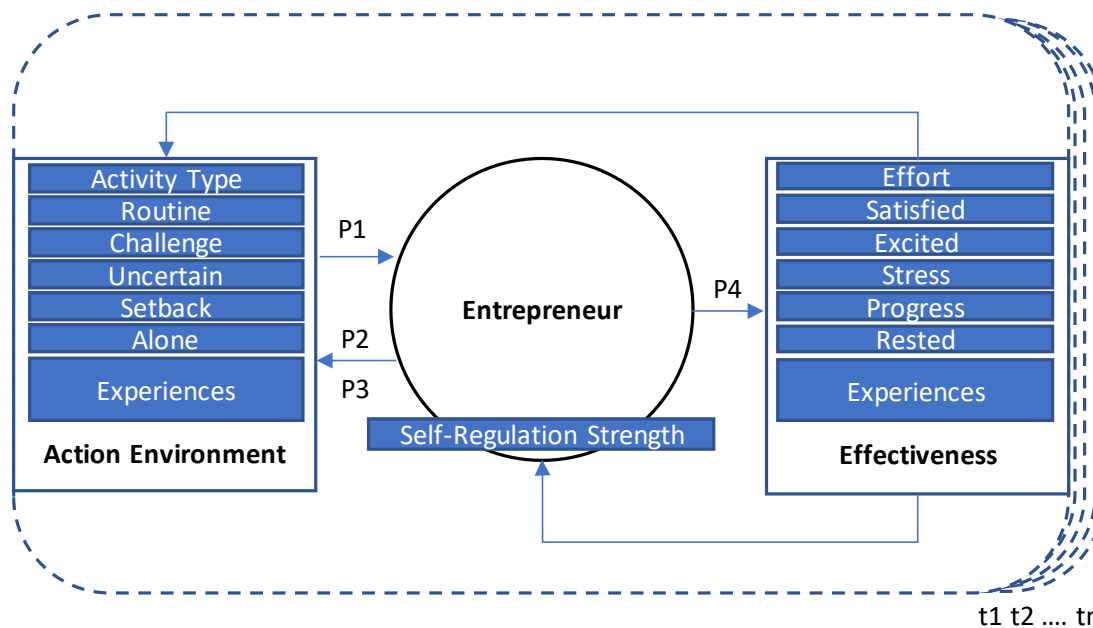


Figure 4-1: Conceptual Model with Measurement Variables

The mixed method qualitative and quantitative data collected in this study is representative of the emergence of big data and related analytic techniques that are creating opportunities to advance empirical entrepreneurship theory and practice. Advancements in information technologies continue to reshape economic and social conditions and the ability to capture, store, and process vast amounts of information has enabled the creation of what has been labelled big data - large data sets that contain fine-grained information of micro-events and activities including novel approaches to observe human behaviour (Schwab & Zhang 2019). The increasing use of smart electronic devices, sensors, digital communication networks, and the Internet is at ever-increasing rates creating and storing data of human behaviour and its outcomes. And while entrepreneurship research has long exploited large data sets, such as patent or census data, big data presents not only new opportunities, but also new methodological challenges represented by large volumes of data combined with high variety and velocity—often combined with low veracity (McAfee et al. 2012) which are very different from past methodological approaches to large data sets (George, Haas & Pentland 2014; Tonidandel, King & Cortina 2018).

Exploiting big data opportunities often depends on the methodological capabilities to address these challenges. The required capabilities fall into two categories: first, data-management

capabilities to efficiently clean, restructure, integrate, and combine the massive data, and second, data-analysis capabilities tailored to extract meaningful empirical information from big data (Braun, Kuljanin & DeShon 2018). Hence, the era of big data is also associated with the emergence of novel investigative tools and approaches. In general, the real-time observation data at the heart of many big data sets are usually not clean and well-structured, tending to contain substantial amounts of missing or miscoded data (Tonidandel, King & Cortina 2018). Data clean-up and integration are also challenges associated with traditional large data sets, but in big data these challenges tend to be different in quality as well as in scale. Consequently, they often require fundamentally different clean-up approaches (Tonidandel, King & Cortina 2018).

Researchers, for example, often must spend substantial effort to make sense of what has and what has not been recorded and what the recorded information actually tells them (Guzzo et al. 2015; Schwab & Zhang 2019). These efforts may include deep consistency investigations to confirm that coding patterns in the data correspond with recording protocols and given the volume of observations manual recoding is typically no longer feasible and researchers must be adept in using software tools and diagnosing data in order to identify and address erroneous and missing information (Braun, Kuljanin & DeShon 2018). Another major challenge is integrating data from various sources particularly if the same micro-event is captured by several different devices or recording methods, as this information needs to be linked exploiting time, location, participant, and other information. And while researchers often face similar integration challenges in traditional data sets, with big data, the sheer volume of observations and the level of data heterogeneity and messiness tend to substantially raise the bar with regard to required integration efforts (Kitchin 2014; McAfee et al. 2012). In addition, big data can also create new challenges for human subject protection. Where in the past anonymisation has been an effective tool to prevent unanticipated harm for study participants, the wealth of information in big data, often allows for reidentification and hence, researchers should consider additional data privacy strategies (Guzzo et al. 2015).

In summary, the skills and effort required to prepare and analyse big data sets are substantial and while quantitative entrepreneurship research is dominated by deductive hypothesis

tests, and researchers tend to prefer qualitative designs for exploratory investigations; big data provides new opportunities for quantitative exploratory studies (Guzzo et al. 2015; Putka & Oswald 2015; Schwab & Zhang 2019). Where for example investigating behaviour, micro-events, and dynamic processes for which research models and theory may not exist becomes a possibility. Across management research broadly the emergence of big data has stimulated renewed interest in quantitative inductive studies (Putka & Oswald 2015; Waller & Fawcett 2013). However categorising studies into inductive and deductive might also miss another opportunity to combine approaches where big data can enable iterative sequences of inductive, abductive, and deductive investigations (Kitchin 2014). Academic entrepreneurship research is a human endeavour where exploiting big data opportunities requires scholars who are motivated and able to execute such studies. Hence, it requires scholars who are curious, risk-taking, and interested in the future (Schwab & Zhang 2019). Big data studies require some fundamentally different research skills and so researchers must be open to learning new skills and methods, be open to collaboration and partnerships in emerging disciplines, and be able to access the necessary data collection and analysis infrastructure (George, Haas & Pentland 2014; Guzzo et al. 2015; McAfee et al. 2012; Schwab & Zhang 2019).

#### 4.3.5. Data Integration and Analysis

To integrate the data from the mixed sources including wearable sensors, ESM and supporting contextual information the major challenge was linking the information exploiting common characteristics namely time and participant. Methodological procedures, first in data management to efficiently clean, restructure, integrate, and combine the data from its different sources; and second, data analysis tailored to extract meaningful empirical information were developed, first testing and trialling approaches to check effectiveness and then replicating them across the depth and breadth of data collected and then repeating these procedures for each case study participant (Saunders, Lewis & Thornhill 2016; Schwab & Zhang 2019; Yin 2014). A summary of the data collected from the mixed sources for each of the five participants A through E is provided in Table 4-1. The results and analysis for each of the five participants is then presented as a separate case study A through E in the results and analysis chapter.



Table 4-1: Data Summary for Integration and Analysis

Period	Participant Age (M/F)	A-Period 1 29yrs (M)	A-Period 2 29yrs (M)	B 34yrs (M)	C 27yrs (M)	D 39yrs (M)	E 30yrs (M)	TOTALS
	Collection period	1/Aug/18 - 30/Aug/18	31/Oct/18 - 30/Nov/18	4/Sep/19 - 7/Dec/19	18/Sep/19 - 6/Nov/19	2/Oct/19 - 26/Nov/19	9/Dec/19 - 17/Jan/20	
	#Days in period	30	31	95	50	56	40	302
Wearable Sensor	#Days with E4 recordings	30	22	56	18	37	40	203
	Total E4 time recorded H:M:S	653:11:44	444:30:40	992:16:17	258:36:49	603:25:23	894:57:34	3846:58:27
	Average/day H:M:S	21:46:23	20:12:18	17:43:09	14:22:03	16:18:31	22:22:26	18:47:29
	Participant E4 recording notes	Very Consistent- 1 day not recorded	Missed-5 day E4 failure, 3 days sick + 1 other	Good start, missed-4 day weekend then intermittent until end	Sporadic, unable to establish routine (1 consistent week)	Missed-weekends + inconsistent recordings (time, duration)	Very consistent- 1 day incomplete	
Experience Sampling	#Days with ESM surveys	29	18	37	17	42	22	165
	#ESM End of Day surveys completed	27	14	37	10	35	22	145
	#ESM Activity surveys completed	183	103	*	45	153	146	630
	#Maximum Activity surveys/day	13	14	*	5	8	9	9.8
	#Average Activity surveys/day	6.31	5.72	*	2.65	3.64	6.63	4.99
	Participant ESM completion notes	Consistent. Missed last day (holiday)	Missed-end of day survey 3 of 4 weekends (Sat&Sun) and 3 of 6 Fridays	Missed-end of day survey most weekends/some Fridays+10 days(mid Oct) and after 11/Nov. *No activity surveys-own method not compatible with study	Sporadic for both end of day and activity surveys. Only 1-2 weeks consistent collection	Missed-end of day survey on weekends/some Fridays. Activity survey frequency inconsistent (improved end of period)	Consistent. Missed-end of day survey on weekends & 24/Dec-1/Jan (holidays)	
Contextual Information	Sources used	Background Survey Calendar info x 2 (startup, consulting) To Do list Regular Routine Semi structured interview Check-ins & reminders	Background Survey Calendar info x 2 (startup, consulting) To Do list Regular Routine Semi structured interview Check-ins & reminders	Background Survey Participant's own Activity/ Finance/ Project/ Time tracking data Regular Routine Semi structured interview Mood tracking Coffee consumption Check-ins & reminders	Background Survey Regular Routine Semi structured interview Check-ins & reminders	Background Survey Regular Routine Semi structured interview Check-ins & reminders	Background Survey Regular Routine Semi structured interview Check-ins & reminders	

Data from different sources were exported in compatible formats, in this case CSV files or excel, and referenced by a unique participant identifier. As is common with big data set integration, the data collected from each source required review and clean-up. Consistency investigations were used to confirm the recording protocols of different data sets collected given the large volume of observations recorded using wearables and ESM technologies. As time is the critical marker linking different data sources for each participant and was often recorded based on UTC (Coordinated Universal Time) given different technologies used there was substantial effort made to ensure timestamps were accurately converted to local time of the participants so all sources of data could be accurately integrated. The data sources referenced in local time were then assembled in a master excel spreadsheet for each participant and integrated on the basis of momentary, daily, and ongoing investigation.

With this exploratory investigative approach, graphic displays as a means of integrating large amounts of both qualitative and quantitative information were used as a first step in the overall analysis process. In this thesis they are shown as an example for participant A only (seen in Appendix 8.6) and provide for communication and presentation of integrated results over different time frames – in the moment, daily and ongoing. The use of graphic displays in analysing complex data sets to examine individual behaviour in detail in case study or single subject research is common (Gast 2009; Yin 2014). This study focuses on exploring the trend or change in cycles of depletion and recovery in self-regulation as the action environment changes in a time sensitive way where graphic displays are useful for showing change over time. It is important to note that in this study the absolute values in measurement are specific to the individual and are not comparable to other participants in absolute terms, but that changes or trends over time are of interest and can be compared to other individuals.

The next step was to examine the collective data for each participant in greater detail by combining the momentary results for interactive analysis and the daily results (ongoing) for cumulative analysis. The momentary results are summarised in two tables for each participant with both tables summarising the mean, standard deviation, min, max and range of RMSSD and also include the mean and standard deviation of the three subjective responses (happiness, stress, and alertness) compared against the different activity types in the first

table and the characteristics (or combination of characteristics) of activities in the second table. The mean value and standard deviation is important in order to show the direction and magnitude of change from the average RMSSD alongside corresponding changes in effectiveness measures for the individual. The direction and magnitude of change provide the basis for exploring how the cycles of depletion and regulation and effectiveness are influenced by changing activities measured many times across the duration of the study.

The daily results are summarised in one further table where the data for each day (by day and date) is compared on an ongoing and cumulative basis. The absolute number expressed as a percentage of the maximum value for that participant for each day is given for each of the six subjective effectiveness measures and the change from the day before is calculated to look at the ongoing change in these variables day to day which is then compared to the nightly resting RMSSD and the change from the day before and difference to the average resting RMSSD for the period of collection. Quotes from the daily diary and other supporting contextual information for each day provide information on the experiences of the participant. The comparison day to day provides an ongoing and cumulative view on the change in self-regulation and subjective effectiveness measures over time so for analysis and visual representation a positive change in the direction of the value is represented in green and a negative change in the direction of the value is represented in red. The shade of the green or red changing represents the intensity of the change from the day before or different to average using a conditional formatting approach. The conditional formatting is unique to the individual responses for the participant, using the range of values for that individual and that measure where the darkest red or darkest green the highest value in the individual range in the direction of either positive or negative change of that variable. The shade of red or green becomes lighter the closer to zero or neutral the values get. Therefore, the shading will be slightly different for each individual case but from an illustrative perspective makes the complexity and duration of the data more accessible to the reader enabling sense checking and interpretation of the data in a cumulative way.

To simplify the presentation and discussion of the results, each case study is structured in a similar way to facilitate within-case and then cross-case analysis. The importance of within-

case analysis is driven by one of the realities of case study research, the staggering volume of data (Eisenhardt 1989), which in this study started with the number of charts for momentary, daily and ongoing results over the periods recorded for each participant. For the researcher, the idea is to become intimately familiar with each case as a stand-alone entity allowing the unique patterns of each case to emerge before seeking to generalise patterns across cases (Eisenhardt 1989; Eisenhardt & Graebner 2007; Yin 2014). Familiarity with each case in turn facilitates cross-case comparison (Eisenhardt 1989). Cross-case analysis supports consistency in the presentation and structure of the results to facilitate the cross-case search for patterns (Eisenhardt 1989). The idea behind cross-case analysis tactics is to force researchers to go beyond initial impressions, especially through the use of structured and diverse lenses on the data, improving the likelihood of accurate and reliable analysis and theory that is a close fit with the data and enhancing the probability that researchers will capture the novel findings which may exist in the data (Eisenhardt 1989; Yin 2014).

#### 4.3.6. Biases, Sampling and Error Detection

Wearables collect physiological data, produced by the body as automatic responses, which individuals can't easily or readily control, and the ESM surveys collect subjective data from the entrepreneur on a frequent basis enabling the exploration of the entrepreneur journey. The unit of exploration is the entrepreneur themselves where the fluctuations, change and trends in their self-regulation and subjective effectiveness is the focus, not the absolute values collected themselves. The challenge in this exploration is the appropriate interpretation of the mixed method data collected to lessen the effect of the researcher's bias, sampling variations and incomplete data that is part of exploring the time-based journey of the entrepreneur participant (Kraus, Meier & Niemand 2016; Saunders, Lewis & Thornhill 2016; Schwab & Zhang 2019; Yin 2014). And while method bias can occur when participants may respond or provide information in a manner that their responses are acceptable in society or to their peers or to maintain consistency with their own self value rather than articulating their true feelings (Podsakoff et al. 2003) every effort has been made in the instructions and ongoing interactions with participants to encourage them to truly articulate

their true feelings and thus reduce common method bias as anonymity of the participants is maintained (Podsakoff, MacKenzie & Podsakoff 2012).

This is also a small-n study, utilising both qualitative and quantitative techniques where the aim is to strike a balance between managing quantitative study type errors and biases of single-subject research versus the interpretive nature of understanding peoples' subjective experiences of qualitative studies while providing a detailed description of the individual as a case study. Although the small sample size initially may suggest limited generalisability, small-n designs establish external validity by replicating effects across multiple participants as it is typical that somewhere between two and 10 participants are studied (Gast 2009) and cross-case analysis is used to structure the cases to facilitate synthesis and explore consistency of relationships within and across cases (Eisenhardt 1989; Yin 2014). Small-n studies are used when it is important to focus intensively on the behaviour of individual participants as group research can hide individual differences and generate results that do not represent the behaviour of any individual (Gast 2009; Price et al. 2017).

Using a large number of observations made on a relatively small number of experimental participants enables the researcher to investigate systematic, functional relationships as they are manifested at the individual participant level where the estimation of population parameters, while not unimportant, is arguably of secondary concern and should probably be investigated using more refined techniques for characterizing individual differences than the blunt instrument of simple averaging that conventional statistical methods provide (Grice et al. 2017; Normand 2016; Smith & Little 2018). Findings from small-n case studies lead to knowledge about the causal configurations (combinations of causal conditions or social mechanisms) that make specific outcomes possible (Blatter & Haverland 2012).

Maintaining consistency and internal validity in the sampling rates and error detection used in the data collection has been specific to the data sources used. The E4's BVP signal has a fixed sampling rate of 64Hz (64 times per second) and is obtained from a PPG sensor by a proprietary algorithm. The output may vary depending on the user and environmental settings which are sources of potential error. The E4 must be worn snugly (but not uncomfortably tight) to receive good quality data and the participants were advised and

reminded of being consistent in the wearing of the device on their non-dominant hand as well as to avoid where possible further error due to inadvertent knocking of the device. However, it was clear through observation and discussion that participants had usability and comfort issues with the E4 wearable, for example sometimes forgetting to turn on or wear the device, not wearing the device snugly on a consistent basis, not being able to get used to it from a comfort or aesthetic point of view while sleeping or attending meetings or wanting the freedom from the device on weekends or for important events.

Due to its methodological interest and practical application Appendix 8.4 provides further discussion on the use of wearables and the HRV analysis software Kubios to ensure consistency in error detection and HRV results including a brief comparison of artefact correction methods. In the presentation of results for this thesis Kubios's automatic correction method has been used as it provides a robust algorithm for detecting artefacts (missed beat detections, misplaced beats etc.) and ectopic beats (e.g. premature ventricular beats) providing greater detail in the direction, intensity, and duration of the change of HRV with the data collected in real life conditions. But for methodological comparison the medium artefact correction method, which identifies all IBIs that are larger/smaller than 0.25 seconds compared to the local average, was also used where correction is made by replacing the identified artefacts with interpolated values using a cubic spline interpolation.

The sampling rate of ESM surveys varied between participants and day to day to reflect the routines and nature of each individual participants' journey and work/life schedule over time. Participants were asked to complete an activity survey ideally every hour or as frequently as related to changes in work activity anytime through the day and night to match their work routines which built inherent flexibility into the sampling frequency. However, it was made clear to participants the critical nature of completing the end of day questions and daily diary each and every day. In all cases and with regular reminders participants were asked to answer questions as honestly as possible based on the activity or day to most accurately reflect what the participant was thinking, feeling, and doing in that context.

Through observation and discussion with participants, much like the use of the E4 wearable, the participants had select usability challenges, for example on some days and in some

moments forgetting or becoming too absorbed or distracted by work and life to complete the surveys through to missing cumulative days or weekends in some cases for various work and life reasons. In some cases, participants requested frequent reminders to be set in the app to complete their ESM surveys, while other participants deprioritised these reminders when needed to focus on their work regardless of their insistence and assurances, they would regularly complete the surveys. The sampling differences saw participant 1 and 5 regularly complete between 9-13 activity surveys each day and average 6-7 per day over a long duration period while also completing end of day survey questions the majority of days while participants 3 and 4 for example typically only completed 2-5 activity surveys per day but sometimes as low as only one end of day survey and where the consistency of surveys taken varied between 3-5 days with then a gap of several days or more before the next samplings.

To fill gaps in activity information and provide deeper supporting contextual information to the entrepreneur journey the participants were asked to share where possible calendar information and in discussion provide information on their daily and weekend routines. There was variability in how each participant operated and what information was recorded and through observation and discussion with participants it was clear that the timing of scheduled tasks and to-do information would change or not occur for a variety of reasons. And as such it's a guide to key meetings and events but the day-to-day minutia and activities are changing all the time given the uncertainty of the entrepreneur journey and as such all information gathered was primarily used for further investigative and contextual insights and where relevant discussion points with the entrepreneurs for further clarification of positive or negative outcomes and experiences in their journey.

Each individual naturally has differences in their personality and routines with some participants being extremely focussed and consistent in their data collection across all sources while others were more varied and inconsistent depending on work/life circumstances. Another key issue in collection was the consistency of data collection across all sources as there were times and days where E4 wearable data was collected but ESM surveys were missing or vice versa the ESM surveys were completed but no E4 data was collected. In either case this resulted in a loss of usable data for fully exploring the research question and

propositions. It was a particular detriment to the exploration of ongoing and cumulative effect of the entrepreneurs' journey where one or more days of missing data results in inconsistent investigation.

In working with long duration participants there is a balance to be sought in the amount of data collected versus the burden of data collection for the participants given the intensity of their work as entrepreneurs, but the continued improvement of this balance is necessary for appropriate time-sensitive investigation of dynamic entrepreneur journeys and in particular the ongoing or cumulative effects. These practical challenges in maintaining engagement, commitment and awareness of the participants and ensuring consistency and control of the data are critical in maximising the opportunity of everyday data collection over long durations.

#### **4.4. Ethical Considerations**

Approval from the university's ethics committee was obtained for the purposes of using wearable sensor technology to advance entrepreneurship research (see Appendix 8.5). Privacy and risk assessment procedures were undertaken to ensure overall research integrity and a participant information and consent form was provided to each participant. The collection, integration and analysis of big data sets create new challenges for participant protection. Where in the past anonymisation has been an effective tool to prevent unanticipated harm for study participants, the wealth of information collected in big data collection, can allow with investigation reidentification of the participant and hence additional data privacy strategies may be necessary (Guzzo et al. 2015). Data privacy and management is an ethical issue where to ensure privacy, data has been de-identified in storage and the presentation of the findings. Data has been collected and stored on proprietary cloud services using different technologies such as wearable sensors and mobile apps. For each source the data has been exported for integration where it is only linked by unique identifiers including the wearable device ID number and the individual expimetrics participant ID. All integrated data is collected and stored in RMIT approved password-protected folders only accessible to the researchers.



The use of wearable sensor technology in research that may be worn 24 hours a day 7 days a week also presents emerging ethical issues and challenges beyond the large amounts of data collected. Although the measurement of physiological response and meaning is still being advanced and needs to be repeated in a consistent way the use of wearables have the potential to provide insights into the health and wellbeing of participants as well as enable the understanding of emotions as diverse as fear and happiness. To this end it was made clear to participants that data collected will not be used for any medical diagnosis and that if participation in the research leads to any discomfort then the participant is free to skip the activity, take a break or cease the research and they should direct any issues related to their health and wellbeing to a medical practitioner or relevant counselling service.

## 5. Results & Analysis

*“No more romanticizing about how cool it is to be an entrepreneur. It’s a struggle to save your company’s life – and your own skin – every day of the week.”* - Spencer Fry, founder of Podia

### 5.1. Case Study - Participant A

Participant A (male, age 29) is a portfolio entrepreneur who is engaged with setting up a new business, managing an on-going business and supporting a long-standing family business alongside doing some regular project consulting for income purposes. He does not drink or smoke and has a history of exercising regularly in the gym and kickboxing. He sleeps on average 7 hours a night but typically does not feel well rested when he wakes up. He is married and his highest education level is a higher university degree (Masters). He describes himself as positive and optimistic, someone who plans ahead and is organised, always willing to push himself very hard to achieve a goal. He pays attention to and worries about the details in everything he does and feels both excited and anxious about his entrepreneurial journey. He comments that he is overly active and compelled to do things, like he is driven by a motor. He sets short- and long-term goals for his life and sees himself as capable and committed to achieving them with hard work regularly working over 100 hours a week. Being a founder, owning his own company, and pushing himself and his team to make it a success is an important part of his identity.

Structure and discipline are key aspects in Participant A’s work and life routine where work is the overriding focus of his attention during all parts of his life. He aims to go to the gym and exercise early mornings at 5:00-5:30 Monday, Wednesday, and Friday and while doing so listens to a business lecture/podcast at the same time. Lunch time is scheduled networking time with various customers so that he can identify new business opportunities and build good relationships. As a portfolio entrepreneur whilst consulting he is often presented with various related opportunities for his businesses which he tries to explore when time permits, and he supports the family business via phone or in person by guiding one of their staff or helping his father make decisions about the business. He will make work calls while driving to (arriving ~7:30-8:00) and from (leaving ~17:00) various work locations. Arriving home, he

generally has a ~30-minute break before getting back to work and breaking for dinner for ~30 minutes at ~19:00 and then returns to working from 19:30-22:00 trying to get as much as he can get done before heading to sleep. Weekends are also work focussed with Saturdays usually working all day but Sundays he aims to relax a little, spending time with his wife in the morning or day before returning to work on the business in the late afternoon.

Data collection for Participant A occurred in 2018 for 30 days in August (period 1) and 31 days in November (period 2). The data collection routine for period 1 was very consistent but became less consistent in period 2. Following the first few days of data collection in period 2 an issue that was not able to be rectified with the participant's E4 wearable resulted in nearly 6 days of data collection being lost before a new wearable was provided to the participant and data collection was restarted. The first nine days of this period have therefore been excluded from the daily results due to the gap in the ongoing data collection. Period 2 is also marked by an intense seven-day period with incomplete data collection starting with a pitch event where he believes he gets sick from a friend at the event. He is then unwell and recovering for the week during which he also moves home with the main motivator being he felt he was not sleeping well because his previous apartment was on a busy road and hopes the new one will mean he is better rested.

A summary of momentary results overall for both periods 1 and 2 examining the interactive effects of his activities on self-regulation strength and subjective responses are presented in Table 5-1 and Table 5-2. Table 5-1 indicates that the most common activities for participant A was to work analytically and conceptually (73) and exchange information and opinion (46) while the least common was non entrepreneur work and study (0), monitor and control (1) and consult and sell (2). The mean RMSSD was highest for consult and sell (438ms) and exchange information and opinion (406ms) and lowest for personal (326ms), monitor and control (346ms) and work analytically and conceptually (360ms). For all activities with more than two instances the range between highest RMSSD and lowest RMSSD was over 100ms with the highest for personal (446ms) and work analytically and conceptually (319ms) and lowest for learn and develop (109ms) while the standard deviation was between 34ms (exchange information and opinion) and 125ms (personal). These results indicate broad

variation in self-regulation in the moment both within and across different activities. For the subjective responses in the moment excluding the activities with two or less instances mean-alert varies between 69% (travel) and 83% (learn and develop), mean-happy between 72% (learn and develop) and 75% (exchange information and opinion), and mean-stress between 72% (exchange information and opinion, organise and coordinate) and 83% (learn and develop) and all standard deviations were in the range of 4% (SD-stressed for learn and develop) to 17% (SD- happy for travel) indicating a narrow range based on the momentary activity results.

Table 5-1: Participant A Activity Comparison

Activity =	Exchange information and opinion	Work analytically and conceptually	Organise and coordinate	Network and maintain relationships	Direct and lead	Learn and develop	Monitor and control	Consult and sell	Travel	Personal	Non entrepreneur work or study
Number of Activities	46	73	33	19	19	7	1	2	20	39	0
MEAN-RMSSD (ms)	406	360	370	395	386	403	346	438	396	326	
SD-RMSSD (ms)	34	83	80	67	72	45		4	49	125	
MIN-RMSSD (ms)	288	124	258	220	180	353	346	435	285	26	
MAX-RMSSD (ms)	466	443	453	456	461	462	346	440	448	472	
RANGE-RMSSD (ms)	177	319	195	236	281	109	0	6	163	446	
MEAN-Alert (%)	73%	73%	81%	73%	80%	83%	72%	67%	69%	71%	
SD-Alert (%)	11%	13%	8%	8%	9%	5%		11%	11%	10%	
MEAN-Happy (%)	75%	74%	74%	73%	74%	72%	80%	82%	73%	74%	
SD-Happy (%)	15%	13%	18%	16%	13%	20%		14%	17%	15%	
MEAN-Stressed (%)	72%	77%	72%	74%	75%	83%	87%	54%	74%	74%	
SD-Stressed (%)	10%	12%	10%	11%	11%	4%		8%	10%	11%	

In Table 5-2 the results further indicate that the characteristics of the activity have an influence on self-regulation strength and support the proposition that the action environment has an effect on the entrepreneur's self-regulation strength. And in comparing Table 5-1 and Table 5-2 the characteristics of the activity have a greater impact on the range of RMSSD than the activity itself. Activities that are challenging (362ms) or have an uncertain outcome (376ms) deplete self-regulation strength more than when they are not challenging (379ms) or the outcome is certain (381ms). A setback (395ms vs no setback 367ms) had the opposite

effect, but the low number (2) is inconclusive while not routine (381ms) vs routine (379ms) showed a similar result. For participant A being alone or not alone and interacting with others also has an impact with results showing significantly lower self-regulation strength when the entrepreneur is alone (344ms) compared to interacting with others (394ms) which fits with his background preferences to be engaging with other people.

Table 5-2: Participant A Activity Characteristics Comparison

Activity Characteristic =	Not Routine	Routine	Challenge	No Challenge	Uncertain Outcome	Certain Outcome	Setback	No Setback	Not Alone	Alone	Not Routine Challenge Uncertain Outcome	Not Routine Challenge Uncertain Outcome Setback	Not Routine Challenge Uncertain Outcome Not Alone	Not Routine Challenge Uncertain Outcome Alone
Number of Activities	128	92	28	192	159	61	2	144	149	71	19	0	11	8
MEAN-RMSSD (ms)	381	379	362	379	376	381	395	367	394	344	374		391	338
SD-RMSSD (ms)	79	65	69	74	75	67	95	78	57	86	68		67	58
MIN-RMSSD (ms)	124	146	218	124	124	135	328	124	180	124	261		266	261
MAX-RMSSD (ms)	466	457	461	466	466	456	462	466	466	443	461		461	408
RANGE-RMSSD (ms)	342	311	244	342	342	321	134	342	285	319	200		195	147
MEAN-Alert (%)	75%	72%	71%	75%	75%	72%	94%	72%	75%	73%	71%		70%	75%
SD-Alert (%)	11%	13%	13%	12%	12%	12%	1%	14%	11%	13%	11%		9%	14%
MEAN-Happy (%)	75%	74%	75%	74%	74%	73%	91%	89%	74%	73%	74%		75%	71%
SD-Happy (%)	14%	17%	14%	16%	15%	15%	2%	5%	16%	15%	14%		14%	14%
MEAN-Stressed (%)	74%	75%	77%	74%	75%	74%	72%	75%	73%	77%	79%		78%	79%
SD-Stressed (%)	12%	9%	10%	11%	12%	10%	22%	12%	11%	11%	9%		7%	11%

And activities characterised as not routine, a challenge, having an uncertain outcome when being alone showed the lowest mean RMSSD (338ms) of all combinations of characteristics. And similar to the activity comparison the range between highest RMSSD and lowest RMSSD was over 100ms in all cases and over 300ms in most cases and standard deviations between 57ms (alone) and 95ms (setback). Overall, these momentary results support the propositions that depleted self-regulation indicate entrepreneurs are performing more challenging or demanding activities while recovery indicates that entrepreneurs are performing more routine or comfortable activities, but the results can be inconclusive in certain cases or where the context to the moment is unclear. Subjective responses in the moment based on changes in only one characteristic of the activity all sat within a relatively narrow mean range of 70%

to 77% with a standard deviation at maximum 17% (SD-Happy for routine) and minimum of 9% (SD-stressed for routine) except for the setback/no setback set of characteristics which has a low number of activities (2) for setback and highest mean-happy (89%) outside of the range for all other single characteristics. Mean-stressed was highest (79%) for combinations of characteristics that were not routine, challenge, an uncertain outcome and mean-happy (71%) lowest when also alone. These results indicating the participant maintains their subjective responses with limited variability only through a typical day.

Support for the propositions that the action environment does have an effect on self-regulation and that self-regulation depletion or recovery can be an indicator of when activities are more or less demanding respectively is further illustrated by the momentary activity charts in Appendix 8.6 Section 8.6.1. There is one chart for each of the 30 days of period 1 as examples showing the fluctuating momentary changes in direction, duration, and intensity of RMSSD are occurring, some of which can be contextualised specifically with the ESM activity or supporting information collected showing where the activity is challenging or more demanding versus more routine or comfortable. For example on Thursday 2/August/2018, ten activities and their characteristics are shown with large fluctuations in RMSSD from 7:30–8:30 and 17:30–18:30 as well as a period of decline and then recovery between 19:00 and 21:30. Monday 13/August/2018 is also illustrative in regard to contextual information provided at a pitch event where participant A pitched to a large audience just after 6pm where a medium drop of RMSSD is seen and then quickly recovers to a high but when he receives feedback from the judges for his pitch in front of the audience at 7pm a large drop of momentary RMSSD is seen before quick recovery. Post this feedback he then networks and is excited and energised to be sharing his idea with attendees at the event as the moving average RMSSD rises over the next hour before steadily declining as he leaves the event and heads home to work on a not routine and an uncertain outcome analytical activity between 21:30 and 22:30 before recovering again and then getting ready for sleep.

A summary of daily and ongoing results for both periods 1 and 2 examining the change in daily self-regulation strength and subjective effectiveness measures ongoing over time are presented in Table 5-3. The change in REST\_RMSSD day to day shows daily self-regulation

fluctuations and in the first 8 days there is a decrease (-16ms), then increase (63ms), then decrease the next 2 days (-60ms, -7ms), an increase (59ms), a decrease for the next 2 days (-6ms, -22ms) and an increase (9ms). This pattern continues, most frequently alternating increases (green) and decreases (red) daily but sometimes two days and at most 3 days before a change throughout both periods. The quotes from the daily diary also frequently (but not always) show that a decrease (red) occurs on a subjective negative, stressful, challenging day while an increase (green) occurs on days which are more subjectively positive, less stressful, less challenging. As an example, in the first week decreases (red) on days that the participant commented were “stressful as usual”, “not enough time”, “not enough sleep” or “feel behind on work” and increases (green) on good days where the participant commented “Good day, MVP progress” or “Day was good” and some other context to progress or otherwise when he was pleased he worked hard to successfully complete a task for example “Grant submit by midnight deadline (pleased)”.

The change in the six effectiveness measures collectively also frequently (but not always) follow a similar pattern of red (worse) or green (better) related to the change in REST\_RMSSD. When REST\_RMSSD decreases (red) more of the change of measures are also red than green and when it increases (green) more of the change of measures are green than red. For example, on Thursday 2/August/2018 the change REST\_RMSSD decreases (-16ms) and change in effort, excited, stress and progress are also red with only satisfied and rested green. The following day Friday 3/August/2018 the change REST\_RMSSD increases (63ms) and change in excited, stress, progress and rested are also green with only effort and satisfied red. This pattern continues through both periods with frequently at least 4 variables green or red when change in REST\_RMSSD is green or red respectively but occasionally 5 or all 6 variables follow the pattern. For example, Tuesday 14/August/2018 all change is red and Thursday 9/August/2018 all change is green (or 0% change for excited). Some of the anomalies are also contextualised by events on that day, for example when there has been a late night of work, for example Monday 6/August/2018 rested (-54%) and stress (13%) are red due to the late work effort for “Grant submit by midnight deadline”. Or when there is a feeling of succeeding through challenging conditions, for example Thursday 23/August/2018 satisfied (33%) and excited (15%) are green because the outcome of some challenging meetings were positive

even though in his daily diary he commented “Running around, working on adrenalin, stressful meetings” through the day.

Overall, these daily results show that the cycles of depletion and recovery support the propositions that more often than not on days with depleted self-regulation that entrepreneurs have encountered more challenging or demanding activities while on days with recovery entrepreneurs have encountered more routine and positive activities. It also suggests that daily an entrepreneurs' self-regulation can deplete, and this negatively impacts their performance and wellbeing, but the effect is typically short, and the impact is variable as the entrepreneur cycles to recovery often the next day. And it follows that much like in the moment, that self-regulation for effective performance and wellbeing can be maintained through the day-to-day ups and downs of the entrepreneurs' journey.

Now examining the results on an ongoing and cumulative daily basis, the intensity of fluctuations in REST\_RMSSD were calculated and were greater in period 1 between depletion and recovery (range = 131ms, SD = 33ms) than period 2 (range = 115ms, SD = 28ms) and the mean RMSSD is higher in period 1 (56ms) than period 2 (46ms). The difference each day versus the average resting RMSSD across both periods (TOTAL AVG REST\_RMSSD = 52ms) also indicates that there is more consistent recovery (green) than depletion (red) in period 1 (17 versus 13 days) than period 2 (4 versus 14 days). In period 2 as the majority of the days see depletion the majority of the effectiveness measures also appear worse (red) as the daily trend has shown. This is further supported by contextual information gained from discussions with the entrepreneur as he is full of possibility for his new start-up business in period 1, focussed on plans and potential, while in period 2 he is challenged by technical development, funding, and other issues necessary to making the business viable. In period 2 also many of the routines the participant tries to maintain in his normal routine such as exercise in the gym on Mondays, Wednesdays and Fridays or enjoying networking lunches during the week or spending weekend evenings or Sundays with his wife or family and friends have declined in this intense period as he focussed on key priorities such as pitch preparation while also moving home and recovering from a period of illness.



Table 5-3: Participant A Daily Comparison

Day	Date	EFFORT	CHANGE EFFORT	SATISFIED	CHANGE SATISFIED	EXCITED	CHANGE EXCITED	STRESS	CHANGE STRESS	PROGRESS	CHANGE PROGRESS	RESTED	CHANGE RESTED	REST_RMSSD (ms)	CHANGE REST_RMSSD (ms)	DIFFERENCE vs AVG REST_RMSSD (ms)	Quotes from Participant Daily Diary
Wed	1/08/2018	100%		83%		95%		85%		100%		48%		47		-5	
Thu	2/08/2018	95%	-5%	97%	14%	74%	-21%	92%	7%	86%	-14%	69%	22%	31	-16	-21	Stressful as usual, Not enough time
Fri	3/08/2018	81%	-14%	79%	-18%	79%	5%	82%	-10%	97%	11%	100%	31%	94	63	42	Good Day, MVP Progress
Sat	4/08/2018	71%	-10%	99%	19%	84%	5%	58%	-24%	92%	-5%	54%	-46%	34	-60	-18	Feel behind on work, Not enough sleep/time this week
Sun	5/08/2018	77%	6%	86%	-13%	79%	-5%	83%	25%	87%	-5%	92%	38%	27	-7	-25	Feel behind on work, Not enough sleep/time this week
Mon	6/08/2018	81%	4%	99%	13%	80%	1%	96%	13%	87%	0%	38%	-54%	87	59	34	Grant submit by midnight deadline (pleased)
Tue	7/08/2018	69%	-12%	100%	1%	86%	6%	86%	-10%	71%	-16%	35%	-3%	80	-6	28	
Wed	8/08/2018	70%	1%	78%	-22%	79%	-7%	96%	10%	25%	-46%	65%	29%	58	-22	5	
Thu	9/08/2018	76%	6%	88%	10%	79%	0%	79%	-17%	94%	68%	71%	6%	67	9	15	Lots of working with people today
Fri	10/08/2018													43	-24	-9	Out late networking with clients
Sat	11/08/2018	76%		90%		72%		81%		92%		58%		61	18	9	Good Day, MVP Progress
Sun	12/08/2018	53%	-23%	82%	-8%	71%	-1%	63%	-18%	90%	-2%	68%	9%	62	1	10	family time during day, website work 7pm to late
Mon	13/08/2018	81%	28%	99%	17%	92%	21%	82%	19%	65%	-25%	66%	-2%	77	15	24	Pitch nerves but post pitch excited to talk about idea
Tue	14/08/2018	52%	-29%	85%	-14%	81%	-11%	83%	1%	62%	-3%	58%	-8%	50	-27	-3	Upset Bid lost
Wed	15/08/2018	66%	14%	90%	6%	85%	4%	86%	3%	65%	3%	94%	35%	34	-15	-18	Worry winning work + new bids (works late)
Thu	16/08/2018	67%	1%	85%	-6%	88%	4%	88%	1%	67%	2%	60%	-34%	88	53	35	Convinced client re proposal + Very busy
Fri	17/08/2018	71%	4%	86%	1%	79%	-9%	85%	-3%	84%	17%	62%	2%	55	-33	2	
Sat	18/08/2018	51%	-20%	83%	-3%	87%	8%	61%	-24%	62%	-22%	85%	23%	35	-19	-17	Little work today, need to catch up
Sun	19/08/2018	64%	13%	89%	6%	78%	-9%	100%	39%	62%	0%	62%	-23%	52	17	0	
Mon	20/08/2018	81%	17%	63%	-26%	73%	-5%	89%	-11%	63%	2%	62%	0%	67	15	15	Submit Bid (potential)
Tue	21/08/2018	71%	-10%	75%	13%	89%	16%	88%	-1%	90%	27%	42%	-20%	39	-28	-13	Hectic days, not enough sleep (working on bid)
Wed	22/08/2018	78%	7%	58%	-17%	74%	-15%	82%	-6%	87%	-3%	82%	40%	100	60	47	
Thu	23/08/2018	53%	-25%	92%	33%	89%	15%	81%	-1%	62%	-25%	57%	-25%	32	-67	-20	Running around, working on adrenalin, stressful meetings
Fri	24/08/2018	47%	-6%	60%	-32%	99%	9%	89%	8%	65%	3%	54%	-3%	28	-4	-24	Busy day

Sat	25/08/2018	51%	4%	61%	1%	92%	-7%	63%	-26%	51%	-14%	83%	29%	42	13	-11	
Sun	26/08/2018													58	16	6	
Mon	27/08/2018	48%		74%		68%		86%		67%		88%		55	-3	3	Wrap up work pre holiday
Tue	28/08/2018	72%	24%	56%	-18%	91%	22%	64%	-22%	60%	-6%	85%	-3%	86	31	33	Wrap up work pre holiday
Wed	29/08/2018	77%	5%	58%	3%	100%	9%	93%	29%	68%	8%	25%	-60%	69	-17	16	Holiday with wife, up early for flight to Cairns
Thu	30/08/2018													35	-34	-18	Work where possible (e.g. spent hike on phone)
Fri	9/11/2018	54%		65%		55%		76%		70%		65%		34		-18	Good Day, Evening movie with wife but work at same time
Sat	10/11/2018	45%	-10%	47%	-18%	66%	11%	47%	-29%	51%	-19%	65%	0%	31	-3	-22	Relaxing day with some embedded work
Sun	11/11/2018	65%	20%	76%	28%	62%	-4%	61%	14%	70%	19%	57%	-8%	35	4	-17	Organising various things + practice, practice my pitch
Mon	12/11/2018	49%	-16%	81%	5%	52%	-11%	82%	21%	68%	-2%	65%	8%	50	15	-2	Evening practicing my pitch + Team training for consulting
Tue	13/11/2018	52%	2%	59%	-22%	68%	16%	81%	-1%	68%	0%	60%	-5%	59	8	6	Evening final pitch practice + spoke to platform developer
Wed	14/11/2018													25	-33	-27	StartCon Melb pitch. Thinks gets sick from a friend at event
Thu	15/11/2018	72%		68%		59%		69%		65%		89%		30	5	-22	Startup program + team dinner, sick so energy low
Fri	16/11/2018													99	68	46	WFH while recovering from illness + Moving Home
Sat	17/11/2018																WFH while recovering from illness + Moving Home
Sun	18/11/2018																WFH while recovering from illness + Moving Home
Mon	19/11/2018																Hectic day working past midnight on bid to submit
Tue	20/11/2018	60%		68%		59%		69%		90%		57%		65		12	Day OK. Lacking energy & not a lot of sleep last night
Wed	21/11/2018	60%	0%	68%	0%	59%	0%	69%	0%	73%	-17%	65%	8%	37	-27	-15	Day was good. Gym at 5:30AM. Busy as usual
Thu	22/11/2018	55%	-5%	78%	11%	59%	0%	69%	0%	79%	6%	63%	-2%	44	7	-8	Not too productive today, booked tickets StartCon Sydney
Fri	23/11/2018													37	-7	-15	WFH, Prep for StartCon + admin, tech issues
Sat	24/11/2018													49	12	-3	Prep for StartCon + admin, tech issues
Sun	25/11/2018													38	-11	-14	Prep for StartCon + admin, tech issues
Mon	26/11/2018	60%		72%		59%		69%		65%		71%		45	7	-8	WFH, some admin and prep for StartCon
Tue	27/11/2018	51%	-10%	65%	-7%	52%	-7%	69%	0%	79%	14%	69%	-2%				Consulting today + prep for StartCon
Wed	28/11/2018	52%	1%	59%	-5%	56%	5%	69%	0%	73%	-6%	63%	-6%	44	44	-8	Consulting, then pitch deck (submit 5pm) & final practice
Thu	29/11/2018													72	27	19	Accelerator funding pitch (410PM) then rush to airport
Fri	30/11/2018													25	-46	-27	StartCon pitches (12:22PM, 4:30PM) -a bit stressed

Colour Legend:      Red = negative change in direction of value (darkest is highest value in direction of individual range, becomes lighter the closer to zero/neutral)  
                             Green = positive change in direction of value (darkest is highest value in direction of individual range, becomes lighter the closer to zero/neutral)

These results collectively provide support to the proposition that overtime, cumulatively if there is more depletion and not enough recovery of self-regulation then the entrepreneur's effectiveness is negatively impacted in some ways. This is further illustrated graphically in Appendix 8.5 Section 8.6.2 where the daily and ongoing results are shown visually as an example for period 1 in Figure 8-3 and period 2 in Figure 8-4 and then compared in Figure 8-5. Examining Figure 8-5, the decreasing average REST\_RMSSD values on this ongoing basis and the subjective effectiveness measures against RMSSD decline between period 1 and 2. For period 1 the direction of effort tracks RMSSD relatively consistently so when RMSSD trends up effort trends up and when RMSSD trends down effort trends down. Satisfaction and progress as well as stress and rested track consistently on some days but are also opposite in other days.

The linear trend of subjective effort, satisfied, and progress measures contextualised by his start-up activity decline over period 1 as the entrepreneur is challenged in his time management and prioritisation versus consulting and other conflicts in his time. He does not feel he is putting in the effort needed, and his progress and satisfaction do not meet his subjective expectations. His excitement, stress and rested linear trend hold relatively constant in period 1 as he navigates this ongoing workload in his disciplined and structured manner. In period 2 the trend of subjective measures remains broadly constant as this period is contextualised by consistent intense work practicing his pitch for funding and resolving technical development challenges but with a feeling of some progress being made as he prepares and delivers his pitches. The level of subjective measures for effort and satisfied that declined in period 1 remain at around the same depressed level throughout period 2. Measures of excitement and stress are at a lower level in period 2, his excitement of being an entrepreneur is very low compared to period 1 but his perceived feeling of stress is also lower. His rested measure stays relatively constant across both periods and it is only the measure of progress that is increasing in period 2 compared to the decline seen in period 1.

## **5.2. Case Study - Participant B**

Participant B (male, age 34) runs a customer focussed web and mobile app development agency. He is an experienced digital entrepreneur having founded four businesses including successfully selling his previous product development business. He sleeps on average 7-8 hours a night but often does not feel well rested when he wakes up. He is married and his highest education level is a diploma. He describes himself as a risk taker, who is creative and interested in most things, who is organised and willing to do whatever it takes to reach a goal or achieve an outcome. He is passionate about finding the best solution and works hard to achieve them and is happy to stand apart from others and do things differently if he feels that is the right approach. He comments that he is overly active and compelled to do things, like he is driven by a motor, but the end outcome is more important to him than focussing on every detail. He feels comfortable dealing with most challenges, issues and difficult situations during his journey but worries about reaching the best outcome. Being a founder and growing the company is not important to him but owning his own company and being able to choose to take on difficult and challenging work and having opportunities to develop new skills and knowledge is very important to him.

He has over 10 years' experience in his field working with clients to support their digital innovation and is passionate about using technology to improve processes. This passion crosses over to how he manages and understands his own life, as he has developed and uses his own tools and systems to track his activity, use of time, productivity (both personal and client covering finance and progress) and other performance and wellbeing factors of interest to him such as coffee consumption, mood, exercise, and diet. In his journey as an entrepreneur, he acknowledges he has had past challenges with his mental health and wellbeing often working obsessively hard in the pursuit of the best solutions which led him to make changes to how he manages and monitors his mind and body and overall work life balance. He is interested and willing to engage with health practitioners and psychologists, wellbeing innovators and new products (he uses an apple watch to monitor his health) to continue to understand and improve his own self-awareness and self-management and for example has tested his cortisol, hormone, blood, and other factors on a semi regular basis. He is open to solutions and learnings from any field and is willing to take risks to experiment

with them seeking to test it himself and verify effects using his own data, accepting the parts he finds effective and useful for him and his routine and disregarding anything that doesn't.

Seeing himself as a creative individual with many interests and pursuits within and beyond work, participant B's normal work and life routine can vary significantly from day to day and week to week. His mornings though typically start at around 6:30 with a cup of coffee, and then he will drink three or more coffees through the morning usually finishing with a final coffee at around 10:00 (he says he can't have coffee after 11:00 otherwise he won't be able to sleep that evening). He will have regular meetings with his team of ten both individually and in groups to discuss issues and integration challenges for projects, but the day and timing will vary, and can be face to face, over the phone or online. Half day workshops to scope and co-design solutions with clients are common and necessary steps in his process. He will also spend focussed periods of time on systems architecture, software development and user experience himself to get to the best solutions, during the day or also evenings depending on project deadlines and will sometimes work on Sundays as and when project needs require. Some days he would be asleep by 21:30, other days he would not go to sleep until past midnight and sometimes 1:00 or later so there was no consistency in his end of day and sleeping routine. He did always rest on Saturdays, not working in observation of the Sabbath. He handles project and client management as required and uses his own systems to try and manage this efficiently. He allocates time for his marriage, personal and health and wellbeing within his weekly schedule with the aim to balance his work life effort on a consistent basis.

Data collection for participant B occurred in 2019 over 95 days between 4/September/2019 and 7/December/2019. Over this period there was 56 days with E4 data and 37 days with ESM end of day survey information collected. He did not complete regular activity surveys like other participants as this did not fit in his existing daily data recording routine and habits however other contextual information was provided, including his own processes for tracking of activity, finance, project, time, coffee consumption and mood for select periods during data collection. The first 12 days of data collection was very consistent before he became sick and was not working for several days where data collection stopped. He became really sick over this week and had to work on select days due to some necessary meetings but overall was

only getting limited work done while trying to recover and over this period data collection became less consistent sometimes completing end of day surveys, sometimes wearing the E4 but stopping his normal data collection processes. The next two weeks see intermittent collection before an 11-day gap (starting 5/October/2019) in end of day survey completion while E4 collection remained inconsistent during a busy working period. Following this through to the end of the study, data collection consistency improved but end of day surveys most weekends and some Fridays were missed. Through the entire period when he did complete the end of day survey it showed good levels of detail and reflection however it was a challenge for him to make time in his routine to do it consistently at the end of the day as he did not have a consistent routine in the evenings and sometimes he would complete the survey the next day or days later reflecting back on multiple days.

As this participant did not complete regular activity surveys as he used his own very personalised data recording routine there is no summary of momentary results in line with the conceptual framework examining the interactive influence of his activities on self-regulation strength and subjective responses. A summary of daily and ongoing results for the 95-day collection period is presented in Table 5-4 examining the change in daily self-regulation strength and daily subjective effectiveness measures ongoing over time. The change in REST\_RMSSD day to day shows daily self-regulation fluctuations and in the first week there are only two readings as data collection was inconsistent, both increases (+10ms, +31ms). From Friday 13/September/2019 there are 5 days in sequence starting with a decrease (-25ms), then two days of increases (13ms, 18ms), a decrease (-36ms) and a decrease (14ms). Inconsistent E4 collection from participant B shows change in primarily one but sometimes up to two or three consecutive days through the remainder of the collection period with the majority of instances where data was collected being increases (green) on days through to mid-October and decreases (red) after this through to the final 3 day consecutive sequence being a decrease (-19ms), increase (26ms) and decrease (-16ms) ending on 11/November/2019 (the last day of data collected by participant B).

Table 5-4: Participant B Daily Comparison

Day	Date	EFFORT	CHANGE EFFORT	SATISFIED	CHANGE SATISFIED	EXCITED	CHANGE EXCITED	STRESS	CHANGE STRESS	PROGRESS	CHANGE PROGRESS	RESTED	CHANGE RESTED	REST_RMSSD (ms)	CHANGE REST_RMSSD (ms)	DIFFERENCE vs AVG REST_RMSSD (ms)	Quotes from Participant Daily Diary
Wed	4/09/2019	67%		89%		78%		33%		44%		50%					Good day doing admin& catching up/no real fee work.
Thu	5/09/2019	33%	-33%	67%	-22%	89%	11%	33%	0%	56%	11%	30%	-20%	23		-28	Slow day, resetting after a big few last weeks.
Fri	6/09/2019													33	10	-19	
Sat	7/09/2019	0%		67%		89%		0%		22%		70%		64	31	12	Rest day for Sabbath, so no work, but thinking on things
Sun	8/09/2019	11%	11%	78%	11%	78%	-11%	0%	0%	56%	33%	90%	20%				Made a lot of creative progress, very happy with that
Mon	9/09/2019	67%	56%	67%	-11%	78%	0%	33%	33%	56%	0%	100%	10%	45		-6	Busy, covered a-lot off today and seeing progress
Tue	10/09/2019	56%	-11%	78%	11%	89%	11%	33%	0%	44%	-11%	80%	-20%				Good day at capital raising workshop
Wed	11/09/2019	67%	11%	78%	0%	78%	-11%	33%	0%	67%	22%	80%	0%				Sent off report to client, met with executive coach
Thu	12/09/2019	67%	0%	89%	11%	89%	11%	44%	11%	78%	11%	20%	-60%	61		10	Got a lot done- client & admin, worked 14hrs but all good
Fri	13/09/2019	100%	33%	100%	11%	100%	11%	67%	22%	100%	22%	40%	20%	37	-25	-14	Shot promotional video for new POS product
Sat	14/09/2019	11%	-89%	89%	-11%	89%	-11%	0%	-67%	33%	-67%	90%	50%	50	13	-1	Rest Day, but finalised legal docs (expensive) in PM
Sun	15/09/2019													67	18	16	
Mon	16/09/2019	78%		56%		67%		67%		56%		90%		31	-36	-20	Nasty run in with a horrible CEO+consultant (both frustrating)
Tue	17/09/2019													45	14	-7	Feeling sick, not working
Wed	18/09/2019																Sick, not working
Thu	19/09/2019	44%		44%		56%		33%		44%		70%					Been sick, doing bits & pieces, anxious about things I have to do
Fri	20/09/2019	67%	22%	67%	22%	78%	22%	22%	-11%	44%	0%	50%	-20%	34		-17	Still sick but had meetings (went well), client has 3 projects for us
Sat	21/09/2019													27	-7	-24	Resting, still sick
Sun	22/09/2019																
Mon	23/09/2019	67%		56%		56%		44%		56%		80%		23		-28	Blah day, corporate advisor quit(not helpful), slow progress



Tue	24/09/2019	67%	0%	89%	33%	100%	44%	44%	0%	78%	22%	80%	0%				Client progress, projects meeting went well. Work piling up
Wed	25/09/2019																
Thu	26/09/2019													36		-15	Worked late
Fri	27/09/2019	78%		100%		100%		89%		78%		60%		48	12	-3	Great day, closed a client, good meetings & panel discussion
Sat	28/09/2019	22%	-56%	78%	-22%	78%	-22%	0%	-89%	22%	-56%	70%	10%				Relaxing day of rest
Sun	29/09/2019	33%	11%	78%	0%	89%	11%	22%	22%	67%	44%	80%	10%	69		18	Good day, went for walk. Worked on investor docs (progress)
Mon	30/09/2019	56%	22%	44%	-33%	44%	-44%	33%	11%	56%	-11%	50%	-30%	32	-37	-19	Admin stuff for boring clients, trying to get on top of work
Tue	1/10/2019	22%	-33%	22%	-22%	33%	-11%	100%	67%	11%	-44%	40%	-10%	62	30	11	Crisis mode (personal/work) issues, stressful but resolved
Wed	2/10/2019																
Thu	3/10/2019																
Fri	4/10/2019	78%		78%		78%		44%		56%		70%		56		5	Good client meetings - hopefully easier work load
Sat	5/10/2019													150	94	99	
Sun	6/10/2019																
Mon	7/10/2019																
Tue	8/10/2019													49		-2	
Wed	9/10/2019																
Thu	10/10/2019																
Fri	11/10/2019													31		-20	
Sat	12/10/2019													39	9	-12	
Sun	13/10/2019																
Mon	14/10/2019													37		-15	
Tue	15/10/2019													16	-21	-36	
Wed	16/10/2019	78%		78%		89%		44%		67%		80%					New client signed + movement with other projects
Thu	17/10/2019	56%	-22%	89%	11%	89%	0%	33%	-11%	56%	-11%	80%	0%	30		-22	New client kick off. Team member back to help with work load
Fri	18/10/2019	78%	22%	100%	11%	100%	11%	22%	-11%	78%	22%	80%	0%				Closed client. Huge week-things happening! Super excited!!
Sat	19/10/2019																
Sun	20/10/2019																
Mon	21/10/2019	67%		78%		89%		56%		67%		40%		69		18	Stressful day (personal), now in a good place, got admin done

Tue	22/10/2019													35	-34	-16	
Wed	23/10/2019																
Thu	24/10/2019																
Fri	25/10/2019	56%		78%		89%		56%		67%		70%		130		79	Good day busy with new clients & opportunities
Sat	26/10/2019													49	-81	-2	
Sun	27/10/2019																
Mon	28/10/2019	78%		89%		89%		56%		89%		80%		48		-3	Good day, significant progress on tech projects
Tue	29/10/2019	78%	0%	89%	0%	89%	0%	44%	-11%	56%	-33%	80%	0%	44	-4	-7	Good day. Happy clients, on top of everything!
Wed	30/10/2019	67%	-11%	78%	-11%	78%	-11%	44%	0%	56%	0%	80%	0%	31	-13	-20	Meh day, busy, sprint reviews went well which was good
Thu	31/10/2019	89%	22%	89%	11%	89%	11%	56%	11%	89%	33%	60%	-20%				Good day, 4 massive sprint reports, achieved a lot
Fri	1/11/2019																
Sat	2/11/2019																
Sun	3/11/2019																
Mon	4/11/2019	33%		44%		67%		22%		56%		80%		138		87	Took day off.
Tue	5/11/2019	33%	0%	78%	33%	78%	11%	11%	-11%	56%	0%	80%	0%	87	-51	36	Public holiday. Time off with wife. Did design work/email later
Wed	6/11/2019	56%	22%	78%	0%	89%	11%	67%	56%	67%	11%	90%	10%	30	-57	-21	Busy back at it. Good day, a few good wins with clients
Thu	7/11/2019																
Fri	8/11/2019	67%		78%		78%		33%		67%		30%		53		2	Lots of admin today. Getting on-top of it all though
Sat	9/11/2019													34	-19	-17	
Sun	10/11/2019	22%		78%		89%		0%		11%		80%		60	26	9	Rest day
Mon	11/11/2019													44	-16	-7	

Colour Legend: Red = negative change in direction of value (darkest is highest value in direction of individual range, becomes lighter the closer to zero/neutral)  
Green = positive change in direction of value (darkest is highest value in direction of individual range, becomes lighter the closer to zero/neutral)

The quotes from the daily diary sometimes but not always support that a decrease (red) in RMSSD occurs on a subjective negative, stressful, challenging day while an increase (green) occurs on days which are more restful and subjectively positive, less stressful, less challenging. The change in daily effectiveness measures are also inconsistent in relation to being primarily red (worse) or green (better) for the majority of the six measures when the change in REST\_RMSSD is red or green respectively. The data however does indicate that daily an entrepreneurs' self-regulation can deplete, and this can negatively impact the entrepreneur's effectiveness but also on some days this depletion does not negatively impact the subjective effectiveness measures indicating the effect is variable in the day-to-day short context. Participant B completed end of day surveys on 37 days and E4 recordings on 56 days but was very inconsistent in collection of both on the same day resulting in only 22 days out of 95 in the period but only 9 days with consecutive readings where the day-to-day change in self-regulation and subjective effectiveness measures from one day to the next is seen. This provided limited data or other contextual information that was conclusive supporting or opposing the relationship between the change in the entrepreneur's self-regulation and change in subjective effectiveness.

Looking at the ongoing and cumulative trends in the data examining the difference each day versus the average resting RMSSD across the collection period (TOTAL AVG REST\_RMSSD = 51ms) there are a couple of periods of a week or more where there is consistent depletion (red) mixed with days with no E4 collection. For example over two working weeks and the middle weekend from Monday 16/September/2019 through to Friday 27/September/2019 where the difference versus the average is red (-20, -7, -17, -24, -28, -15, -3 ms) and quotes from the daily diary starts with "Nasty run in with a horrible CEO + consultant (both frustrating)" before getting and then remaining sick, the first day "Feeling sick, not working" then varies as he tries to work where possible while also resting to recover stating "Been sick, doing bits & pieces, anxious about things I have to do" or "Still sick but had meetings (went well), client has 3 projects for us". A second example occurs between Tuesday 8/October/2019 and Thursday 17/October/2019 where the difference versus the average is red (-2, -20, -12, -15, -36, -22 ms) but there is limited contextual data for most of this period as there was no end of day surveys and daily diary entries completed and the only context

given was that this was an intense and busy period of work. Around these periods of depletion, the ongoing trend shows fluctuation between recovery (green) and depletion (red) where contextual information supports that the difference is green on days that are more restful and subjectively positive, less stressful, less challenging, and red on days that are busier and more subjectively negative, stressful, and challenging.

Therefore although there were only 9 days comparing the change in daily self-regulation and effectiveness measures, the 22 days overall with both self-regulation and effectiveness measures collection alongside other contextual data supports the proposition that the action environment has an effect on the entrepreneur's self-regulation strength and generally that depleted self-regulation indicates entrepreneurs are performing more challenging or demanding activities, and recovery indicates more positive or relaxed activities, albeit that the results can be variable in the shortened day to day context. The results show that individual performance and wellbeing can be maintained through the day-to-day ups and downs of the entrepreneurs' journey where effectiveness can be subjectively high even when self-regulation is low on a given day but that overtime, cumulatively if there is more depletion and not enough recovery of self-regulation that the entrepreneur's effectiveness is negatively impacted in some ways. However, given the length of the collection period more efficient data collection by the participant throughout the period would have been useful and more conclusive.

### **5.3. Case Study – Participant C**

Participant C (male, age 27) has spent the last six months actively starting a new online marketing business. He has only one year of experience in the industry he is starting his business, and this is the second time he has started a new business. He is artistic and creative and has a passion for music which includes working as a deejay to provide income. He has never been married and his highest education level is a bachelor's degree. He describes himself as easy going and relaxed, organised but not obsessively so, and neither optimistic nor pessimistic. He prefers work that involves active social interaction than being alone, believes he is good at paying attention to details and works hard to achieve a goal. He is outgoing and dynamic, interested and challenged by new ideas and unconventional views but when working can find it challenging to get things planned out and may often delay getting started on tasks requiring a lot of thought and have difficulty wrapping up the finer details once the challenging parts have been done. His preference is not to take large risks and to be able to find a balance between work and personal goals. He spends about 70% of working hours on his business and recognises that his current business may not succeed. Being a founder is important to him and he enjoys the process of engaging with clients to sell products/services but owning and nurturing companies and the process of assembling the right skills to run a business is not important or a motivation for him.

Participant C's normal routine changes based on whether he is deejaying that evening or not and can be during the week or weekend. His morning routine normally involves waking up around 7:00 in the morning but he may sleep later depending on the evening before and anytime between 7:00-9:00 he is getting ready for the day or catching up on tasks from the night or day before. This could be emails, social media, returning a phone call, chasing invoices, or investigating an artist for deejaying or if needed going for a walk to think and contemplate his actions for the day. If he is not deejaying that evening he leaves home to catch a train between 9:00 – 10:00 taking around one hour into the city to work where he may continue activities preparing for the day. He then works from ~10:00–15:00, these 4-5 hours focussed on getting his core work done, only breaking sometimes to get a coffee with friends or networking for business. He does not break for lunch until 15:00, knowing he is a little unproductive after this time, so he grabs lunch, checks emails, thinks, watches YouTube,

mullets over ideas and as he puts it procrastinates only working on small tasks through to the end of the day at ~17:30. He then often heads to a networking event through to 20:00/20:30 before heading either home or to his girlfriends, catching up on work for the hour on the train again. If at home, he will spend some time mixing or producing music as his creative outlet and occasionally will meditate or read a book briefly before going to bed at 23:00 and no later than midnight. If he does have a gig and is deejaying his morning routine stays the same until 11:00 where he'll pick up a rental car, then returns home and does focussed work until 15:30. He then packs the car which is quite stressful for him as he has a lot of deejaying equipment before showering and getting ready, driving to the venue aiming to arrive by 18:00. He sets up at the venue and networks before his performance from 20:00/20:30 through to end at 23:00/23:30, packing up his equipment and returning home in the early hours of the morning.

Participant C was willing and eager to participate in the study engaging in the setup and opportunities to meet and engage with others involved. Data was collected between 18/September/2019 and 6/November/2019 but collection frequency and duration each day was very inconsistent with 18 and 17 days of E4 and ESM data collected respectively but frequently days only included a shorter daily E4 measurement and no resting or sleeping measurement and or no ESM survey completion on the same day as wearing the E4. His data collection was consistent for both E4 and ESM the first five weekdays of the study period split across two weeks (Wednesday- Friday and then Monday-Tuesday) before all routine in his collection was disrupted resulting in sporadic wearing of the E4 and completing ESM surveys despite reminders and follow-ups and a stated desire from the participant to continue with the study. The results for participant C are limited in this regard and its inclusion is more for methodological and practical learning of the complexity of long duration collection from participants.

A summary of momentary results examining the interactive influence of participant C's activities on self-regulation strength and subjective responses are presented in Table 5-5 and Table 5-6. Table 5-5 indicates the most common activity recorded was Travel (12) and Personal (4) highlighting the limited number of work activities participant C was able to record overall and his difficulty in general following the collection process for the study. The mean

RMSSD was lowest for work activities learn and develop (353ms) and consult and sell (386ms) and the mean-alert (88% for both) and mean-stress (88% and 90%) was near or at the highest levels for both. Mean-happy (64% and 55%) was also at lowest points for both. Overall, the RMSSD was lowest for personal (322) and indicated low mean-stress (33%) and mean-alert (51%) and mean-happy (65%) that was close to the low of the learn and develop activity (64%).

Table 5-5: Participant C Activity Comparison

Activity =	Exchange information and opinion	Work analytically and conceptually	Organise and coordinate	Network and maintain relationships	Direct and lead	Learn and develop	Monitor and control	Consult and sell	Travel	Personal	Non entrepreneur work or study
Number of Activities	2	3	2	0	0	2	0	1	12	4	2
MEAN-RMSSD (ms)	445	440	436			353		386	395	322	436
SD-RMSSD (ms)	5	21	6			109			56	169	9
MIN-RMSSD (ms)	441	415	431			276		386	262	70	430
MAX-RMSSD (ms)	448	453	440			430		386	448	422	442
RANGE-RMSSD (ms)	7	37	9			154		0	186	351	12
MEAN-Alert (%)	44%	59%	90%			88%		88%	62%	51%	77%
SD-Alert (%)	27%	25%	15%			3%			24%	8%	3%
MEAN-Happy (%)	78%	71%	71%			64%		55%	69%	65%	76%
SD-Happy (%)	7%	30%	22%			18%			23%	20%	2%
MEAN-Stressed (%)	80%	39%	72%			88%		90%	63%	33%	44%
SD-Stressed (%)	18%	43%	22%			5%			24%	23%	3%

Results in Table 5-6 show that activities that are challenging (427ms) or have a setback (420ms) are less depleting for participant C than activities that are not challenging (399ms) or no setback (390ms) while not routine (405ms) vs routine (407ms) and uncertain (407ms) vs certain (405ms) outcome or being alone (399ms) vs not alone (392ms) showed a similar result. The range between highest RMSSD and lowest RMSSD was between 66ms and 382ms for all characteristics with challenge (66ms) and setback (82ms) having the smallest range and not alone (378ms) and no setback (382ms) having the largest. However, for each characteristic the number of responses is very small making the results inconclusive in regard

to depletion indicating performing more challenging or demanding activities while recovery indicating performing more routine or comfortable activities.

Subjective responses in the moment based on changes in only one characteristic of the activity mostly sat in the range of 60%-70% however mean-alert was highest (74%) for non-routine activities and lowest (51%) for routine activities; mean-happy was highest (76%) for routine activities and lowest (62%) for activities with an uncertain outcome; and mean-stress was highest (73%) for routine activities and lowest (44%) when there was a setback. These results could indicate that participant C was perhaps more emboldened and engaged by setback or challenge, was happy with some of his routine but also felt stress when no new work or challenge was available as he tried to engage himself in building his venture. Only one activity was not routine, a challenge and had an uncertain outcome and had the lowest mean RMSSD (386ms) and highest mean-alert (88%) and mean-stress (90%) and lowest mean-happy (55%) showing that a particularly difficult activity was depleting and stressful as expected.

Table 5-6: Participant C Activity Characteristics Comparison

Activity Characteristic =	Not Routine	Routine	Challenge	No Challenge	Uncertain Outcome	Certain Outcome	Setback	No Setback	Not Alone	Alone	Not Routine Challenge Uncertain Outcome	Not Routine Challenge Uncertain Outcome Setback	Not Routine Challenge Uncertain Outcome Not Alone	Not Routine Challenge Uncertain Outcome Alone
Number of Activities	14	8	5	17	7	15	5	23	14	14	1	0	1	0
MEAN-RMSSD (ms)	405	407	427	399	407	405	420	390	392	399	386		386	
SD-RMSSD (ms)	63	41	28	59	68	49	85	31	96	66				
MIN-RMSSD (ms)	262	326	386	262	262	276	370	70	70	262	386		386	
MAX-RMSSD (ms)	453	452	453	448	452	453	452	448	448	453	386		386	
RANGE-RMSSD (ms)	190	126	66	186	190	177	82	382	378	190				
MEAN-Alert (%)	74%	51%	70%	65%	59%	69%	64%	65%	64%	65%	88%		88%	
SD-Alert (%)	18%	28%	23%	25%	27%	23%	29%	21%	21%	25%				
MEAN-Happy (%)	65%	76%	69%	69%	62%	72%	63%	70%	68%	70%	55%		55%	
SD-Happy (%)	23%	15%	22%	21%	19%	21%	24%	26%	15%	24%				
MEAN-Stressed (%)	62%	73%	60%	67%	72%	63%	44%	63%	62%	57%	90%		90%	
SD-Stressed (%)	30%	21%	41%	23%	23%	29%	23%	34%	27%	29%				



While the number of activities recorded by participant C in the study are limited, the results in Table 5-5 and

Results in Table 5-6 show that activities that are challenging (427ms) or have a setback (420ms) are less depleting for participant C than activities that are not challenging (399ms) or no setback (390ms) while not routine (405ms) vs routine (407ms) and uncertain (407ms) vs certain (405ms) outcome or being alone (399ms) vs not alone (392ms) showed a similar result. The range between highest RMSSD and lowest RMSSD was between 66ms and 382ms for all characteristics with challenge (66ms) and setback (82ms) having the smallest range and not alone (378ms) and no setback (382ms) having the largest. However, for each characteristic the number of responses is very small making the results inconclusive in regard to depletion indicating performing more challenging or demanding activities while recovery indicating performing more routine or comfortable activities.

Subjective responses in the moment based on changes in only one characteristic of the activity mostly sat in the range of 60%-70% however mean-alert was highest (74%) for non-routine activities and lowest (51%) for routine activities; mean-happy was highest (76%) for routine activities and lowest (62%) for activities with an uncertain outcome; and mean-stress was highest (73%) for routine activities and lowest (44%) when there was a setback. These results could indicate that participant C was perhaps more emboldened and engaged by setback or challenge, was happy with some of his routine but also felt stress when no new work or challenge was available as he tried to engage himself in building his venture. Only one activity was not routine, a challenge and had an uncertain outcome and had the lowest mean RMSSD (386ms) and highest mean-alert (88%) and mean-stress (90%) and lowest mean-happy (55%) showing that a particularly difficult activity was depleting and stressful as expected.

Table 5-6 indicate that changes in activities and characteristics of the action environment do have an effect on momentary self-regulation and there is variation in the subjective responses across different activity characteristics in the moment, but they are generally maintained within a limited range through for example a setback or challenge. The daily and ongoing results are provided for participant C in Table 5-7 and are limited beyond the first 7 days of

collection due to the inconsistent data collection by participant C but highlight some novel findings. On Friday 20/September/2019 participant C participates in an afternoon protest march (Global Climate Strike) in Melbourne city and that night records an extremely high REST\_RMSSD (405ms) and although he makes less progress (-9%) in his work and is more stressed (+6% change to absolute high of 99%) than the extremely negative day before all other indicators are positive (green) as he feels he has put in more effort (+38%), is more satisfied (+41%), more excited (37%) and more rested (+40%) than the day before aligning with comments in discussion of feeling more engaged and positive due to taking some action by participating in the protest.

A few days later on Tuesday 24/September/2019 participant C has a low REST\_RMSSD (82ms) and a large decrease from the day before (-93ms) on a day where his diary states "Sister rang (getting married), work planning & meetings to 730pm" in that he receives a call early in the morning from his sister to tell him she is getting married and ask him to walk her down the aisle. He then has a busy day with meetings until 19:30 where for the day his stress has increased (+43% to absolute high of 100%) and he is less excited (-8%) but he feels he has put in more effort (+38%), is slightly more satisfied (+4%), has made more progress (+8%) and feels more rested (+23%) than the day before possibly indicating a weight of expectation and activity is now upon him in his business but also personally with his sister marrying. Though this is a limited set of daily data these daily fluctuations of subjective measures and cycles of depletion and recovery in REST\_RMSSD between days indicate that daily an entrepreneurs' self-regulation can deplete, and this can negatively impact the entrepreneur's effectiveness, but the effect is short, and the impact is variable as the entrepreneur cycles to recovery often the next day.

Table 5-7: Participant C Daily Comparison

Day	Date	EFFORT	CHANGE EFFORT	SATISFIED	CHANGE SATISFIED	EXCITED	CHANGE EXCITED	STRESS	CHANGE STRESS	PROGRESS	CHANGE PROGRESS	RESTED	CHANGE RESTED	REST_RMSSD (ms)	CHANGE REST_RMSSD (ms)	DIFFERENCE vs AVG REST_RMSSD (ms)	Quotes from Participant Daily Diary
Wed	18/09/2019	68%		100%		96%		43%		100%		0%		167		-7	Day satisfying overall but need to measure time more effectively
Thu	19/09/2019	28%	-40%	20%	-80%	48%	-48%	93%	49%	56%	-44%	22%	22%				Too busy, equipment/admin hassles
Fri	20/09/2019	66%	38%	61%	41%	85%	37%	99%	6%	47%	-9%	62%	40%	405		231	Phone call surveys, joined Melb. protest, some work on bus home
Sat	21/09/2019																
Sun	22/09/2019																
Mon	23/09/2019	52%		77%		87%		57%		48%		46%		172		-2	Slept in, big emotional weekend, left work in AM (rested instead)
Tue	24/09/2019	91%	38%	82%	4%	79%	-8%	100%	43%	56%	8%	69%	23%	82	-90	-93	Sister rang (getting married), work planning & meetings to 730pm
Wed	25/09/2019																
Thu	26/09/2019																
Fri	27/09/2019																
Sat	28/09/2019																
Sun	29/09/2019																
Mon	30/09/2019																
Tue	1/10/2019													161		-13	
Wed	2/10/2019	100%		75%		59%		90%		58%		62%					Emails, personal study in AM, project meeting in PM
Thu	3/10/2019													116		-58	
Fri	4/10/2019																
Sat	5/10/2019																
Sun	6/10/2019																
Mon	7/10/2019																
Tue	8/10/2019																

Wed	9/10/2019																
Thu	10/10/2019																
Fri	11/10/2019																
Sat	12/10/2019																
Sun	13/10/2019																
Mon	14/10/2019	23%		59%		52%		87%		39%		56%					Admin/phone calls in AM, coordination and interviews PM
Tue	15/10/2019																
Wed	16/10/2019	88%		85%		100%		58%		100%		100%					Admin in AM, meetings in PM then analytical work to late
Thu	17/10/2019																
Fri	18/10/2019																
Sat	19/10/2019																
Sun	20/10/2019																
Mon	21/10/2019																
Tue	22/10/2019																
Wed	23/10/2019																
Thu	24/10/2019																
Fri	25/10/2019													116		-58	Up late deejaying

Colour Legend: Red = negative change in direction of value (darkest is highest value in direction of individual range, becomes lighter the closer to zero/neutral)  
Green = positive change in direction of value (darkest is highest value in direction of individual range, becomes lighter the closer to zero/neutral)

Overall, there are not enough ongoing or cumulative results collected from participant C to give context to explore if more depletion and not enough recovery has an ongoing negative impact on participant C's effectiveness. As the REST\_RMSSD values were only recorded for a handful of days the average resting RMSSD (TOTAL AVG REST\_RMSSD = 174ms) is skewed considerably by the one extremely high REST\_RMSSD value (405ms) on Friday 20/September/2019 which indicates that the average value for the period is not accurate and cannot be used for a comparison versus daily values. The REST\_RMSSD values recorded for the majority of days are also higher than what would normally be expected so it is uncertain if this is a consistent trend for this participant or an anomaly based on some of the comments representing some uniquely challenging days in terms of activities or emotions during those days.

#### **5.4. Case Study – Participant D**

Participant D (male, age 39) is the CEO and co-founder of his first entrepreneurial business which he has been working on for over 3 years in an industry that was new to him. He has invested over \$250,000 of his own savings in this business over this period to establish and grow the business but it has yet to turn a profit. He developed the original business idea and is satisfied with the performance of the business to date which has required research and development of a technical solution. He sleeps on average 7 hours a night and his highest education level is higher university degree (Masters). He describes himself as being confident in his opinions (and other people sometimes tell him he is stubborn), efficient and accurate in how he works but believes most people are more dynamic and upbeat than him. He is enthusiastic, excited, and confident about the business idea and its potential but worries that he may not be able to secure the financial resources and manage cash flow to continue to operate the business. He sometimes feels stressed, despondent, or depressed but is confident that tough problems won't get him down, that he can keep persisting and bounce back when things go badly. He is prepared to take risks to succeed and work hard on challenging work which also give him opportunities to develop new skills and knowledge. He disagrees that his life is close to ideal and neither agrees nor disagrees that he is satisfied with his life. Owning his own company and establishing the company does not excite or energize him but being a founder, assembling the right people to build the business, and solving unmet market needs that can be commercialised is important to him and his identity.

Participant D's routine reflects his responsibility for all aspects of his business and supporting a small team of six. He wakes up usually between 6:00-8:00 in the morning and goes to sleep between 22:00 and midnight and normally gets about 6-7 hours of sleep. Through the day he has both internal and external meetings, by phone or face to face, engaging his team, finding customers, and working on fundraising. Between meetings he may be travelling to his next meeting or working so he is frequently stopping and starting different activities. He spends much of his time synthesising information from different sources, providing direction or feedback to his team, discussing his product/service, and selling to customers, thinking about strategy and his business model engaging with potential funders. He spends some time each week usually one or two evenings as part of a start-up mentoring program, supporting his

fundraising, and getting other perspectives on his strategy. Other evenings he may have a late meeting, attend funding or industry networking events, or work late adapting his investor memorandum or pitch deck. Through the week he constantly feels like he has deadlines to meet and is behind on his work and feels a strong desire to support his team and make sure they are focussed and happy. He tries to spend time away from the business on weekends doing triathlon training and improving his general wellbeing but as needed will work to catch up on important tasks, administration and emails or prepare for the next week.

Data collection for Participant D occurred in 2019 over 56 days between 2/October/2019 and 26/November/2019. Over this period there was 37 days with E4 data and 42 days with ESM surveys of which 35 days had end of day survey information collected. This included three days where he completed ESM activity and end of day surveys at the start of the collection period before his first day where E4 wearable data was collected on 8/October/2019 marking the first day where momentary, daily, and ongoing analysis of results is possible. The data collection for participant D was consistent across the period but somewhat inconsistent in what was collected on any given day indicating his collection routine and habits were as varied as his day-to-day entrepreneurial activities. He missed more collections on Friday, Saturday, and Sundays than Monday to Thursday but on any given day he might collect E4 data and not activity surveys or complete an end of day survey but have only worn the E4 for part of the day or night and not recording a resting value. For example, participant D was at an intensive three-day accelerator program the first three days of the collection period (Tue – Thu) where he collected good data then missed three days (Fri- Sun), then collected ESM surveys but not E4 the next day (Mon) and then E4 data the next day but no ESM end of day survey (Tue).

Participant D actively commented and requested that he needed help to remember to complete surveys and that in app reminders and notifications on his phone were not enough, so he added alarms and other post activity reminders that assisted him to remember. And due to his ever-changing schedule and not consistent start and end times for each day he struggled to develop a consistent routine for charging the E4 wearable and transferring data which also resulted sometimes in forgetting to put it on again after taking it off to recharge, have a shower or before rushing to a meeting, which resulted in missing the E4 collection for

a period of time for the day or evening. For him the end of day survey completion was the easiest to remember each day as a moment to reflect and as a last activity to complete his day but frequent activity survey completion through the day as activities changed was challenging. ESM activity surveys were completed more frequently when he was not changing locations through the day for meetings and for example was at the office with his team or at an accelerator program or conference all day.

The momentary results examining the interactive influence of participant D's activities on self-regulation strength and subjective responses are presented in Table 5-8 and Table 5-9. Table 5-8 indicates that the most common activity recorded was work analytically and conceptually (25), personal (20) and exchange information and opinion (19) while the least common was consult and sell (0), maintain networks and relationships (2) and non entrepreneur work and study (2). The mean RMSSD was highest for learn and develop (385ms) and travel (375ms) and lowest for monitor and control (276ms) and personal (283ms). The range between highest RMSSD and lowest RMSSD and standard deviation was small at 80ms and 35ms respectively for learn and develop but 370ms and 106ms for personal indicating not much deviation for learn and develop as an activity but high variability for personal. For other work-related activities, the standard deviation varied between 31ms (network and maintain relationships) and 81ms (exchange information and opinion). These results indicate broad variation in self-regulation in the moment both within and across different activities but some activities like learn and develop were reasonably stable for participant D.

For the subjective responses in the moment excluding the activities with two or fewer instances, mean-alert varies between 35% (personal) and 82% (direct and lead), mean-happy between 47% (work analytically and conceptually) and 74% (direct and lead), and mean-stress between 54% (personal, learn and develop) and 68% (work analytically and conceptually) while standard deviation is highest at 27% (SD-alert for travel) and lowest at 3% (SD-alert for direct and lead) indicating greater variability in subjective alertness for participant D and a slightly tighter range for his other subjective responses based on the momentary activity results. For work related activities, mean RMSSD was lowest for monitor and control (276ms) and work analytically and conceptually (307ms) and the mean-stress (69% and 68%) was



highest for both and mean-happy (62% and 47%) was amongst the lowest or lowest (work analytically and conceptually).

Table 5-8: Participant D Activity Comparison

Activity =	Exchange information and opinion	Work analytically and conceptually	Organise and coordinate	Network and maintain relationships	Direct and lead	Learn and develop	Monitor and control	Consult and sell	Travel	Personal	Non entrepreneur work or study
Number of Activities	19	25	8	2	3	7	3	0	8	20	2
MEAN-RMSSD (ms)	373	307	349	360	319	385	276		375	283	338
SD-RMSSD (ms)	81	75	65	31	47	35	79		49	106	103
MIN-RMSSD (ms)	186	158	240	338	283	337	185		313	61	265
MAX-RMSSD (ms)	448	442	425	381	372	416	323		442	432	410
RANGE-RMSSD (ms)	261	285	185	43	89	80	137		129	370	146
MEAN-Alert (%)	70%	58%	55%	50%	82%	77%	71%		54%	35%	30%
SD-Alert (%)	15%	16%	25%	21%	3%	21%	6%		27%	22%	16%
MEAN-Happy (%)	66%	47%	58%	62%	74%	68%	62%		68%	52%	65%
SD-Happy (%)	19%	19%	22%	7%	6%	19%	4%		21%	28%	44%
MEAN-Stressed (%)	61%	68%	64%	66%	56%	54%	69%		58%	54%	52%
SD-Stressed (%)	16%	13%	11%	13%	10%	20%	9%		16%	18%	25%

In Table 5-9 the results further indicate that the characteristics of the activity have an influence on self-regulation strength and the subjective responses sit within a moderate range for participant D, but the characteristics have a greater impact on this range than the activity itself. Activities that are challenging (340ms) or have a setback (318ms) deplete self-regulation strength more than when they are not challenging (353ms) or where there is no setback (339ms). The opposite or a recovery effect occurred when the activity was not-routine (396ms vs routine 340ms) or an uncertain outcome (346ms vs certain outcome 337ms) but the low number (2) for non-routine is inconclusive. For participant D being alone or not alone and interacting with others also has an impact with results showing significantly lower self-regulation strength when the entrepreneur is alone (308ms) compared to interacting with others (358ms) which supports his role as CEO constantly engaging with people and seeking support for his business.

There was only one instance characterised as not routine, a challenge and having an uncertain outcome but there was positive news in this instance resulting in a high mean RMSSD (425ms) and high mean-happy (100%) even though for the activity itself he was very alert (mean-alert of 79%) and stressed (mean-stress of 73%). And like the activity comparison there was considerable variability in the range between highest RMSSD and lowest RMSSD from 58ms (not routine) to 382ms (no setback) and standard deviations between 41ms (not routine) and 91ms (setback). Subjective responses in the moment based on changes in only one characteristic of the activity all sat within the mean range of 48% (mean-alert for alone) to 72% (mean happy for no challenge) with a standard deviation at maximum 26% (SD-alert for no challenge) and minimum of 13% (SD-stressed for challenge, no challenge and setback) excluding not routine which has a low number of instances (2). In summary, overall, the results in Table 5-8 and Table 5-9 indicate that changes in activities and characteristics of the action environment do have an effect on momentary self-regulation. And broadly where the context is clear these momentary results support the propositions that depleted self-regulation indicate entrepreneurs are performing more challenging or demanding activities while recovery indicates that entrepreneurs are performing more routine or comfortable activities.

Table 5-9: Participant D Activity Characteristics Comparison

Activity Characteristic =	Not Routine	Routine	Challenge	No Challenge	Uncertain Outcome	Certain Outcome	Setback	No Setback	Not Alone	Alone	Not Routine Challenge Uncertain Outcome	Not Routine Challenge Uncertain Outcome Setback	Not Routine Challenge Uncertain Outcome Not Alone	Not Routine Challenge Uncertain Outcome Alone
Number of Activities	2	73	61	14	36	39	46	51	42	55	1	0	1	0
MEAN-RMSSD (ms)	396	340	340	353	346	337	318	339	358	308	425		425	
SD-RMSSD (ms)	41	75	75	75	73	78	91	80	70	90				
MIN-RMSSD (ms)	367	158	158	186	185	158	100	61	186	61	425		425	
MAX-RMSSD (ms)	425	448	448	442	448	442	448	443	448	442	425		425	
RANGE-RMSSD (ms)	58	290	290	256	262	284	348	382	261	381	0		0	
MEAN-Alert (%)	65%	64%	64%	62%	59%	68%	51%	62%	69%	48%	79%		79%	
SD-Alert (%)	20%	20%	18%	26%	18%	21%	23%	23%	16%	24%				
MEAN-Happy (%)	65%	59%	56%	72%	55%	64%	46%	69%	63%	54%	100%		100%	
SD-Happy (%)	49%	20%	20%	16%	21%	20%	20%	19%	20%	24%				
MEAN-Stressed (%)	67%	63%	66%	49%	67%	58%	69%	54%	60%	61%	73%		73%	
SD-Stressed (%)	7%	15%	13%	13%	14%	14%	13%	15%	17%	15%				

Now shifting to the summary of daily and ongoing results presented in Table 5-10 examining the change in daily self-regulation strength and daily subjective effectiveness measures over 50 days. The quotes from the daily diary for each day frequently (but not always) show that a decrease (red) occurs on a subjective negative, stressful, challenging day while an increase (green) occurs on days which are more subjectively positive, less stressful, less challenging which overall support the propositions. The first three days as an example, he is at an intensive accelerator program and per his comments for example “network with CEOs (more progress than us. Tech sprint” he is constantly comparing the progress of his venture and his own performance to others at the event while completing a tech sprint and preparing for a final day pitch. The first two days are a challenge but the third day a relief when the pitch is completed and he receives positive feedback stating “sprint day 3, then pitch to industry (enthusiasm)” on his business and he can relax and be pleased with himself. In the first three days the change in REST\_RMSSD day to day shows daily self-regulation fluctuations, a decrease (-4ms) from the first day but then an increase on the final day (+45ms) where he completes his pitch to industry who are enthusiastic about its potential. His difference to the AVG REST\_RMSSD in the first two days is also low (-24ms and -28ms) before the recovery on the final day. In the following four weeks through to the start of November when there is consistent data over cumulative days the REST\_RMSSD shows a pattern decrease (red) then increase (green), decrease (red) then increase (green) consistently day in day out with at most two days increase or decrease.

Table 5-10: Participant D Daily Comparison

Day	Date	EFFORT	CHANGE EFFORT	SATISFIED	CHANGE SATISFIED	EXCITED	CHANGE EXCITED	STRESS	CHANGE STRESS	PROGRESS	CHANGE PROGRESS	RESTED	CHANGE RESTED	REST_RMSSD (ms)	CHANGE REST_RMSSD (ms)	DIFFERENCE vs AVG REST_RMSSD (ms)	Quotes from Participant Daily Diary
Tue	8/10/2019	84%		70%		100%		86%		72%		0%		63		-24	Accelerator-network with CEOs(more progress than us). Tech sprint
Wed	9/10/2019	88%	4%	75%	5%	69%	-31%	35%	-51%	72%	0%	50%	50%	59	-4	-28	Accelerator-learning for investor memorandum (IM). Tech sprint
Thu	10/10/2019	81%	-6%	46%	-29%	55%	-14%	48%	13%	58%	-13%	15%	-35%	103	45	17	Accelerator- sprint day 3, then pitch to industry (enthusiasm)
Fri	11/10/2019																
Sat	12/10/2019																
Sun	13/10/2019																
Mon	14/10/2019	85%		75%		94%		31%		80%		45%					Big customer sale + new co-founder. Org. business validation sprint
Tue	15/10/2019													70		-16	
Wed	16/10/2019	99%		33%		23%		65%		38%		21%					Got hammered by mentor about IM
Thu	17/10/2019	77%	-22%	85%	51%	67%	44%	84%	19%	45%	7%	89%	68%	94		8	Working on IM. Angry at how much work to do in short time
Fri	18/10/2019	77%	0%	89%	5%	86%	19%	33%	-51%	66%	21%	92%	3%	89	-5	3	Team meeting re next steps for IM and customer validation
Sat	19/10/2019													55	-34	-31	
Sun	20/10/2019	49%		82%		42%		21%		61%		83%		115	60	29	Catchup emails and Jira issue tracking tickets
Mon	21/10/2019	73%	23%	38%	-44%	44%	2%	31%	10%	60%	-1%	92%	9%	117	2	31	Need to be more efficient + insights from competitor analysis
Tue	22/10/2019	36%	-37%	25%	-13%	18%	-27%	78%	46%	44%	-16%	92%	0%	82	-36	-5	Pushed to get more done (product), feedback on customer dev.
Wed	23/10/2019	54%	19%	79%	54%	76%	59%	77%	-1%	52%	8%	71%	-21%	77	-4	-9	Good strategy realisation and must document in IM
Thu	24/10/2019	68%	14%	69%	-10%	39%	-37%	66%	-11%	62%	10%	82%	11%	97	20	11	Strategic thinking and conversations
Fri	25/10/2019	88%	20%	65%	-4%	42%	3%	83%	17%	73%	11%	83%	2%				Competitor analysis > realise we have to change our strategy
Sat	26/10/2019													95		8	
Sun	27/10/2019																
Mon	28/10/2019	81%		33%		42%		66%		65%		53%		51		-35	IM takes too long. My head limited in speed to get things done
Tue	29/10/2019																

Wed	30/10/2019													85		-2	
Thu	31/10/2019	75%		31%		11%		81%		46%		14%		82	-2	-4	More strategy clarity but frustrated with head bus dev (too slow)
Fri	1/11/2019	90%	15%	73%	42%	60%	48%	100%	19%	69%	22%	55%	41%	141	58	54	Very productive meetings (IP lawyer, mentor) but info overload
Sat	2/11/2019																
Sun	3/11/2019																
Mon	4/11/2019	44%		74%		21%		86%		64%		32%		75		-12	Pricing progress. I'm so tired - need break but too many deadlines
Tue	5/11/2019	0%	-44%	23%	-51%	9%	-11%	13%	-73%	0%	-64%	100%	68%	106	32	20	Public holiday. Supposed to work on IM but didn't get it done
Wed	6/11/2019	40%	40%	13%	-10%	15%	6%	44%	31%	18%	18%	27%	-73%	60	-46	-26	Low energy, maybe on verge burnout. Trying prevent (meditate)
Thu	7/11/2019	65%	26%	20%	7%	19%	3%	73%	28%	30%	12%	68%	41%	70	9	-17	Finished exec sum. Mistake in some personal legal docs (frustrated)
Fri	8/11/2019	73%	7%	69%	49%	58%	39%	37%	-35%	64%	34%	86%	18%				Finished pitch deck. Advisor 3 interviews. Nothing negative!
Sat	9/11/2019																
Sun	10/11/2019																
Mon	11/11/2019	75%		39%		42%		42%		70%		85%		87		1	Mentor feedback (+ve strategy/model, -ve pitch deck amateurish)
Tue	12/11/2019	47%	-28%	37%	-2%	69%	27%	70%	27%	66%	-3%	44%	-41%	92	5	6	Pitch and feedback (AM), so tired after, very unproductive PM
Wed	13/11/2019	52%	5%	29%	-8%	70%	1%	28%	-41%	55%	-11%	56%	12%				Attend leadership course. Need head of business more immersed
Thu	14/11/2019	64%	12%	61%	32%	49%	-21%	79%	51%	64%	9%	79%	23%	100		13	Office search resume / My own work goes very slowly.
Fri	15/11/2019	83%	19%	100%	39%	93%	43%	57%	-22%	85%	21%	73%	-6%				Finished Grant EOI. Resolved team responsibilities. New customer!
Sat	16/11/2019																
Sun	17/11/2019													40		-46	
Mon	18/11/2019	72%		63%		56%		77%		62%		71%					Team is bonding well. But so much work to do!
Tue	19/11/2019	33%	-38%	29%	-35%	20%	-36%	55%	-22%	36%	-26%	11%	-61%	119		33	Team understands database limitations. Things take really long
Wed	20/11/2019	33%	0%	21%	-7%	3%	-16%	61%	6%	18%	-18%	26%	15%				I feel burnt out
Thu	21/11/2019																
Fri	22/11/2019	80%		96%		77%		74%		100%		48%					Finished milestones for accelerator funding. Feel super tired
Sat	23/11/2019																
Sun	24/11/2019																
Mon	25/11/2019	74%		13%		20%		82%		40%		82%		123		37	Breathing space (submitted accelerator docs), Database challenges
Tue	26/11/2019	100%	26%	96%	83%	71%	52%	83%	1%	87%	46%	83%	2%	69	-54	-17	Positive conversations and dinner meeting. Long day up late!

Colour Legend: Red = negative change in direction of value (darkest is highest value in direction of individual range, becomes lighter the closer to zero/neutral)  
Green = positive change in direction of value (darkest is highest value in direction of individual range, becomes lighter the closer to zero/neutral)

The change in daily effectiveness measures sometimes are consistently red (worse) or green (better) on the days where change in REST\_RMSSD are red or green respectively but overall the results are mixed and there are some anomalies where the effectiveness measures are consistently red or green when the change in REST\_RMSSD is the opposite (i.e. green or red respectively). For example, on Tuesday 22/October/2019 the change REST\_RMSSD decreases (-36ms) and all effectiveness measures are red, while on Friday 1/November/2019 when the change REST\_RMSSD increases (+58ms) five of the six effectiveness measures are also green. One anomaly is for example the last day of the accelerator program at the start of the period shows a change REST\_RMSSD that increases (+45ms) but all six effectiveness measures are red, however this can be explained contextually as he is finished with the program and can recover but from constant comparison to others in the program his subjective measures are low. The mixed results over these weeks could indicate a highly fluctuating and unsure journey for participant D in terms of their subjective effectiveness measures.

This journey leads into the first mention that participant D feels on the verge of burnout on Wednesday 6/November/2019, the day after a public holiday which he used dwelling on work he should be doing and progress that should have been made. During the first seven days of November between 1/November/2019 and 7/November/2019 the absolute values of the effectiveness measures vary considerably day to day, for example subjective stress is 100% on 1/November/2019 decreasing to 13% on the public holiday of 5/November/2019 and increasing back to 73% on 7/November/2019 and progress on these same days shift from 69% to 0% to 30% respectively and satisfaction from 73% to 23% to 20% (but a low of 13% on 6/November/2019). From this first mention of burnout on 6/November/2019 through to the end of the collection period on 26/November/2019 the difference vs AVG REST\_RMSSD is consistently red or a small increase (green) in the initial part before instances of larger recovery (green) on 19/November/2019 and 25/November/2019 are seen. Effectiveness measures and contextual information continue to reflect daily ups and downs during this period but subjective absolute effort, satisfaction and progress that is frequently low until near the end of the period where these absolute numbers start to see higher highs again and the contextual information indicates participant D feels greater breathing room and progress in completing some activities that have been wearing him down.

Over the collection period the daily fluctuations of subjective effectiveness measures and cycles of depletion and recovery in REST\_RMSSD between days indicate that daily an entrepreneurs' self-regulation can deplete, and this can negatively impact the entrepreneur's subjective effectiveness, but the effect is generally short, and the impact is generally variable as the entrepreneur cycles to recovery often the next day and focusses on what needs to be done next to progress. However as seen in the ongoing results through October, and the first mention of burnout in early November through to the end of the collection period in late November that overtime, cumulatively if there is more depletion and not enough recovery of self-regulation over a period of time that the entrepreneur's effectiveness is negatively impacted in some ways. And that the entrepreneur can enter a cycle of self-doubt and overall poorer individual effectiveness. In the case of participant D this cycle appears to start to be turning around by the end of the collection period, based on his commentary in his daily diary including "Breathing space (submitted accelerator docs), Database challenges" and "Positive conversations and dinner meeting. Long day up late!" accompanied by a potential return to a more normal cycle of depletion and recovery in REST\_RMSSD day to day over the last two days (25/November/2019 and 26/November/2019) of the period.



### **5.5. Case Study – Participant E**

Participant E (male, age 30) is the technical co-founder of his first entrepreneurial business which he has been working on for almost 2 years. He sleeps on average 6-7 hours a night and typically feels tired when he wakes up. He is married and his highest education level is a bachelor's degree. He describes himself as someone who plans ahead and is organised, so he avoids scrambling at the last minute. He is enthusiastic and excited about his business but is also anxious and nervous and often can't help worrying about little things. He is creative but also a perfectionist, working very hard to get things right and paying attention to detail always trying to make sure he has not missed something. He is uncomfortable in social settings, sees other people as more upbeat and dynamic than him and dislikes dealing with difficult situations or conflict, needing support from others to navigate or handle these situations as he can easily get emotional. He thinks before he acts, seeks a balance between work and life, and is not compelled to do things unless he has planned them. He feels that his life is good but does not always feel he is worthy and wants more from his life and feels that he can do things differently. He somewhat agrees that being a founder and owning his own company is important to him and his identity, but he strongly agrees assembling the right people to work on the business and developing a new business towards success is enjoyable.

The routine of participant E is consistent, and he typically works from 9:00 to 17:30 Monday to Friday finishing work once he has arrived home to spend time with his family. He occasionally works after his normal hours if necessary but is most comfortable sticking with routine going to bed each night between 23:00 and midnight and getting up usually between 6:00-7:00. His role focused on leading technical and product development means the majority of his time is focused on working analytically and conceptually as well as exchanging information and opinion as part of a small team. Occasionally each week he may be involved in organising and coordinating as well as learning and development. As a co-founder he is involved in key external meetings as well as strategy and financial discussions from time to time but only prioritises or attends meetings his co-founder and CEO believes are necessary for him to attend as these meetings or discussions are more uncomfortable or stressful for him than his preferred day to day technical and analytical work. He plans before he acts so he is consistent in his actions and routine dedicated to his work during the week and rarely has

the need to work on the weekend. He uses time at home with family to disengage from the issues, stresses and anxiety of the business which is still trying to find its path to sustainability after three years.

Data collection of 40 days for Participant E occurred from 9/December/2019 to 17/January/2020. Participant E was very consistent in his E4 data collection covering every day of the period. He established a routine where he would upload data and recharge the E4 each morning before work recording on average twenty-two and a half hours of data each day but on the occasional day would have multiple recordings per day due to taking the E4 off or forgetting to turn it on even though it was on his wrist. He also completed ESM surveys each workday of the period totalling 22 days except for one Monday at the end of the collection period but he did not complete any surveys on weekends as he aims to keep these primarily work free as well as the holiday period over Christmas and New Year's Day between 24/December/2019 and 1/January/2020. He consistently completed 6-7 ESM activity surveys each day between 10:00 and 18:15 and completed his end of day survey indicating end of his workday with the last survey between 17:00 and 18:15 but occasionally earlier in the afternoon.

The momentary results examining the interactive influence of participant E's activities on self-regulation strength and subjective responses in the moment are presented in Table 5-11 and Table 5-12. Table 5-11 indicates that the most common activity recorded was work analytically and conceptually (50), and exchange information and opinion (43) while the least common all with zero instances was consult and sell (0), monitor and control (0), direct and lead (0) and non entrepreneur work and study (0). Where there were more than two instances the mean RMSSD was highest for personal (330ms) and travel (310ms) and lowest for work analytically and conceptually (200ms) and organise and coordinate (213ms). The range between highest RMSSD and lowest RMSSD and standard deviation was smallest at 128ms and 38ms respectively for personal but 405ms and 94ms for exchange information and opinion indicating low variability in personal interactions but high variability in the types of meetings and settings for exchange information and opinion involving either new and external audiences or internal and known audiences explaining the difference.

Table 5-11: Participant E Activity Comparison

Activity =	Exchange information and opinion	Work analytically and conceptually	Organise and coordinate	Network and maintain relationships	Direct and lead	Learn and develop	Monitor and control	Consult and sell	Travel	Personal	Non entrepreneur work or study
Number of Activities	43	50	26	1	0	4	0	0	3	10	0
MEAN-RMSSD (ms)	248	200	213	394		217			310	330	
SD-RMSSD (ms)	94	82	78			120			96	38	
MIN-RMSSD (ms)	55	74	80	394		112			239	264	
MAX-RMSSD (ms)	460	356	330	394		323			419	392	
RANGE-RMSSD (ms)	405	282	251	0		211			179	128	
MEAN-Alert (%)	63%	52%	63%	89%		40%			74%	53%	
SD-Alert (%)	24%	25%	30%			17%			17%	25%	
MEAN-Happy (%)	63%	59%	66%	87%		69%			68%	72%	
SD-Happy (%)	18%	13%	14%			6%			16%	14%	
MEAN-Stressed (%)	57%	45%	45%	19%		30%			41%	36%	
SD-Stressed (%)	21%	20%	22%			2%			18%	13%	

For other work-related activities, the range varied between 211ms (learn and develop) and 282ms (work analytically and conceptually) indicating large variation in self-regulation in the moment both within and across different work activities for participant E possibly being an indicator of the change in comfort dealing with known vs unknown environments or people in different activities. For subjective responses in the moment excluding the activities with two or fewer instances, mean-alert varies between 52% (work analytically and conceptually) and 74% (travel), mean-happy between 59% (work analytically and conceptually) and 72% (personal), and mean-stress between 30% (learn and develop) and 57% (exchange information and opinion) while standard deviation is highest at 30% (SD-alert for organise and coordinate) and lowest at 2% (SD-stressed for learn and develop) indicating greater variability in subjective alertness in organising and coordinating tasks. For work related activities exchange information and opinion had the biggest range in RMSSD (405ms) and the highest mean-stressed (57%) showing that in some instances participant E found meetings or discussions very depleting and stressful but in other cases enabled recovery.

In Table 5-12 the results show that the majority of activities for participant E were routine in nature (116 routine vs 11 not routine), but many had an uncertain outcome (103 uncertain vs 24 certain outcome). Approximately three quarters of activities had no challenge (vs one quarter that were challenging) and the majority had no setback (131 vs 6 with setback). Overall, this indicates participant E was mostly engaged in activities he could plan for and manage within his comfort level even if they were challenging and only occasionally would he find himself in a work circumstance that was either not routine or where he might have a setback. Activities that were not routine (230ms), a challenge (239ms) and an uncertain outcome (228ms) have a slightly higher RMSSD than if the activity was routine (223ms), not a challenge (219ms) and a certain outcome (206ms) but a setback (226ms) was more depleting than no setback (232ms). For participant E being alone or not alone and interacting with others had the largest impact on self-regulation strength with results showing significantly lower self-regulation strength when the entrepreneur is alone (208ms) compared to interacting with others (261ms).

Table 5-12: Participant E Activity Characteristics Comparison

Activity Characteristic =	Not Routine	Routine	Challenge	No Challenge	Uncertain Outcome	Certain Outcome	Setback	No Setback	Not Alone	Alone	Not Routine Challenge Uncertain Outcome	Not Routine Challenge Uncertain Outcome Setback	Not Routine Challenge Uncertain Outcome Not Alone	Not Routine Challenge Uncertain Outcome Alone
Number of Activities	11	116	32	95	103	24	6	131	61	76	4	0	1	3
MEAN-RMSSD (ms)	230	223	239	219	228	206	226	232	261	208	157		146	161
SD-RMSSD (ms)	120	87	93	89	90	90	85	92	88	88	96			117
MIN-RMSSD (ms)	79	55	74	55	74	55	113	55	94	55	79		146	79
MAX-RMSSD (ms)	419	460	460	424	460	419	307	460	460	419	295		146	295
RANGE-RMSSD (ms)	339	405	386	369	386	364	194	405	366	364	216		0	216
MEAN-Alert (%)	51%	59%	60%	58%	57%	65%	71%	57%	61%	56%	46%		59%	41%
SD-Alert (%)	26%	26%	26%	26%	26%	25%	29%	26%	26%	26%	32%			38%
MEAN-Happy (%)	61%	63%	59%	64%	61%	70%	49%	64%	64%	63%	48%		37%	51%
SD-Happy (%)	14%	16%	18%	14%	15%	13%	24%	15%	17%	14%	8%			3%
MEAN-Stressed (%)	46%	49%	58%	45%	49%	44%	82%	46%	53%	43%	59%		84%	51%
SD-Stressed (%)	23%	21%	23%	20%	22%	16%	23%	20%	23%	19%	24%			21%

However, the four instances characterised as not routine, a challenge and having an uncertain outcome were the most depleting (157ms) and considerably more depleting than the mean of any one characteristic. Mean-stressed (59%) is high and mean-alert (46%) and mean-happy (48%) low for these four instances compared to other mean performance measures for single characteristics except for setback alone with a mean-stressed (82%) and mean-alert (71%) being very high and mean-happy (49%) low. Overall though the subjective responses in the moment based on changes in only one characteristic of the activity all sat within the mean range of 43% (mean-stressed for alone) to 82% (mean stressed for setback) with a standard deviation at maximum 29% (SD-alert for setback) and minimum of 13% (SD-happy for certain outcome).

Table 5-11 and Table 5-12 appear to show that within the normal routine of participant E that the individual characteristics of the activity in the work environment have a small influence on self-regulation strength and the subjective responses sit within a moderate range indicating that generally the entrepreneur operates in a consistent manner day in day out. But when an activity was significantly outside of the entrepreneurs normal and multiple characteristics were difficult for example not routine, a challenge and having an uncertain outcome that these activities and the context in which they took place were considerably more depleting (RMSSD between 146ms and 161ms) than the mean of any one characteristic. In addition the average difference in RMSSD between work activities and non-work activities in Table 5-11 is informative where work activities (excluding the one instance of network and maintain relationships) have a RMSSD of between 200ms-250ms and are depleting where non-work activities (personal and travel) both have a RMSS of between 300ms-350ms and are more recovering implying that regardless of the characteristic of the activity that the participant finds work activities broadly more negative, challenging or demanding activities than non work activities and for this participant per his routine that time away from work is critical in him maintaining balance in his work and life overall. For this participant overall work activities deplete self-regulation and are for him are more challenging or demanding because of the interactions and anxiety felt due to lack of progress, while being away from work is subjectively more positive, less stressful, less challenging and results in recovery.

A summary of daily results examining the ongoing change in self-regulation strength and subjective effectiveness measures over 40 days are presented in Table 5-13. Effectiveness measures are seen for two working weeks in December before the holiday break and then for just over two weeks in January while REST\_RMSSD is collected each day of the period except one at the end of the collection period providing a good basis for exploring daily and ongoing change of participant E. In the first two weeks (9/December/2019 to 20/December/2019) of collection REST\_RMSSD day to day fluctuates within a relatively narrow range (+18ms to -20ms but the majority are single digit changes), with one or two days of decreases (red) followed by one or two days of increases (green). In this two-week period the difference to average REST\_RMSSD is also in a small range and is primarily red (8 days) compared to green (4 days) indicating depletion overall as he finishes up the year. During this two week period the subjective effectiveness measures are primarily red reflecting this difference to average also being primarily red through this period and matching with the quotes from the daily diary the majority of days where entrepreneur E is feeling negative about funding of the business, stating for example “Negative day overall as funding situation is not good” but finds some opportunities to be positive through interactions with friends or positive meetings such as “Day was mixed, but one positive client meeting at 10am”.

With the work year effectively ending on Friday 20/December/2019, the following day Saturday sees REST\_RMSSD increase significantly (+35ms), and stays elevated through Sunday (+1ms) showing recovery before a decrease (-19ms) on Monday 23/December/2019 as he does a final normal day of work with no positive or negative moments before the holiday break. Over the next 9 days of the holiday his REST\_RMSSD decreases and stays at a lower level much like the first two weeks alternating red or green every one or two days but the difference to average REST\_RMSSD remains mostly red indicating depletion through the holidays and is also highlighted by late nights for Christmas eve and Christmas day as well as a very late night on New Year’s eve (stating “New Years Eve, up until 2am”) where he records his lowest absolute REST\_RMSSD (60ms) with a large change from the day before (-34ms) and large difference from average (-31ms) indicating depletion. New Year’s Day itself he recovers back to near his average REST\_RMSSD as he prepares to get back to work the next day.

Table 5-13: Participant E Daily Comparison

Day	Date	EFFORT	CHANGE EFFORT	SATISFIED	CHANGE SATISFIED	EXCITED	CHANGE EXCITED	STRESS	CHANGE STRESS	PROGRESS	CHANGE PROGRESS	RESTED	CHANGE RESTED	REST_RMSSD (ms)	CHANGE REST_RMSSD (ms)	DIFFERENCE vs AVG REST_RMSSD (ms)	Quotes from Participant Daily Diary
Mon	9/12/2019	72%		65%		77%		74%		90%		50%		86		-5	Back from holiday, catching up on past week
Tue	10/12/2019	88%	16%	96%	31%	61%	-15%	74%	0%	99%	9%	27%	-23%	79	-7	-12	Productive but very demanding day, intense lunch meeting
Wed	11/12/2019	100%	12%	100%	4%	100%	39%	32%	-42%	100%	1%	42%	15%	85	7	-5	Positive customer meeting & UI/UX vendor interview
Thu	12/12/2019	97%	-3%	58%	-42%	72%	-28%	66%	34%	98%	-2%	50%	8%	104	18	13	Negative morning re funding but positive afternoon (friends)
Fri	13/12/2019	77%	-20%	68%	10%	65%	-7%	78%	12%	100%	2%	37%	-13%	84	-20	-7	Some positive meetings, normal day
Sat	14/12/2019													85	1	-6	
Sun	15/12/2019													91	7	1	
Mon	16/12/2019	82%		76%		81%		62%		55%		40%		94	2	3	Very positive meeting with client
Tue	17/12/2019	79%	-3%	48%	-28%	35%	-46%	88%	26%	76%	22%	19%	-21%	93	-1	3	Stressful phone call at 12:30pm, impacted mood rest of day
Wed	18/12/2019	70%	-9%	43%	-5%	71%	37%	71%	-17%	66%	-10%	33%	13%	81	-12	-9	Day was mixed, but one positive client meeting at 10am
Thu	19/12/2019	70%	0%	50%	7%	49%	-22%	74%	3%	68%	2%	38%	6%	84	3	-6	Normal day, no positive or negative moments
Fri	20/12/2019	68%	-2%	26%	-24%	32%	-17%	100%	26%	16%	-52%	21%	-17%	85	1	-6	Negative day overall as funding situation is not good
Sat	21/12/2019													120	35	29	
Sun	22/12/2019													121	1	30	
Mon	23/12/2019	61%		52%		47%		61%		63%		19%		102	-19	11	Normal day, no positive or negative moments
Tue	24/12/2019													77	-25	-14	Christmas Eve, up until midnight
Wed	25/12/2019													74	-3	-17	Christmas Day, up until midnight
Thu	26/12/2019													89	16	-1	Boxing Day Public Holiday
Fri	27/12/2019													82	-7	-8	
Sat	28/12/2019													77	-5	-13	
Sun	29/12/2019													88	11	-2	
Mon	30/12/2019													94	6	4	
Tue	31/12/2019													60	-34	-31	New Year's Eve, up until 2am
Wed	1/01/2020													88	28	-2	
Thu	2/01/2020	66%		48%		51%		50%		66%		25%		80	-8	-10	Back to regular routine

Fri	3/01/2020	72%	6%	39%	-9%	38%	-13%	74%	24%	63%	-3%	44%	19%	74	-6	-16	A bit negative today, due to difficulties with cash flow
Sat	4/01/2020													82	8	-8	
Sun	5/01/2020													90	7	-1	
Mon	6/01/2020	61%		32%		23%		69%		65%		19%		114	25	24	Fairly negative given funding, positive from lunch (relaxing)
Tue	7/01/2020	64%	3%	49%	17%	32%	8%	69%	0%	73%	8%	48%	29%	79	-36	-12	Mostly positive day (research partner meeting), up post midnight
Wed	8/01/2020	87%	23%	54%	5%	70%	39%	49%	-20%	97%	24%	35%	-13%	127	49	37	Extremely productive (external facilitator) workshop all morning
Thu	9/01/2020	89%	2%	100%	46%	94%	23%	44%	-5%	93%	-4%	100%	65%	97	-31	6	Moderately positive day, some productive meetings
Fri	10/01/2020	79%	-10%	52%	-48%	22%	-71%	71%	27%	95%	2%	40%	-60%	103	6	12	OK day, became negative after 330pm meeting (company status)
Sat	11/01/2020													80	-23	-10	
Sun	12/01/2020													102	21	11	
Mon	13/01/2020													108	6	18	
Tue	14/01/2020	80%		49%		66%		79%		90%		52%		66	-42	-25	OK day, 3pm mentoring mostly positive, but no energy post 5pm
Wed	15/01/2020	67%	-13%	52%	3%	70%	4%	28%	-51%	62%	-28%	19%	-33%				Early start, energy low, some informative lectures in AM (conf.)
Thu	16/01/2020	60%	-7%	51%	-1%	22%	-48%	70%	42%	61%	-1%	15%	-4%	92		2	Woke up feeling sick, low energy so left work early
Fri	17/01/2020	84%	24%	65%	14%	45%	22%	63%	-7%	92%	31%	37%	21%	114	21	23	Normal day (feeling much better)

Colour Legend: Red = negative change in direction of value (darkest is highest value in direction of individual range, becomes lighter the closer to zero/neutral)  
Green = positive change in direction of value (darkest is highest value in direction of individual range, becomes lighter the closer to zero/neutral)



Participant E's first two days back at work in the new year (2/January/2020 and 3/January/2020) both see decreases in REST\_RMSSD (-8ms and -6ms respectively) and are lower than his average REST\_RMSSD indicating that getting back to work is depleting and is contextualised by the realities of cash flow issues for the business. The weekend then sees small increases in REST\_RMSSD to close to average and then over the subsequent two weeks of work until the finish of the collection period REST\_RMSSD day to day fluctuates within a much wider range (+49ms to -42ms) with an increase (green), then decrease (red) repeating green then red with greater intensity each day than the two weeks at the start of the collection period. In this final two-week period, the difference to average REST\_RMSSD includes this greater range and is primarily green (8 days) compared to red (3 days) feeling recovery more than depletion being the opposite of the first two weeks at the end of the previous year. The subjective effectiveness measures are also slightly more green than red, reflecting this difference to average also being primarily green through this period. The supporting contextual data is a mix of positive and negative and the business has the same or more challenges than the last 2 weeks of the year.

Over the collection period the daily fluctuation of subjective measures and cycles of depletion and recovery in REST\_RMSSD between days indicate that daily an entrepreneurs' self-regulation can deplete, and this can negatively impact the entrepreneur's effectiveness, but the impact is generally variable as the entrepreneur cycles to recovery and focusses on what needs to be done next often the next day. However as seen in the ongoing results both the two working weeks pre-Christmas holidays and the two weeks following New Years that overtime, there can be a cumulative effect that negatively influences subjective effectiveness. The first two weeks of the period there is more depletion and not enough recovery of self-regulation and the entrepreneur's effectiveness is also negatively impacted. However, after the holiday which is also depleting for lack of rest in the new year participant E comes back to the business and has a majority of days that are green, and recovering, more than red and depleting and his subjective measures are also majority green than red even though the business itself has the same or more problems than it did at the end of the year. The intensity of fluctuations in REST\_RMSSD are lower in the first 2-week period (range = 61ms, SD = 15ms) than the last 2 weeks (range = 91ms, SD = 27ms) and the mean RMSSD is lower in the first

two weeks (92ms) than period 2 (94ms) indicating that the two weeks leading up to Christmas are more depleting and there is less variability in self-regulation strength than the two weeks after New Year's Day.

## 5.6. Cross-Case Analysis

### 5.6.1. Interactive Effects

Each case study except participant B (who did not complete momentary activity surveys through the day) explored the interactive context and changing nature of the journey of the entrepreneur as the activities and characteristics of those activities changed in the moment and throughout the day. Results supported Proposition 1 showing that the action environment has an effect on the entrepreneur's self-regulation strength. A summary of the changes in momentary results by activity and characteristic of activity indicated that different types of activities were more depleting than others for each participant and for some characteristics of activities than others. A broad look at the interactive patterns on any given day show that there can be peaks and valleys in self-regulation strength based on contextual factors including the characteristics of the activities and for example interacting with other people may utilise differing amounts of self-regulation than being alone. This was further illustrated graphically (example for participant A in Appendix 8.6.1) where changes can be seen moment by moment throughout the day based on the type and characteristics of the activities. In each daily chart the fluctuating momentary changes in direction, duration, and intensity of RMSSD every moment are wide ranging but the change of direction of the trend is informative relating to activity preference, changes, and challenges specific to the individual entrepreneur while recognising it is impossible to collect contextual information to understand the depletion and recovery for each and every moment in the day.

Comparative summaries of the participants self-regulation by activity and activity characteristic are provided in Table 5-14 and Table 5-15 respectively. For each participant, the number of activities recorded, the mean-RMSSD and standard deviation (SD-RMSSD) is given for either the activity or characteristic of the activity. From Table 5-14 the activities, working analytically and conceptually and organise and coordinate for all participants were on average more depleting than other work-related activities with a few exceptions (but where number of activities is low) but the standard deviation shows there was in many cases a wide range in the RMSSD recorded. Personal and Travel as non work activities were also generally as or more depleting than the most depleting work-related activities, but the large standard deviation indicates a much wider range in personal activities than any other activity

– some being very depleting but some very recovering. The exception to this was participant E who from the case study description is very anxious in many work situations and very particular about separating work and personal life. For him the RMSSD recorded was on average low for all work-related activities each and every day but considerably higher for personal activities indicating that personal activities were a much-needed recovery from depleting work-related activity for him. It could also be considered that participants A, C and D must constantly balance work and life activities throughout their day given their responsibilities where they might be more intertwined together whereas participant E has a clearer separation between work (and a more clearly defined role) and life.

Table 5-14: Comparative Participant RMSSD and Activity Summary

Participant	Activity =	Exchange information and opinion	Work analytically and conceptually	Organise and coordinate	Network and maintain relationships	Direct and lead	Learn and develop	Monitor and control	Consult and sell	Travel	Personal	Non entrepreneur work or study
A	Number-Activities	46	73	33	19	19	7	1	2	20	39	0
A	MEAN-RMSSD (ms)	406	360	370	395	386	403	346	438	396	326	
A	SD-RMSSD (ms)	34	83	80	67	72	45		4	49	125	
C	Number-Activities	2	3	2	0	0	2	0	1	12	4	2
C	MEAN-RMSSD (ms)	445	440	436			353		386	395	322	436
C	SD-RMSSD (ms)	5	21	6			109			56	169	9
D	Number-Activities	19	25	8	2	3	7	3	0	8	20	2
D	MEAN-RMSSD (ms)	373	307	349	360	319	385	276		375	283	338
D	SD-RMSSD (ms)	81	75	65	31	47	35	79		49	106	103
E	Number-Activities	43	50	26	1	0	4	0	0	3	10	0
E	MEAN-RMSSD (ms)	248	200	213	394		217			310	330	
E	SD-RMSSD (ms)	94	82	78			120			96	38	

In Table 5-15, the RMSSD was generally relatively similar between single opposing characteristics such as not routine and routine activities or uncertain outcome and certain outcome but the more demanding characteristic such as challenge was typically more depleting than the opposite. And for specific instances where other contextual information was available from the daily diary where the participants indicated a more difficult and challenging day those activities on those days were generally more depleting.

The largest differences seen in Table 5-15 were between alone or not alone (interacting with others) with being alone being more depleting except for participant C who across all characteristics had a mean-RMSSD that were relatively similar. For participant A and E activities whose characteristics were not routine, a challenge, having an uncertain outcome when being alone showed the lowest mean RMSSD of all combinations of characteristics and being more depleting of self-regulation strength. Participant C and D did not have an instance when alone but did each have one instance when not alone (interacting) and were at levels closer to the averages of single characteristics. And as such where contextual or ESM data such as multiple negative characteristics indicated a particularly demanding or challenging activity or day the propositions were supported showing that depleted self-regulation generally indicates entrepreneurs are performing more challenging or demanding activities and where self-regulation showed recovery indicates that entrepreneurs are performing more routine or comfortable activities specific to the individual's context.

*Table 5-15: Comparative Participant RMSSD and Activity Characteristics Summary*

Participant	Activity Characteristic =	Not Routine	Routine	Challenge	No Challenge	Uncertain Outcome	Certain Outcome	Setback	No Setback	Not Alone	Alone	Not Routine Challenge Uncertain Outcome	Not Routine Challenge Uncertain Outcome Setback	Not Routine Challenge Uncertain Outcome Not Alone	Not Routine Challenge Uncertain Outcome Alone
A	Number-Activities	128	92	28	192	159	61	2	144	149	71	19	0	11	8
A	MEAN-RMSSD (ms)	381	379	362	379	376	381	395	367	394	344	374		391	338
A	SD-RMSSD (ms)	79	65	69	74	75	67	95	78	57	86	68		67	58
C	Number-Activities	14	8	5	17	7	15	5	23	14	14	1	0	1	0
C	MEAN-RMSSD (ms)	405	407	427	399	407	405	420	390	392	399	386		386	
C	SD-RMSSD (ms)	63	41	28	59	68	49	85	31	96	66				
D	Number-Activities	2	73	61	14	36	39	46	51	42	55	1	0	1	0
D	MEAN-RMSSD (ms)	396	340	340	353	346	337	318	339	358	308	425		425	
D	SD-RMSSD (ms)	41	75	75	75	73	78	91	80	70	90				
E	Number-Activities	11	116	32	95	103	24	6	131	61	76	4	0	1	3
E	MEAN-RMSSD (ms)	230	223	239	219	228	206	226	232	261	208	157		146	161
E	SD-RMSSD (ms)	120	87	93	89	90	90	85	92	88	88	96			117

The standard deviation in the RMSSD was relatively large for the majority of characteristics across all participants indicating that specific activities at certain times could be either more

depleting or more recovering and that other information in that activity would be important to truly understand the context to when it was more depleting or recovering. The graphic illustrations (provided as an example for participant A in Appendix 8.6.1) also showed that sometimes at the start of an activity when interacting with others (not alone) where the activity may involve a challenge or setback or some other contextual issue that RMSSD increases at first as the entrepreneur engages on managing the interaction but then may decrease at the end of the activity or at its conclusion (that is an increase, plateau then valley at the end or once alone or activity is completed). As changes of depletion and recovery of self-regulation strength are seen throughout the day based on the context that the activities take place and are influenced by characteristics such as if they are alone or interacting with others, have a setback or not, a challenge or not and many other variables some of which were asked but most of the context is not known in the moment.

In respect to the participants subjective responses, these results may be higher or lower in particular moments through the day but broadly the results showed that through the day the entrepreneur is able to maintain their responses within a range that is normal for the individual, but it is influenced by the context of the moment. For example, self-regulation may deplete when an action is not routine, a challenge, and have an uncertain outcome and the subjective responses may decline but once the activity is complete and the entrepreneur moves to another activity their response return to their normal range. Comparative summaries of the participants self-regulation and subjective responses by activity and activity characteristic are provided in Table 5-16 and Table 5-17 respectively. For each participant the mean-RMSSD, mean-ALERT, Mean-Happy and Mean-Stressed is given for either the activity or characteristics of the activity.

Table 5-16: Comparative Participant Subjective Responses and Activity Summary

Participant	Activity =	Exchange information and opinion	Work analytically and conceptually	Organise and coordinate	Network and maintain relationships	Direct and lead	Learn and develop	Monitor and control	Consult and sell	Travel	Personal	Non entrepreneur work or study
A	MEAN-RMSSD (ms)	406	360	370	395	386	403	346	438	396	326	
A	MEAN-Alert (%)	73%	73%	81%	73%	80%	83%	72%	67%	69%	71%	
A	MEAN-Happy (%)	75%	74%	74%	73%	74%	72%	80%	82%	73%	74%	
A	MEAN-Stressed (%)	72%	77%	72%	74%	75%	83%	87%	54%	74%	74%	
C	MEAN-RMSSD (ms)	445	440	436			353		386	395	322	436
C	MEAN-Alert (%)	44%	59%	90%			88%		88%	62%	51%	77%
C	MEAN-Happy (%)	78%	71%	71%			64%		55%	69%	65%	76%
C	MEAN-Stressed (%)	80%	39%	72%			88%		90%	63%	33%	44%
D	MEAN-RMSSD (ms)	373	307	349	360	319	385	276		375	283	338
D	MEAN-Alert (%)	70%	58%	55%	50%	82%	77%	71%		54%	35%	30%
D	MEAN-Happy (%)	66%	47%	58%	62%	74%	68%	62%		68%	52%	65%
D	MEAN-Stressed (%)	61%	68%	64%	66%	56%	54%	69%		58%	54%	52%
E	MEAN-RMSSD (ms)	248	200	213	394		217			310	330	
E	MEAN-Alert (%)	63%	52%	63%	89%		40%			74%	53%	
E	MEAN-Happy (%)	63%	59%	66%	87%		69%			68%	72%	
E	MEAN-Stressed (%)	57%	45%	45%	19%		30%			41%	36%	

Both tables indicate that in the moment and through the day that subjective responses sit on average within a relatively narrow range as momentary self-regulation also fluctuates in the moment and through the day. The range is unique to the individual entrepreneur and can be an indicator of their average effectiveness in different types of activities, even though like self-regulation itself there are fluctuations based on other contextual factors some of which are known but for others cannot easily be measured or known. For example, the range of subjective responses for participant A is much narrower (70-80% for most activities) than participant E whose range is much wider (40-80% for most activities). Table 5-16 for example indicates that participant A on average is more subjectively alert in directing and leading activities and more subjectively stressed in monitor and control activities; or that participant D is least subjectively happy during work analytically and conceptually activities while participant E is most subjectively stressed on average in activities to exchange information and opinion such as meetings where he is interacting with others. Table 5-17 indicates that

characteristics of the activity have an impact on subjective responses for example participant C is more alert for non-routine activities than routine activities and participant D is much less subjectively stressed than any other characteristic when the activity is not a challenge or has no setback.

Table 5-17: Comparative Participant Subjective Responses and Activity Characteristics Summary

Participant	Activity Characteristic =	Not Routine	Routine	Challenge	No Challenge	Uncertain Outcome	Certain Outcome	Setback	No Setback	Not Alone	Alone	Not Routine Challenge Uncertain Outcome	Not Routine Challenge Uncertain Outcome Setback	Not Routine Challenge Uncertain Outcome Not Alone	Not Routine Challenge Uncertain Outcome Alone
A	MEAN-RMSSD (ms)	381	379	362	379	376	381	395	367	394	344	374		391	338
A	MEAN-Alert (%)	75%	72%	71%	75%	75%	72%	94%	72%	75%	73%	71%		70%	75%
A	MEAN-Happy (%)	75%	74%	75%	74%	74%	73%	91%	89%	74%	73%	74%		75%	71%
A	MEAN-Stressed (%)	74%	75%	77%	74%	75%	74%	72%	75%	73%	77%	79%		78%	79%
C	MEAN-RMSSD (ms)	405	407	427	399	407	405	420	390	392	399	386		386	
C	MEAN-Alert (%)	74%	51%	70%	65%	59%	69%	64%	65%	64%	65%	88%		88%	
C	MEAN-Happy (%)	65%	76%	69%	69%	62%	72%	63%	70%	68%	70%	55%		55%	
C	MEAN-Stressed (%)	62%	73%	60%	67%	72%	63%	44%	63%	62%	57%	90%		90%	
D	MEAN-RMSSD (ms)	396	340	340	353	346	337	318	339	358	308	425		425	
D	MEAN-Alert (%)	65%	64%	64%	62%	59%	68%	51%	62%	69%	48%	79%		79%	
D	MEAN-Happy (%)	65%	59%	56%	72%	55%	64%	46%	69%	63%	54%	100%		100%	
D	MEAN-Stressed (%)	67%	63%	66%	49%	67%	58%	69%	54%	60%	61%	73%		73%	
E	MEAN-RMSSD (ms)	230	223	239	219	228	206	226	232	261	208	157		146	161
E	MEAN-Alert (%)	51%	59%	60%	58%	57%	65%	71%	57%	61%	56%	46%		59%	41%
E	MEAN-Happy (%)	61%	63%	59%	64%	61%	70%	49%	64%	64%	63%	48%		37%	51%
E	MEAN-Stressed (%)	46%	49%	58%	45%	49%	44%	82%	46%	53%	43%	59%		84%	51%

Overall, the interactive effects have indicated that through the day the action environment has an effect on the entrepreneur's self-regulation strength and that depleted self-regulation indicates entrepreneurs are performing more challenging or demanding activities while recovery indicates that entrepreneurs are performing more routine or comfortable activities. The results also showed that in the day depletion and recovery changes in the moment as activities changes and there are ups and downs, but the entrepreneur persists in their actions and broadly the entrepreneur is able to maintain their subjective effectiveness within a range that is normal for the individual. This shows that individuals can manage the normal range of



experiences they encounter day in day out but also that outliers where the activity is not in their current range of effectiveness become of interest and where tracking changes in self-regulation may give insights into the moments that are outside of these norms for the individual.

### 5.6.2. Cumulative Effects

Subjective stress may match physiological stress in moments but be different in others and very strong positive or negative moments can impact the subjective effectiveness, but ongoing depletion or recovery cycles may start to occur and be of particular interest. The illustrative momentary charts for 30 days of period 1 for participant A (Appendix 8.6.1) as an example indicated that self-regulation strength typically decreases over the duration of the workday (linear RMSSD (ms) declines) indicating that the cumulative influence of the person-by-situation interactions throughout the day was depleting before expected cumulative recovery through sleep before the next day begins. The cumulative impact is therefore of great interest to understand how the entrepreneur's cycles of depletion or recovery in self-regulation and subjective effectiveness may be impacted over days and weeks during their journey and ongoing challenge and uncertainty.

The cumulative analysis used the value of the resting RMSSD recorded each night and compared the change each day as well as the difference against the average resting RMSSD over the period of collection. While there was mixed consistency with data collection from some participants (particularly participant C), on a daily comparison where data was very consistent (participants A and E) or also when it was disjointed or in short periods (for participants B and D) the results consistently showed that daily, an entrepreneurs' self-regulation can deplete, and this can negatively impact the entrepreneur's subjective effectiveness, but the effect is typically short. The comments from the daily diary provided contextual support to the ups and downs of the entrepreneurs' day consistently matching the depletion or recovery seen in resting RMSSD from day to day and providing further support to proposition 2 and 3. And while the subjective effectiveness across the six measures varied in their direction, more often than not more measures were red when self-regulation was strongly red (decrease) or green when self-regulation was strongly green (increase). But when

the change was not strongly red or green results could be more mixed and contextual clues gave an indication of why some of the subjective measures were in the direction they were. For participant A as an example with depletion it may be expected that feelings of progress and satisfaction may decline but challenges or setback also emboldened the entrepreneur to come back stronger the next day so daily self-regulation fluctuations can see an increase or decrease in subjective effectiveness across measures, but cumulatively a clearer trend should be seen.

Resting RMSSD is itself an indicative physiological measure of performance and wellbeing and the expectation is that depleted self-regulation can decrease feelings of subjective effectiveness but with recovery and refocus that the next day resting RMSSD would recover, and this was consistently seen in the results. Particularly for participants A and E day to day where data collection was consistent the results showed a change from red to green on a day-to-day basis cycling consistently between depletion and recovery and at most only two or rarely three days cumulatively that were red or green. However, for participant A who between two measurements periods (August and November) saw a decline in average RMSSD between the two periods which matched contextually with more challenging and demanding work and life circumstances in the second period there was less variability in the change from day to day and RMSSD was consistently lower on average than days in the first period. The daily difference to the average RMSSD was red for 14 out of 18 recorded days in this second period providing a consistent trend of depletion where also the absolute values of the effectiveness measures were lower than the first period. These results supported proposition 4 indicating that overtime, cumulatively if there is more depletion and not enough recovery of self-regulation the entrepreneur's effectiveness is negatively impacted.

Participant D & E also have relatively consistent ongoing recordings and participant D indicated that he was feeling burnt-out mid-way through his collection period. His absolute subjective effectiveness measures remained relatively quite low and the difference to the average RMSSD remained primarily red or at the average indicating more depletion than recovery for a significant number of days however the RMSSD collection during this period was not consistent day in day out for a clear trend to be seen over multiple weeks. For

participant E, his data collection was very consistent and particularly in the first 2 weeks of collection the variability in RMSSD was within a consistent narrow range leading into the Christmas and New Year's break where variability then increased during this period and continued into the early parts of the new year where he commenced work again. During work periods his RMSSD tended to alternate between depletion and recovery pretty consistently but sometimes he had 3 or 4 days in a row as green or red indicating that his cycles of depletion and recovery were not consistent and could influence his effectiveness but there is no sufficiently long clear trend beyond a few weeks.

These further cases don't provide supporting confirmation on the results seen for participant A but show that cumulative changes in RMSSD could be used as a lead indicator or early warning of effectiveness issues for the entrepreneur. They also reinforce the methodological importance of longitudinal data collection and need for consistency from the participants in engaging with the data collection. By the individual knowing their normal cycles of depletion and recovery consistently over time they can be in a position to be more aware when work and life circumstances may be impacting this normal and how it could influence their effectiveness and take steps to self-manage these changes before it leads to more significant performance and wellbeing issues for the individual. As overtime, with continued depletion and no or limited recovery in self-regulation strength, the entrepreneur could enter a cycle of excess depletion which can cause greater negative impact on their performance and wellbeing.

### 5.6.3. Causal Configurations

Analysis of individual case study results and participant contextual factors alongside the cross-case analysis of interactive and cumulative effects have provided examples of causal configurations which are structured in this section to provide greater sense-making of the findings and causal relationships. Building on the conceptual model with measurement variables originally outlined in Figure 4-1, an inductive conceptual model for causal configurations is provided in Figure 5-1. This model provides for exploratory inductive analysis of how activity characteristics impact self-regulation strength and consequences for

entrepreneurs differently through understanding the trait self-control and experiences of each entrepreneur that was collected at the beginning of the study.

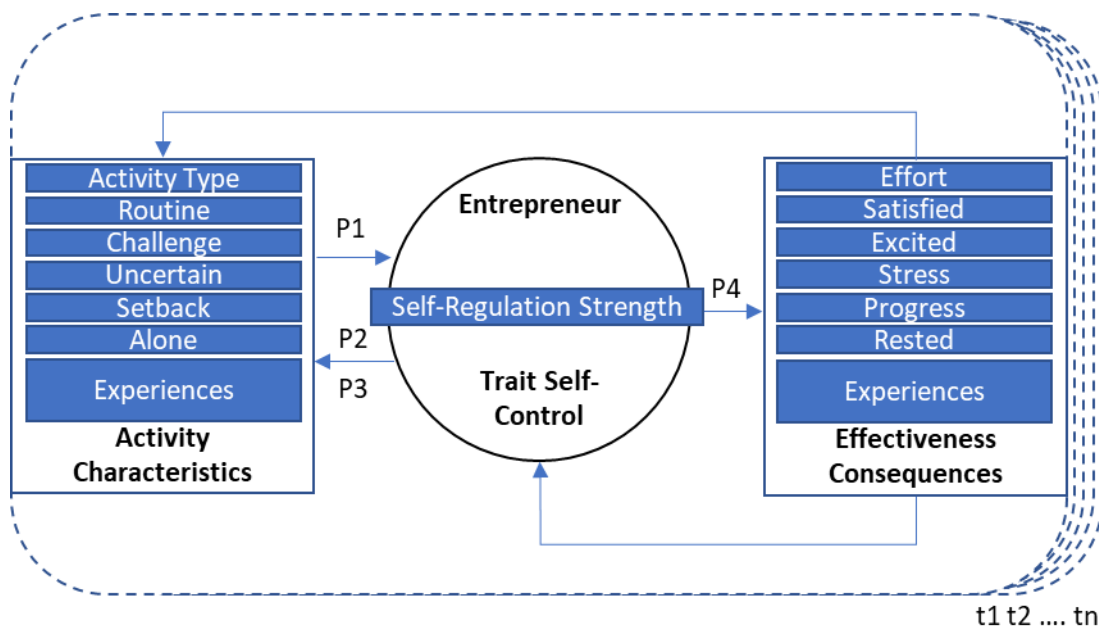


Figure 5-1: Conceptual Model – Inductive Causal Configurations

Entrepreneurs differ from each other in relation to their trait self-control (as well as other traits and experiences) so for each individual entrepreneur the way they construct and manage their entrepreneurial journey will be different and how the activity characteristics impact their self-regulation will vary and have different consequences for their effectiveness. In this study, the background survey for Participant A and E indicated trait similarities for self-control, both participants being disciplined and hardworking, maintaining where possible consistent schedules and who plan ahead so they think before they act. However, they also both worry about the details, and are striving to be recognised for their work and find more from their lives. For this inductive analysis they are categorised as having higher trait self-control. Conversely the background survey for Participant C and D are categorised with lower trait self-control. Participant C and D see themselves as creative with varied interests and pursuits where their work life is not consistent (even when they try and put systems or expectations in place to manage it that way). They worry about the bigger picture of their business and selves and seek to be better with their work-life balance.

Table 5-18 outlines the in the moment potential causal relationships induced from the interactive cross-case analysis tables and understanding of each participant case study in line with the structure of the conceptual model. Each two rows of the table shift provide a contrast between opposite activity characteristics as the basis of the sense making comparison. In the first column a selection of different activity characteristics are shown representing the activity state in the moment. The second column indicates higher or lower trait self-control and the third column the difference in self-regulation strength between contrasting activity characteristics. The difference in self-regulation strength is shown as broadly meaning uses less, use more or nominal, where nominal indicates an expected normal operating range for a particular individual under those conditions. The final column is a summary of the subjective effectiveness consequences that were self-reported by the entrepreneur where under the conditions for the row broadly responses were nominal, being in an expected normal range for those events, or variable, indicating that for the individual their responses were inconsistent and/or being a mix of positive or negative effectiveness response for the conditions. In select cases the subjective responses indicated generally specific effectiveness responses in regard to subjective stress or alertness.

*Table 5-18: Inductive Causal Configurations – Interactive Effects*

Activity Characteristics (in the moment)	Entrepreneur		Effectiveness Consequences (subjective responses)
	Trait Self-control	Self-Regulation Strength	
No Challenge and/or Certain outcome and/or No Setback	Higher	Use Less	Nominal
	Lower	Nominal	Variable
A Challenge and/or Uncertain Outcome and/or Setback	Higher	Nominal (Minor challenge)	Variable
	Higher	Use More (Major challenge)	Higher stress, more alert
Alone	Lower	Use More	Variable
	Higher	Use More	More stress
Not Alone	Lower	Nominal	Variable
	Higher	Use Less	More alert
Activity Type (routine)	Lower	Nominal	Variable
	Higher	Use Less	Nominal
Activity Type (not routine)	Lower	Use More	Variable
	Higher	Use More	Variable

Legend: Nominal = values in an expected normal range for the specific conditions  
Variable = values were inconsistent and/or being a mix of positive or negative for the specific conditions

Table 5-19 outlines potential causal relationships induced from the cumulative cross-case analysis and understanding of the context of the entrepreneur journey and comments in the

daily diary adding the additional variable of the duration of time to the cycles of self-regulation. Cumulative self-regulation depletion over consecutive days or weeks in a period can have consequences for the sustainability of effectiveness of entrepreneurs. There are three rows in the table where in the first column the experience of the day (and its activities) collectively is reported by the individual entrepreneur as either generally a positive day (subjectively less stressful, challenging), a normal day or negative day (subjectively more stressful, challenging) as captured in interviews and their daily dairy reports.

The second column indicates higher or lower trait self-control and the third column whether the resting self-regulation strength is indicating generally depletion, recovery, or nominal values on a daily basis. For the case of a negative day, the column is expanded to highlight the connection between cumulative depletion occurring, over days, weeks or months, and the potential effectiveness consequences expressed in the daily diary and interviews. These consequences ranging from nominal to variable but as seen as an indicator of potential wellbeing and performance issues that may be broadly negative (where cumulative depletion happens over weeks) or severe (where cumulative depletion happens over months). The nominal self-regulation data seen on a day-by-day basis sees self-regulation strength cycle between depletion and recovery on a daily basis, but the data showed that over longer periods of days and weeks ongoing cumulative depletion had a negative influence on overall effectiveness.

*Table 5-19: Inductive Causal Configurations – Cumulative Effects*

Activity Characteristics (daily summary)	Entrepreneur		Effectiveness Consequences (subjective responses)
	Trait Self-control	Self-Regulation Strength	
Negative Day	Higher	Depletion(days) Depletion (weeks) Depletion (months)	Nominal Variable or Negative Negative or Severe
	Lower	Depletion (days) Depletion (weeks) Depletion (months)	Nominal or Negative Variable or Negative Negative or Severe
Normal Day	Higher	Nominal	Variable
	Lower	Nominal	Variable
Positive Day	Higher	Nominal or Recovery	Positive
	Lower	Nominal or Recovery	Variable

Legend: Nominal = values in an expected normal range for the specific conditions  
Variable = values were inconsistent and/or being a mix of positive or negative for the specific conditions

The inductive sense making driven from the conceptual model used provides the foundation for exploring other combinations of the activity, entrepreneur, and consequences in future research where data collection could be expanded that could lead to further causal configurations (combinations of causal conditions or social mechanisms) being identified.

## 6. Findings and Conclusion

*"Some days you're smiling and thinking you're going to make this thing rock. Then the next day a pipe breaks and your costs look too high. You have to learn to keep your eyes on an ultimate goal. If you lose sight of that goal, you have to get out." - Hamdi Ulukaya, founder & CEO of Chobani*

### 6.1. A Time Sensitive Entrepreneurial Framework

The focus of this study was to explore how the changing entrepreneurial journey influences the entrepreneur's self-regulation over time specifically in the moment, through the day and cumulatively over longer durations of days and weeks. With the intent that exploration of the cycles of self-regulation depletion and recovery can provide insights into the interactive and cumulative impacts of the entrepreneur journey on the performance and wellbeing of entrepreneurs. The research methodology included qualitative and quantitative elements in building up a picture of the individual entrepreneurs' journey and the propositions developed were investigated through inductive and deductive interpretation of the data collected.

Findings from small-n case studies lead to knowledge about the causal configurations (combinations of causal conditions or social mechanisms) that make specific outcomes possible (Blatter & Haverland 2012). The few within-person studies on entrepreneurs looking at performance and wellbeing have revealed substantial variability in their weekly experience of work demands (stressors) and psychological strain (Totterdell, Wood & Wall 2006), their daily positive and negative affect (Foo, Uy & Baron 2009; Uy, Sun & Foo 2017), their weekly effort and passion (Gielnik et al. 2015), and their daily sleep and idea generation (Weinberger et al. 2018; Williamson et al. 2019). As the individual capacity to self-regulate is a limited resource (Baumeister & Vohs 2007; Gailliot & Baumeister 2007) understanding the cycles of depletion and recovery as the individual engages in different actions or characteristics (of an action) provides a mechanism to provide insights into the activity preferences of the entrepreneur, what activities and action environments are uncomfortable for an entrepreneur, and where they may need to be supported to improve their performance.



The exploration of the impact of different actions and characteristics showed broadly that depleted self-regulation indicates entrepreneurs are performing more challenging or demanding activities while self-regulation recovery indicates that entrepreneurs are performing more routine or comfortable activities, but the results can be inconclusive in certain cases or where the context to the moment is unclear. Inconclusive results can be explained as the allocation of depleted resources can occur when current demands are exceptionally high, current tasks have motivational priority, and/or replenishment is imminent, but there may be a natural tendency to resist drawing down energy stores too far or too rapidly (Baumeister & Vohs 2016). In the entrepreneurship context we would expect to see this during activities that are of particular importance and significance to the entrepreneur, one example being when the entrepreneur might be trying to sell or influence investors, partners, or customers on the potential of their product or service.

Existing research has looked at activities both over a longer time using PSED (Davidsson & Gordon 2012; Gartner et al. 2004; Reynolds 2016) and daily activities (Mueller, Volery & von Siemens 2012) but this research has not linked activities and their characteristics to self-regulation and ego-depletion or to effectiveness and wellbeing. The potential causal configurations identified in the inductive analysis have shown linkages between the characteristics of the activities and the consequences for effectiveness and wellbeing both interactively and cumulatively. For example, those with lower trait self-control may need to use more self-regulatory strength than those with higher trait self-control to focus on activities with either routine or challenging task characteristics. When activity types are routine to the entrepreneur, entrepreneurs with higher trait self-control use less self-regulation strength as they focus and get their work done but as activity types become less routine and more challenging entrepreneurs with both lower and higher self-control traits use more self-regulation and their effectiveness is variable, that is responses were inconsistent and or being a mix of positive or negative for specific conditions.

Studies on entrepreneurial action have also found that some activities might be more important than others at the various stages of start-up development (Delmar & Shane 2003), hence by timing of an activity, the entrepreneurs can influence their self-regulation strength.

Activities may also be performed in such manner that self-regulation is conserved, for example where an activity is delegated to other team members. Or where entrepreneur seeks the best performance for themselves individually instead of what is best for the venture. Entrepreneurs may also choose activities based on their current level of self-regulation strength, and/or expected amount of depletion or recovery. Entrepreneurs may be able to sacrifice their wellbeing by taking on more stress for the team and venture performance in the short term but done over longer durations of weeks and months can have effectiveness and wellbeing consequences that may be severe if left unchecked. Overall a better understanding how individual performance and wellbeing ties to a team and ventures performance can be a step towards smarter and more sustainable entrepreneurial activity.

Overall, the results provide insights into what the entrepreneurs are doing in a broad sense and how the journey may be influencing their performance and wellbeing. It is not that we can know what exactly they are doing and how performance and wellbeing is impacted in the moment but that we can know what activities or characteristics are important or influential for the wellbeing and performance of the entrepreneur cumulatively in the short term and over long durations. Previous entrepreneurship research has tried to first understand what traits and characteristics make up an entrepreneur while Gartner (1988) proposed that it is not the individual but the actions that matter and so research then focussed on all possible activities and the patterns and sequences that may explain success. In context to this study, it could be asked is better self-control and self-regulation good for the entrepreneur. The answer can be yes and no, yes because it aids in the sustainability of effort in pursuit of specific goals, but also no because it could mean that entrepreneurs may focus in on and spend too much time diligently doing the wrong activities and or avoiding activities that are uncertain or uncomfortable for themselves but are important for success.

An insight from this research is that irrespective of the specific path the entrepreneur is taking, the entrepreneur can sustain effort longer towards their goals, giving themselves more opportunities to get on path to success. And given that individual actions may matter, it is the cumulative effects of the journey on the individual entrepreneur and how the individual manages the effects on themselves that ultimately help explain performance and success.

And so, an important consideration for entrepreneurs is not just what you do, but how you manage the day-to-day cumulative effects of the doing on yourself in order to be able to sustain the entrepreneurial effort to be able to be the most effective. Research has shown the existence of a strong relationship between individuals' self-regulation strategies and various indices of adaptive success (Boekaerts, Maes & Karoly 2005) where this study adds to this conclusion.

This study therefore broadly shows that the nature of the entrepreneurial journey and the context in which actions take place shape the relationship between entrepreneurial actions and the self-regulation and subjective experiences of the entrepreneur as outlined in the conceptual framework in Figure 3-2. Where individual intensity, persistence, and effort of the entrepreneur within the context of their own journey and whether a particular action environment is demanding or not for that individual influences their self-regulation and individual subjective effectiveness in an interactive and cumulative sense. This time-sensitive entrepreneurial framework can therefore be used flexibly to explore the cycles of depletion and recovery of an entrepreneur's self-regulation strength within the context of the changing action environment for understanding broadly an entrepreneur's performance and wellbeing. Where depleted self-regulation indicates entrepreneurs are performing more challenging or demanding activities and self-regulation recovery indicates that entrepreneurs are performing more routine or comfortable activities. Such that the entrepreneur self-regulates within a range of effectiveness interactively through the day but if their self-regulation depletes cumulatively without sufficient recovery over time this can be a lead indicator of decreased effectiveness and potential performance and wellbeing issues and challenges.

This opens up the possibility of individual entrepreneurs being able to use lead indicators to identify changes in the cycles of their self-regulation strength and address potential performance and wellbeing issues before they become more serious. In addition, it allows for exploration of the cause and effect of changes in mediating factors in the entrepreneurs' normal routines such as sleep, exercise, nutrition, and social connections in order to enhance their day to day and ongoing individual effectiveness. In this way, self-awareness, and self-management of the cycles of depletion and recovery relevant to the individual entrepreneur's

journey through their action environment has the potential to be able to improve subsequent performance and wellbeing in a parsimonious form. Such that the framework can help the individual entrepreneur to understand their own self-regulation cycles and help entrepreneurs understand how and when they are more effective and support sustained performance and wellbeing of entrepreneurs in pursuit of their goals.

For the entrepreneurship researcher and or partners and collaborators with the entrepreneur (which could be personal such as a family member through to a financial relationship like an incubator or investor), as a tool HRV data can provide a mechanism to understand an entrepreneur's day and journey over time through both the ups and the downs, where other contextual information or clues may be difficult to obtain. Past difficulties in asking entrepreneurs what they are doing over days and weeks and not being able to get information could be broadly understood through real time physiological data collection providing an understanding of what parts of their journey are challenging or demanding and which are not, both interactively and cumulatively over time. Supplemented with other data collection for further insights, the researcher or supporter of the entrepreneur, can gain a better understanding of how the entrepreneur goes about their journey and insights into how to support the entrepreneur to improve their effectiveness in the short and longer term.

If an entrepreneur manages their cycles of self-regulation well, they have the potential to be more individually effective. However, if they do not manage their cycles of self-regulation well, they may see their self-regulation strength deplete and be less effective. It is apparent that entrepreneurs who are more effective may work smarter in reaching their goals, eliminating unnecessary effort, and wasted time. But those that do not may enter an ongoing cycle of self-regulation strength depletion as they are less effective and must waste effort and time to keep up with goals which has the potential to cause further negative health, wellbeing, and performance impacts. This for example could include increased stress or ultimately burnout as broadly ineffective self-regulation predicts poor physical and emotional health, and other life problems that would decrease performance and wellbeing (Baumeister, Heatherton & Tice 1994; Tangney, Baumeister & Boone 2004).

## **6.2. Contributions**

It has long been recognised by management researchers that it is incredibly difficult to study and investigate the changing experiences of individuals over time even though they are critically important and time impacts nearly all organisational phenomena (Bluedorn & Denhardt 1988). As most phenomena of interest to management researchers fluctuate over time (Dalal & Hulin 2008), static research paradigms that do not account for change fail to capture complex and dynamic states, behaviours, and situations (George & Jones 2000) and therefore to do not capture the full story of change in the phenomena. And while there is extensive knowledge on entrepreneurs as people, the actions or activities they take to be successful, and the environments they work in, there is a gap in understanding the dynamic interplay between these factors and change over time (Byrne & Shepherd 2015; Lévesque & Stephan 2020; Shepherd 2015; Stephan 2018; Wiklund et al. 2019). As the way that each individual entrepreneur constructs and manages their entrepreneurial journey will be different and evolves over time, exploring how the changing action environment of an entrepreneur's journey influences the entrepreneur's performance and wellbeing through their journey is of interest and is where this thesis makes theoretical, methodological, and practical contributions to entrepreneurship research.

Theoretically, this thesis advances a time-sensitive self-regulation framework that enables the exploration of the idiosyncratic nature of entrepreneurial journeys and influence on an entrepreneurs' performance and wellbeing over time. The results showed that the changing action environment has an effect on the entrepreneur's self-regulation strength and periods of depleted self-regulation indicate entrepreneurs are performing more challenging or demanding activities while periods of self-regulation recovery indicate entrepreneurs are performing more routine or comfortable activities. We saw that in the moment entrepreneurs' use self-regulation to maintain their subjective effectiveness within a range individual to them but daily an entrepreneur's self-regulation can deplete, and overtime if there is more depletion and not enough recovery of self-regulation the entrepreneur's effectiveness can be negatively impacted. Sense making through the inductive causal configurations is also instructive where insights have been made that link activity characteristics to self-regulation and effectiveness consequences making novel contributions

to existing research on entrepreneurial activity. And cumulatively understanding the individual cycles of depletion and recovery provide insights into how entrepreneurs cope with stress over extended periods and add to research on entrepreneurs and wellbeing.

The framework itself provides an approach for capturing the complex and dynamic states, behaviours, and situations that an entrepreneur is engaged in during their individual journey and enables investigation of fluctuations over time providing a foundation that can be used with adaption for exploration of dynamic person-by-situation interactions and processes of within-individual change for entrepreneurs in the moment and cumulatively. It has the potential to incorporate exploration of individual development, learning and adaption over time and the dynamic interplay between entrepreneurs as people, the environments they work in, and the actions or activities they take to be effective. It extends entrepreneurship literature on entrepreneurial actions and self-regulation as well as the performance and wellbeing of entrepreneurs in real work-life settings.

Methodologically, this study has provided insights and learnings in using novel technologies and methods such as wearable sensors, HRV analysis and ESM for studying entrepreneurs in their real work and life settings, day in day out over timeframes of weeks to months. It highlights potential in data collection, integration and analysis which are novel in entrepreneurship research highlighting practical challenges encountered as well as approaches to maintain engagement of participants and protocols to ensure consistency and control over the data collection which is critical in maximising the opportunity of everyday data collection over long durations. The complexities in the data management for cleaning, structuring, and integrating the data sources as well as the investigative tools and analysis methods that can be applied provide insights into its application and the new skills, collaborations and partnerships needed in emerging disciplines to be able to access and automate the necessary data collection and analysis infrastructure for scaling up studies from small to large numbers of participants. The emergence of big data and related analytic techniques are creating opportunities to advance empirical entrepreneurship theory and practice (Schwab & Zhang 2019) and this explorative study provides an example. The within-person perspective approach shifts focus from static between-person approaches

traditionally used in entrepreneurship research towards more dynamic person-by-situation interactions and processes showing the potential and limitations for use.

Practically, the thesis advances the potential utility of self-awareness and self-management of self-regulation for giving individual entrepreneurs a framework that can help them understand how and when they are more effective and support sustained performance and wellbeing in pursuit of their goals. The framework can help entrepreneurs be aware of the tripwires and establish lead indicators of potential performance and wellbeing issues that may be very specific to their routine and behaviours. By understanding what mediating factors impact their cycles of self-regulation depletion and recovery the entrepreneur can seek greater effectiveness and balance with work and life giving the potential to improve their effectiveness. Greater awareness and better management of their own effectiveness and how this can be supported within team and organisational settings can be of practical benefit in a range of contexts. For example, incubators, enterprise support agencies, training providers and business mentors can build greater shared understanding of the individuals they support and develop training and coaching programming to improve entrepreneur performance and wellbeing. And for the researcher, it provides a way to gain a contextual understanding of how entrepreneurs spend their day and an insight into their ups and downs through physiological measurements negating some of the past difficulties in asking entrepreneurs what they are doing every moment and over time.

### **6.3. Implications**

The multiple case-study approach used provides a detailed analysis of each of the individual entrepreneurs and their journey highlighting the use of wearables and ESM for exploring self-regulation and the changing action environment showing the potential of these approaches to reveal the kinds of novel insights that are not possible if relying solely on traditional between-person perspectives (McCormick et al. 2020). It highlights that by using physiological data collected with wearables, it can be easier for the researcher and subject to collect information on an ongoing basis to enable exploration of dynamic person-by-situation interactions and entrepreneurs' thinking, feelings, and behaviours in a real world – “in the wild”- setting over time.

Entrepreneurial striving has become a celebrated aspect of human adaption and is associated with societal, economic and scientific advancement and for many countries entrepreneurship is high on the political and economic agenda as a driver of change in society and the economy as the future of work continues to evolve and significant investment at many levels goes into supporting this process (Acs, Szerb & Lloyd 2017; Sternberg & Wennekers 2005). It is also known that entrepreneurship can be a very inefficient process where the start-up process is difficult and uncertain and many new ventures struggle to survive and become sustainable and/or valuable (Haswell & Holmes 1989; Nanda & Rhodes-Kropf 2013). In addition entrepreneurs themselves struggle with their personal wellbeing in areas such as stress and mental health (Cardon & Patel 2015; Rahim 1995). If individual effectiveness, performance, and wellbeing of entrepreneurs can be improved then this can be of great benefit to the individual, organisations of all sizes as well as society and the economy as a whole.

There is an emerging opportunity to focus research, industry, and policy engagement to improve wellbeing and performance of individuals engaged in innovating in the future world. The learnings from this research could be translated into industry and society benefit to:

- Support entrepreneurial individuals to better understand and improve their self-regulation in support of driving better performance and wellbeing.
- Influence how entrepreneurial individuals are educated, invested in, and supported in the future to support improved performance and wellbeing.

Ultimately greater understanding of our underlying physiology and psychology could be realised through the use of wearable technologies and sensors providing significant future research and industry translation potential that could in time be extended into a range of aspects of how people live, learn, and work as greater understanding of these affects are known and applied in a range of contexts. This research exploration shows some of the possibilities but also some of the challenges and limitations that will need to be addressed.

#### **6.4. Limitations**

While novel technologies such as wearable sensors and ESM create opportunities for deeper exploration of the change in states, behaviours, and environments of entrepreneurs over



time, there is a burden of collection on both the researcher and the participant and there are limitations in the consistency and efficacy in the data collected and integrated. There are a range of issues and challenges in how these tools are applied and used by participants as highlighted in the methodology and results chapters of this thesis. Focus on long duration participants collecting data for more than a few hours or days has limited the number of participants willing and able to commit to the burden of data collection in this exploratory stage. The study also only had male participants and so has not been able to explore any gender differences, for example how any mediating factors may impact entrepreneurs' cycles of self-regulation depletion and recovery differently.

However, the volumes of data collected continuously 24 hours a day over weeks and months far exceed what would normally be collected in shorter studies with many more participants. And where preparations needed to analyse it have required considerable amounts of investigation and time. While it is relatively easy and non-intrusive to ask a participant entrepreneur to attend a 90-minute workshop session and use a wearable device while completing laboratory tasks, due to the nature of entrepreneurial work and life even in this instance entrepreneurs would sometimes not attend or become unavailable at the last minute. It is a far more significant sacrifice of time for entrepreneurs to commit to an ongoing 24 hour a day study for weeks or months on end while wearing a wearable device and completing regular surveys. Additional long-term participants had started to be identified and recruited before the Covid-19 pandemic in 2020 created lockdown conditions which changed the day-to-day nature of entrepreneurial work life and participation availability resulting in the decision to exclude any further data collection from this study and to focus on data analysis of the participants that had been already collected.

The data integration and analysis learnings in this study are a first step to the future potential of iterative sequences of inductive, abductive, and deductive investigations (Kitchin 2014) where data analysis can be increasingly automated with machine learning and other technologies. Integrating and exploring the data collected which is not comprehensively clean and well-structured and contains missing or miscoded data depends on the data management capabilities to efficiently clean, restructure, integrate, and combine the data and the data-

analysis capabilities tailored to extract meaningful information. Substantial effort must be spent in this process where major challenges in integrating data from various sources for the same activities must be linked by time, participant, or other information. The integration and analysis was carried out using both manual and automated software processes due to the complexity of data integration and verification required. However, some of the more ambitious plans for collaborations with internal and external partners focussed on data science that were being set up in the latter half of 2019 and early 2020 for further automation of the processes had changed or cancelled due to resource and collaboration availability challenges caused by the Covid-19 disruptions in 2020. These processes are necessary for real time and large-scale participant analysis that offers future potential in entrepreneurship research as well as practical applications. Where the possibility of incorporating additional physiological factors such as EDA, movement, heart rate and other factors such as cortisol levels alongside additional contextual data of the changing action environment offer promise for further insights.

This study focussed on the analysis of entrepreneurs as they go about their day-to-day work and life to investigate entrepreneurship as it is happening and how it impacts an individual's self-regulation and subjective effectiveness. While this context opens up opportunities to use wearable devices and related technologies to understand the behaviours and thinking of entrepreneurs individually in ways previously largely unexplored in entrepreneurship research it also has limitations in sampling and error detection in the way data collected and analysed. This is an acknowledged limitation as in this case the within person multiple case-study approach is very individualised regarding the individual effect and the priority in this exploratory study is to understand the direction, intensity, and duration of the effect not the absolute numbers themselves. Overall, the exploratory and deductive investigation of multiple streams of data is a challenge in making sense of what the data is actually telling us, when the data is also messy and incomplete. It is in this collection, preparation, cleaning, integration, and interpretation of the data where insights and lessons can be learned for the future use of these methods in entrepreneurship research and practice.

## **6.5. Future Research**

This study has used a limited set of variables collected from the wearable sensor, ESM and contextually when compared to the potential data that could be collected and integrated. It was also an exploratory small-n study with a limited number of participants and collected data for weeks not months continuously. Future research can build on this foundation and apply the methodological learnings in data collection and consistency over longer durations of many months and for larger-n while also adding additional variables and context in what data is collected, integrated, and analysed. This creates further opportunities to explore patterns and meaning in the entrepreneurial journey over time to uncover novel insights in the thinking, feeling and behaviours of entrepreneurs. The framework developed can also help explain how to protect performance and wellbeing behaviour change from temptations, in particular before the new behaviour becomes habitual where its utility should be further tested and explored. The standard deviation in the RMSSD was generally quite large for the majority of characteristics of activities across all participants indicating that specific activities at certain times could be either more depleting or more recovering and that other information in that activity would be important to truly understand the changing contexts when it was more depleting or recovering.

A within-person approach also provides research opportunities for more detailed exploration of the interactions between the individual entrepreneur and their social and work environments, including for example processes within the venture, such as communication and decision-making processes within founder or management teams, or interactions between entrepreneurs and their families or employees (Gorgievski & Stephan 2016). This can help researchers build a fuller understanding of how entrepreneurs design their ventures and work environments including how for example they shape the culture and structure of their ventures, develop environments for themselves and their employees or build networks with investors, partners, and other stakeholders. This basis can be used to explore differences in approach between male and female entrepreneurs, or entrepreneurs from different cultures. It can also be used to explore variations between experienced and novice entrepreneurs to explore what thinking, feeling and behaviours may lead to higher

proficiency as well as explore differences between entrepreneurs and non-entrepreneurs in how they go about their day-to-day life and work.

Going further, by tracking individual performance over longer periods of time from weeks to months and years; individuals cumulative success in line with personal or venture variables of development, success and entrepreneurial career performance can start to be explored in order to understand choices over time to look at how individual performance and wellbeing impacts their progress (Davidsson 2008). Tracking individuals over longer periods of time also enables a clearer understanding of how mediating factors such as sleep, fitness and exercise, diet and nutrition, relationships and social connections as examples may influence an entrepreneur's performance and wellbeing. And studies exploring interventions or other novel mediating factors aimed at improving self-regulatory capacity and individual effectiveness can be explored. Without a greater understanding of the context for the individual and how mediating factors influence the individual, a deeper understanding of the cycles of depletion and recovery specific to the individual is left unexplored.

The challenge is any number of factors will have an influence on the individual cycles of depletion and recovery however a number of broad categories of mediating factors will have an influence on the specific cycle of the individual. Changes in any one or a number of factors such as sleep, fitness and exercise, diet and nutrition, relationships, and social connections, may have an influence on the individual cycle of depletion and recovery as was seen as an example in the case study for participant A between period 1 and period 2. Gaining a deeper understanding of how key mediating factors have an influence on the cycles of depletion and recovery of an entrepreneur's self-regulation strength could provide additional insights into the interactive and cumulative effects of the entrepreneurial journey. For example sleep issues carry important implications for organisations of all sizes where inadequate sleep quantity and quality have been linked to organisational consequences such as deviance (Christian & Ellis 2011), unethical behaviour (Barnes et al. 2011), cyberloafing (Wagner et al. 2012), dissatisfaction (Scott & Judge 2006), absenteeism (Westerlund et al. 2008), and a decrease in charismatic leadership (Barnes et al. 2016).

Therefore, sleep issues clearly matter for organisations and sleep has started to be explored as part of understanding broad motivation, and performance and wellbeing characteristics of entrepreneurs (Gish et al. 2019; Gunia 2018). Research has also implicated insufficient sleep to poorer self-regulatory capacity (Altena et al. 2008) and cognitive functioning (Walker 2008) which can impact effectiveness negatively. Sleep facilitates processes in the pre-frontal cortex which are associated with recovery of regulatory resources and thus facilitate self-regulation capacity (Baumeister, Vohs & Tice 2007). Given the recognition of the importance of sleep and its potential role as a mediating factor in supporting better self-regulation, the role of sleep quality and quantity is of importance to understanding the individual cycles of recovery and depletion for the entrepreneur. In this study limited data on sleep quality and quantity was collected as a control variable in the empirical analysis. The data in the case studies indicated that sleep quality and quantity has a mediating role in promoting self-regulation recovery while diminished sleep quality and quantity depleted self-regulation. The entrepreneur journey is long and challenging and sleep patterns may change due to workload and the stresses of the journey but if sleep patterns change and remain changed then this can create cumulative cycles of depletion and potentially serious negative performance and wellbeing issues.

Ubiquitous (also called pervasive) computing is an emerging concept in computer science where computing can take place anytime and everywhere (Ekman et al. 2016). Together wearable sensors, social media, location tracking devices and mobile phones provide a huge network of sensors and embedded computing power that can be harnessed for observing human behaviour and the interactions with the environment or context over time. However, continuous use in wearable devices sets special requirements for power management and memory use so that charging frequency and computing delays can be minimised, and automatic activity or context recognition-based solutions currently are generally limited to manual interactions via mobile phone apps (Siirtola et al. 2009). Future advancements collectively in power management, wireless connectivity and signal and computer processing technology will open up the possibilities of more complex and automated analysis methods (Ekman et al. 2016) that could be applied to entrepreneurship research and more broadly be of benefit to helping people better understand their performance and wellbeing in the

context that they live and work. The possibility of mobile applications to support improved effectiveness will be made possible at the intersection of mobile devices, wearables, and machine learning but there will be regulatory and ethical obstacles to overcome alongside ease of use, reasonable accuracy, and physiologically interpretable models as pre-requisites before the benefits can be applied and realised on a larger scale. The next decade has much promise as developments in these fields continue and potential personalised solutions shift from tracking to behaviour change where they can help people to reach better outcomes rather than just tracking data without understanding changes in the individuals' responses and context each day.

Finally, while these advancements continue, in the short-term further research application in terms of methods and practice may be explored with larger-n using cheaper consumer devices depending on the variables to be collected and the purpose of the study. As wearable devices and sensors become cheaper and more pervasive in their usage, the devices participants already use (or wear) are less invasive in participant engagement and ensuring collection consistency if data can be effectively collected. And although consumer grade wearables may not be as accurate as more expensive research or medical devices, if they show the change and direction of variables such as HRV this can be more useful in understanding changes in longer duration studies than requiring the participant to use or wear a different device. As this study has collected performance and wellbeing data in the form of indicative physiological data as well as subjective effectiveness data and shown they are aligned in many regards it shows the potential of using wearable devices in preference to other research methods to make it easier to collect data over longer durations and in real work life settings. Also, in respect to HRV the use of ultra short measurements, done at the same time each day for the same duration (can be as low as 10 seconds) to get a resting HRV value are starting to be explored and may provide an alternate approach to collecting self-regulation data while being less invasive from a wearable usage perspective.

## 7. References

- Acs, Z., Szerb, L. & Lloyd, A. 2017, *The Global Entrepreneurship Index 2018*, The Global Entrepreneurship and Development Institute, Washington D.C.
- Akande, A. 1994, 'Coping with entrepreneurial stress: Evidence from Nigeria', *Journal of Small Business Management*, vol. 32, no. 1, p. 83.
- Aldrich, H. Z. & Zimmer, C. 1986, 'Entrepreneurship through social networks', In D.L. Sexton and R.W. Smiler, eds. *The Art and Science of Entrepreneurship*. Cambridge, MA: Ballinger, vol., pp. 3-23.
- Alquist, J., Baumeister, R. & Tice, D. 2016, 'Uncertainty depletes self-regulatory resources', *Unpublished manuscript*. Tallahassee, FL: Florida State University, vol.
- Altena, E., Van Der Werf, Y. D., Strijers, R. L. & Van Someren, E. J. 2008, 'Sleep loss affects vigilance: effects of chronic insomnia and sleep therapy', *Journal of Sleep Research*, vol. 17, no. 3, pp. 335-343.
- Amit, R., Muller, E. & Cockburn, I. 1995, 'Opportunity costs and entrepreneurial activity', *Journal of Business Venturing*, vol. 10, no. 2, pp. 95-106.
- Appelhans, B. M. & Luecken, L. J. 2006, 'Heart Rate Variability as an Index of Regulated Emotional Responding', *Review of General Psychology*, vol. 10, no. 3, pp. 229-240.
- Ardichvili, A., Cardozo, R. & Ray, S. 2003, 'A theory of entrepreneurial opportunity identification and development', *Journal of Business Venturing*, vol. 18, no. 1, pp. 105-123.
- Arenius, P., Engel, Y. & Klyver, K. 2017, 'No particular action needed? A necessary condition analysis of gestation activities and firm emergence', *Journal of Business Venturing Insights*, vol. 8, no. C, pp. 87-92.
- Baethge, A., Vahle-Hinz, T. & Rigotti, T. 2020, 'Coworker support and its relationship to allostasis during a workday: A diary study on trajectories of heart rate variability during work', *Journal of Applied Psychology*, vol. 105, no. 5, pp. 506-526.
- Baltes, M. M. & Baltes, P. B. 1986, *The Psychology of control and aging*, L. Erlbaum Associates, Hillsdale, N.J.
- Bandura, A. 1986, *Social foundations of thought and action : a social cognitive theory*, Prentice-Hall, Englewood Cliffs, N.J.
- Bandura, A. 1991, 'Social cognitive theory of self-regulation', *Organizational Behavior and Human Decision Processes*, vol. 50, no. 2, pp. 248-287.
- Bandura, A. 1997, *Self-efficacy : the exercise of control*, W.H. Freeman, New York.
- Bandura, A. 2001, 'SOCIAL COGNITIVE THEORY: An Agentic Perspective', *Annual Review Psychology*, vol. 52, no. 1, pp. 1-26.

- Bandura, A. 2012, 'Social cognitive theory', in *Handbook of theories of social psychology*, Vol. 1, Sage Publications Ltd, Thousand Oaks, CA, pp. 349-373.
- Barnes, C. M., Guarana, C. L., Nauman, S. & Kong, D. T. 2016, 'Too tired to inspire or be inspired: Sleep deprivation and charismatic leadership', *Journal of Applied Psychology*, vol. 101, no. 8, p. 1191.
- Barnes, C. M., Schaubroeck, J., Huth, M. & Ghumman, S. 2011, 'Lack of sleep and unethical conduct', *Organizational Behavior Human Decision Processes Journal*, vol. 115, no. 2, pp. 169-180.
- Baron, R. A. 1998, 'Cognitive mechanisms in entrepreneurship: Why and when entrepreneurs think differently than other people', *Journal of Business Venturing*, vol. 13, no. 4, pp. 275-294.
- Baron, R. A. 2010, 'Job design and entrepreneurship: Why closer connections= mutual gains', *Journal of Organizational Behavior*, vol. 31, no. 2/3, pp. 370-378.
- Baron, R. A. 2012, *Entrepreneurship : an evidence-based guide*, Edward Elgar, Northampton, MA.
- Baron, R. A. & Henry, R. A. 2010, 'How entrepreneurs acquire the capacity to excel: Insights from research on expert performance', *Strategy Entrepreneurship*, vol. 4, no. 1, pp. 49-65.
- Bateman, T. S. & Barry, B. 2012, 'Masters of the long haul: Pursuing long - term work goals', *Journal of Organizational Behavior*, vol. 33, no. 7, pp. 984-1006.
- Bates, T. 2005, 'Analysis of young, small firms that have closed: delineating successful from unsuccessful closures', *Journal of Business Venturing*, vol. 20, no. 3, pp. 343-358.
- Baum, J. R., Frese, M. & Baron, R. A. 2007, *The Psychology of Entrepreneurship*, L. Erlbaum Associates, Mahwah, NJ.
- Baum, J. R., Frese, M., Baron, R. A. & Katz, J. A. 2007, 'Entrepreneurship as an Area of Psychology Study: An Introduction', in M Frese & RA Baron (eds), *The psychology of entrepreneurship*, L. Erlbaum Associates, Mahwah, NJ, pp. 1-18.
- Baum, J. R. & Locke, E. A. 2004, 'The relationship of entrepreneurial traits, skill, and motivation to subsequent venture growth', *Journal of Applied Psychology*, vol. 89, no. 4, p. 587.
- Baum, J. R., Locke, E. A. & Smith, K. G. 2001, 'A Multidimensional Model of Venture Growth', *Academy of Management Journal*, vol. 44, no. 2, p. 292.
- Baumeister, R. & Vohs, K. 2016, 'Strength Model of Self-Regulation as Limited Resource: Assessment, Controversies, Update', *Advances in Experimental Social Psychology*, vol. 54, pp. 67-127.
- Baumeister, R. F. 1984, 'Choking under pressure: Self-consciousness and paradoxical effects of incentives on skillful performance', *Journal of Personality and Social Psychology*, vol. 46, no. 3, pp. 610-620.
- Baumeister, R. F. 2003, 'Ego Depletion and Self - Regulation Failure: A Resource Model of Self - Control', *Alcoholism: Clinical and Experimental Research*, vol. 27, no. 2, pp. 281-284.



Baumeister, R. F. 2014, 'Self-regulation, ego depletion, and inhibition', *Neuropsychologia*, vol. 65, pp. 313-319.

Baumeister, R. F. 2016, 'Limited Resources for Self-Regulation: A Current Overview of the Strength Model', in E. R. Hirt, J. J. Clarkson & L Jia (eds), *Self-regulation and ego control*, Elsevier Academic Press, pp. 1-17.

Baumeister, R. F. & Alquist, J. L. 2009, 'Self-regulation as a limited resource: Strength model of control and depletion.', in JP Forgas, RF Baumeister & DM Tice (eds), *Psychology of self-regulation : cognitive, affective, and motivational processes*, Psychology Press, New York, pp. 21-34.

Baumeister, R. F., Bratslavsky, E., Muraven, M. & Tice, D. M. 1998, 'Ego depletion: Is the active self a limited resource?', *Journal of Personality and Social Psychology*, vol. 74, no. 5, p. 1252.

Baumeister, R. F., Gailliot, M., DeWall, C. N. & Oaten, M. 2006, 'Self - regulation and personality: How interventions increase regulatory success, and how depletion moderates the effects of traits on behavior', *Journal of Personality*, vol. 74, no. 6, pp. 1773-1802.

Baumeister, R. F. & Heatherton, T. F. 1996, 'Self-Regulation Failure: An Overview', *Psychological Inquiry*, vol. 7, no. 1, pp. 1-15.

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

Baumeister, R. F., Tice, D. M. & Vohs, K. D. 2018, 'The Strength Model of Self-Regulation: Conclusions From the Second Decade of Willpower Research', *Perspectives on Psychological Science*, vol. 13, no. 2, pp. 141-145.

Baumeister, R. F. & Vohs, K. D. 2007, 'Self - Regulation, Ego Depletion, and Motivation', *Social and Personality Psychology Compass*, vol. 1, no. 1, pp. 115-128.

Baumeister, R. F., Vohs, K. D. & Tice, D. M. 2007, 'The strength model of self-control', *Current Directions in Psychological Science*, vol. 16, no. 6, pp. 351-355.

Bent, B., Goldstein, B. A., Kibbe, W. A. & Dunn, J. P. 2020, 'Investigating sources of inaccuracy in wearable optical heart rate sensors', *NPJ Digital Medicine*, vol. 3, no. 1, pp. 1-9.

Benzing, C. & Chu Hung, M. 2009, 'A comparison of the motivations of small business owners in Africa', *Journal of Small Business and Enterprise Development*, vol. 16, no. 1, pp. 60-77.

Berntson, G. G., Thomas Bigger, J., Eckberg, D. L., Grossman, P., Kaufmann, P. G., Malik, M., Nagaraja, H. N., Porges, S. W., Saul, J. P., Stone, P. H. & Der Molen, M. W. 1997, 'Heart rate variability: Origins, methods, and interpretive caveats', *Psychophysiology*, vol. 34, no. 6, pp. 623-648.

Bhave, M. P. 1994, 'A process model of entrepreneurial venture creation', *Journal of Business Venturing*, vol. 9, no. 3, pp. 223-242.

Blatter, J. & Haverland, M. 2012, *Designing Case Studies Explanatory Approaches in Small-N Research*, 1st edn, Palgrave Macmillan, UK, London.

Bluedorn, A. C. & Denhardt, R. B. 1988, 'Time and organizations', *Journal of Management*, vol. 14, no. 2, pp. 299-320.

Boekaerts, M., Maes, S. & Karoly, P. 2005, 'Self - Regulation Across Domains of Applied Psychology: Is there an Emerging Consensus?', *Applied Psychology*, vol. 54, no. 2, pp. 149-154.

Boekaerts, M., Pintrich, P. R. & Zeidner, M. 2005, *Handbook of Self-Regulation*, Academic Press, Burlington, MA.

Boyd, D. P. & Gumpert, D. E. 1983, 'Coping with entrepreneurial stress', *Harvard Business Review*, vol. 61, no. 2, p. 44.

Brännback, M. & Carsrud, A. L. 2017, *Revisiting the Entrepreneurial Mind Inside the Black Box: An Expanded Edition*, Springer International Publishing : Imprint: Springer, Cham.

Braun, M. T., Kuljanin, G. & DeShon, R. P. 2018, 'Special considerations for the acquisition and wrangling of big data', *Organizational Research Methods*, vol. 21, no. 3, pp. 633-659.

Brazeal, D. V., Schenkel, M. T. & Azriel, J. A. 2008, 'Awakening the entrepreneurial spirit: Exploring the relationship between organizational factors and perceptions of entrepreneurial self-efficacy and desirability in a corporate setting', *New England Journal of Entrepreneurship*, vol. 11, no. 1, pp. 9-25.

Bridgett, D. J., Burt, N. M., Edwards, E. S. & Deater-Deckard, K. 2015, 'Intergenerational Transmission of Self-Regulation: A Multidisciplinary Review and Integrative Conceptual Framework', *Psychological Bulletin*, vol. 141, no. 3, pp. 602-654.

Brockner, J., Higgins, E. T. & Low, M. B. 2004, 'Regulatory focus theory and the entrepreneurial process', *Journal of Business Venturing*, vol. 19, no. 2, pp. 203-220.

Bruning, P. F. & Campion, M. A. 2018, 'A role—resource approach—avoidance model of job crafting: A multimethod integration and extension of job crafting theory', *Academy of Management Journal*, vol. 61, no. 2, pp. 499-522.

Bruyneel, S., Dewitte, S., Vohs, K. D. & Warlop, L. 2006, 'Repeated choosing increases susceptibility to affective product features', *International Journal of Research in Marketing*, vol. 23, no. 2, pp. 215-225.

Bryant, P. 2006, 'Improving entrepreneurial education through self-regulatory skills', *Proceedings of the NCIIA 2006 annual meeting*, Portland, Oregon, National Collegiate Inventors & Innovators Alliance, pp. 279-289.

Bryant, P. 2007, 'Self-regulation and decision heuristics in entrepreneurial opportunity evaluation and exploitation', *Management Decision*, vol. 45, no. 4, pp. 732-748.

Burke, P. J. & Reitzes, D. C. 1991, 'An Identity Theory Approach to Commitment', *Social Psychology Quarterly*, vol. 54, no. 3, pp. 239-251.

Busenitz, L. W. & Barney, J. B. 1997, 'Differences between entrepreneurs and managers in large organizations: Biases and heuristics in strategic decision-making', *Journal of Business Venturing*, vol. 12, no. 1, pp. 9-30.

Byrne, O. & Shepherd, D. A. 2015, 'Different strokes for different folks: Entrepreneurial narratives of emotion, cognition, and making sense of business failure', *Entrepreneurship Theory and Practice*, vol. 39, no. 2, pp. 375-405.

Cameron, K. & Dutton, J. 2003, *Positive organizational scholarship: Foundations of a new discipline*, Berrett-Koehler Publishers.

Cardon, M. S., Gregoire, D. A., Stevens, C. E. & Patel, P. C. 2012, 'Measuring entrepreneurial passion: Conceptual foundations and scale validation', *Journal of Business Venturing*, vol. 28, no. 3.

Cardon, M. S. & Patel, P. C. 2015, 'Is Stress Worth it? Stress - Related Health and Wealth Trade - Offs for Entrepreneurs', *Applied Psychology*, vol. 64, no. 2, pp. 379-420.

Cardon, M. S., Wincent, J., Singh, J. & Drnovsek, M. 2009, 'The nature and experience of entrepreneurial passion.', *Academy of Management review*, vol. 34, no. 3, p. 511.

Cardon, M. S., Zietsma, C., Saparito, P., Matherne, B. P. & Davis, C. 2005, 'A tale of passion: New insights into entrepreneurship from a parenthood metaphor', *Journal of Business Venturing*, vol. 20, no. 1, pp. 23-45.

Carroll, G. R. & Mosakowski, E. 1987, 'The career dynamics of self-employment', *Administrative science quarterly*, vol., pp. 570-589.

Carter, E. C., Kofler, L. M., Forster, D. E. & McCullough, M. E. 2015, 'A series of meta-analytic tests of the depletion effect: self-control does not seem to rely on a limited resource', *Journal of Experimental Psychology: General*, vol. 144, no. 4, p. 796.

Carter, N. M., Gartner, W. B. & Reynolds, P. D. 1996, 'Exploring start-up event sequences', *Journal of Business Venturing*, vol. 11, no. 3, pp. 151-166.

Carver, C. S. & Scheier, M. F. 1981, *Attention and Self-Regulation A Control-Theory Approach to Human Behavior*, 1st edn, Springer, New York, NY.

Carver, C. S. & Scheier, M. F. 1982, 'Control theory: A useful conceptual framework for personality—social, clinical, and health psychology', *Psychological Bulletin*, vol. 92, no. 1, pp. 111-135.

Carver, C. S. & Scheier, M. F. 1990, 'Origins and Functions of Positive and Negative Affect: A Control-Process View', *Psychological Review*, vol. 97, no. 1, pp. 19-35.

Carver, C. S. & Scheier, M. F. 1998, *On the Self-Regulation of Behavior*, Cambridge University Press, New York, NY, US.

Carver, C. S., Sutton, S. K. & Scheier, M. F. 2000, 'Action, Emotion, and Personality: Emerging Conceptual Integration', *Personality and Social Psychology Bulletin*, vol. 26, no. 6, pp. 741-751.

Casson, M. 1982, *The Entrepreneur: An Economic Theory*, 1st edn, Edward Elgar.

- Castaneda, D., Esparza, A., Ghamari, M., Soltanpur, C. & Nazeran, H. 2018, 'A review on wearable photoplethysmography sensors and their potential future applications in health care', *International Journal of Biosensors & Bioelectronics*, vol. 4, no. 4, p. 195.
- Chen, C. C., Greene, P. G. & Crick, A. 1998, 'Does entrepreneurial self-efficacy distinguish entrepreneurs from managers?', *Journal of Business Venturing*, vol. 13, no. 4, pp. 295-316.
- Christian, M. S. & Ellis, A. P. 2011, 'Examining the effects of sleep deprivation on workplace deviance: A self-regulatory perspective', *Academy of Management Journal*, vol. 54, no. 5, pp. 913-934.
- Cooper, A. C. & Artz, K. W. 1995, 'Determinants of satisfaction for entrepreneurs', *Journal of Business Venturing*, vol. 10, no. 6, pp. 439-457.
- Dalal, R. S. & Hulin, C. L. 2008, 'Motivation for what? A multivariate dynamic perspective of the criterion', *Work Motivation: Past, Present, and Future*, vol. 27, pp. 63-100.
- Davidson, R. J. 2003, 'Seven sins in the study of emotion: Correctives from affective neuroscience', *Brain and Cognition*, vol. 52, no. 1, pp. 129-132.
- Davidsson, P. 2004, *Researching Entrepreneurship*, Springer, Boston, MA.
- Davidsson, P. 2008, *The Entrepreneurship Research Challenge*, Edward Elgar, Cheltenham, UK.
- Davidsson, P. & Gordon, S. R. 2012, 'Panel studies of new venture creation: a methods-focused review and suggestions for future research', *Small Business Economics*, vol. 39, no. 4, pp. 853-876.
- Davidsson, P. & Honig, B. 2003, 'The role of social and human capital among nascent entrepreneurs', *Journal of Business Venturing*, vol. 18, no. 3, pp. 301-331.
- Davidsson, P. & Wiklund, J. 2001, 'Levels of Analysis in Entrepreneurship Research: Current Research Practice and Suggestions for the Future', *Entrepreneurship Theory and Practice*, vol. 25, no. 4, pp. 81-100.
- De Cock, R., Denoo, L. & Clarysse, B. 2020, 'Surviving the emotional rollercoaster called entrepreneurship: the role of emotion regulation', *Journal of Business Venturing*, vol. 35, no. 2, p. 105936.
- de Ridder, D. T. D., Lensvelt-Mulders, G., Finkenauer, C., Stok, F. M. & Baumeister, R. F. 2012, 'Taking Stock of Self-Control: A Meta-Analysis of How Trait Self-Control Relates to a Wide Range of Behaviors', *Personality and Social Psychology Review*, vol. 16, no. 1, pp. 76-99.
- DeCarlo, J. F. & Lynn, P. R. 1980, 'Toward a contingency theory of entrepreneurship', *Journal of Small Business Management*, vol. 18, p. 37.
- Delmar, F. & Shane, S. 2003, 'Does business planning facilitate the development of new ventures?', *Strategic management journal*, vol. 24, no. 12, pp. 1165-1185.

Detienne, D. R. & Chandler, G. N. 2004, 'Opportunity Identification and Its Role in the Entrepreneurial Classroom: A Pedagogical Approach and Empirical Test', *Academy of Management Learning & Education*, vol. 3, no. 3, pp. 242-257.

DeTienne, D. R., Shepherd, D. A. & De Castro, J. O. 2008, 'The fallacy of "only the strong survive": The effects of extrinsic motivation on the persistence decisions for under-performing firms', *Journal of Business Venturing*, vol. 23, no. 5, pp. 528-546.

Dew, N., Read, S., Sarasvathy, S. D. & Wiltbank, R. 2009, 'Effectual versus predictive logics in entrepreneurial decision-making: Differences between experts and novices', *Journal of Business Venturing*, vol. 24, no. 4, pp. 287-309.

DeWall, C. N., Baumeister, R. F., Stillman, T. F. & Gailliot, M. T. 2007, 'Violence restrained: Effects of self-regulation and its depletion on aggression', *Journal of Experimental Social Psychology*, vol. 43, no. 1, pp. 62-76.

Diefendorff, J. M. & Lord, R. G. 2008, 'Goal-striving and self-regulation processes', in *Work Motivation*, Routledge, pp. 179-224.

Dimov, D. 2010, 'Nascent entrepreneurs and venture emergence: Opportunity confidence, human capital, and early planning', *Journal of Management Studies*, vol. 47, no. 6, pp. 1123-1153.

Douglas, E. J. & Shepherd, D. A. 2002, 'Self-employment as a career choice: Attitudes, entrepreneurial intentions, and utility maximization', *Entrepreneurship Theory and Practice*, vol. 26, no. 3, pp. 81-90.

Du Toit, D. 1980, 'Confessions of a successful entrepreneur', *Harvard Business Review*, vol. 58, no. 6, p. 44.

Duckworth, A. L. & Seligman, M. E. P. 2005, 'Self-Discipline Outdoes IQ in Predicting Academic Performance of Adolescents', *Psychological Science*, vol. 16, no. 12, pp. 939-944.

Duening, T. N. & Metzger, M. L. 2017, *Entrepreneurial identity the process of becoming an entrepreneur*, Edward Elgar Publishing Limited, Cheltenham, UK.

Duran-Whitney, M. 2004, Understanding occupational stress and mental health in aspiring small business owners, thesis, Alliant International University, San Francisco Bay.

Edelman, L. F., Brush, C. G., Manolova, T. S. & Greene, P. G. 2010, 'Start-up Motivations and Growth Intentions of Minority Nascent Entrepreneurs', *Journal of Small Business Management*, vol. 48, no. 2, pp. 174-196.

Eden, D. 1975, 'Organizational membership vs self-employment: Another blow to the American dream', *Organizational Behavior and Human Performance*, vol. 13, no. 1, pp. 79-94.

Eisenhardt, K. M. 1989, 'Building Theories from Case Study Research', *The Academy of Management Review*, vol. 14, no. 4, pp. 532-550.

Eisenhardt, K. M. & Graebner, M. E. 2007, 'THEORY BUILDING FROM CASES: OPPORTUNITIES AND CHALLENGES', *Academy of Management Journal*, vol. 50, no. 1, pp. 25-32.

Ekman, U., Bolter, J. D., Diaz, L., Sondergaard, M. & Engberg, M. E. 2016, *Ubiquitous computing, complexity and culture*, Routledge, New York.

Elliot, A. J. & McGregor, H. A. 1999, 'Test Anxiety and the Hierarchical Model of Approach and Avoidance Achievement Motivation', *Journal of Personality and Social Psychology*, vol. 76, no. 4, pp. 628-644.

Esco, M. R. & Flatt, A. A. 2014, 'Ultra-short-term heart rate variability indexes at rest and post-exercise in athletes: evaluating the agreement with accepted recommendations', *Journal of sports science & medicine*, vol. 13, no. 3, pp. 535-541.

Evans, D. S. & Leighton, L. S. 1989, 'The determinants of changes in US self-employment, 1968–1987', *Small Business Economics*, vol. 1, no. 2, pp. 111-119.

Fagenson, E. A. 1993, 'Personal value systems of men and women entrepreneurs versus managers', *Journal of Business Venturing*, vol. 8, no. 5, pp. 409-430.

Faggian, A., Partridge, M. & Malecki, E. J. 2017, 'Creating an Environment for Economic Growth: Creativity, Entrepreneurship or Human Capital?', *International Journal of Urban and Regional Research*, vol. 41, no. 6, pp. 997-1009.

Fischer, R. 2006, 'Congruence and Functions of Personal and Cultural Values: Do My Values Reflect My Culture's Values?', *Personality and Social Psychology Bulletin*, vol. 32, no. 11, pp. 1419-1431.

Fischer, R. & Boer, D. 2016, 'Values: the dynamic nexus between biology, ecology and culture', *Current Opinion in Psychology*, vol. 8, pp. 155-160.

Fisher, R., Maritz, A. & Lobo, A. 2014, 'Evaluating entrepreneurs' perception of success : Development of a measurement scale', *International Journal of Entrepreneurial Behavior & Research*, vol. 20, no. 5, pp. 478-492.

Fong, C. T. 2006, 'The effects of emotional ambivalence on creativity', *Academy of Management Journal*, vol. 49, no. 5, pp. 1016-1030.

Foo, M.-D., Uy, M. & Baron, R. 2009, 'How Do Feelings Influence Effort? An Empirical Study of Entrepreneurs' Affect and Venture Effort', *Journal of Applied Psychology*, vol. 94, no. 4, pp. 1086-1094.

Forgas, J. P., Baumeister, R. F. & Tice, D. M. 2009, *Psychology of Self-Regulation : Cognitive, Affective, and Motivational Processes*, Psychology Press, New York.

Foss, N. J., Klein, P. G. & Bjørnskov, C. 2019, 'The Context of Entrepreneurial Judgment: Organizations, Markets, and Institutions', *Journal of Management*, vol. 56, no. 6, pp. 1197-1213.

Fox, E. 2008, *Emotion science : cognitive and neuroscientific approaches to understanding human emotions*, Palgrave Macmillan, New York.

Francis, Z., Milyavskaya, M., Lin, H. & Inzlicht, M. 2018, 'Development of a Within-Subject, Repeated-Measures Ego-Depletion Paradigm', *Social Psychology*, vol. 49, no. 5, pp. 271-286.

- Frederick, H., O'Connor, A. & Kuratko, D. 2018, *Entrepreneurship*, 5th edn, Cengage, Melbourne.
- Fredrickson, B. L. 2001, 'The role of positive emotions in positive psychology: The broaden-and-build theory of positive emotions', *American Psychologist*, vol. 56, no. 3, p. 218.
- Fredrickson, B. L. 2004, 'The broaden and build theory of positive emotions', *Philosophical Transactions of the Royal Society B: Biological Sciences*, vol. 359, no. 1449, pp. 1367-1377.
- Frese, M. 2009, 'Towards a Psychology of Entrepreneurship — An Action Theory Perspective', *Foundations and Trends® in Entrepreneurship*, vol. 5, no. 6, pp. 437-496.
- Frese, M. & Gielnik, M. 2014, 'The Psychology of Entrepreneurship', *Annual Review of Organizational Psychology & Organizational Behavior*, vol. 1, no. 1, pp. 413-438.
- Fuller, B., Liu, Y., Bajaba, S., Marler, L. E. & Pratt, J. 2018, 'Examining how the personality, self-efficacy, and anticipatory cognitions of potential entrepreneurs shape their entrepreneurial intentions', *Personality and Individual Differences*, vol. 125, pp. 120-125.
- Gailliot, M. T. & Baumeister, R. F. 2007, 'The Physiology of Willpower: Linking Blood Glucose to Self-Control', *Personality and Social Psychology Review*, vol. 11, no. 4, pp. 303-327.
- Gailliot, M. T., Gitter, S. A., Baker, M. D. & Baumeister, R. F. 2012, 'Breaking the rules: Low trait or state self-control increases social norm violations', *Psychology*, vol. 3, no. 12, pp. 1074-1083.
- Gailliot, M. T., Schmeichel, B. J. & Baumeister, R. F. 2006, 'Self-regulatory processes defend against the threat of death: Effects of self-control depletion and trait self-control on thoughts and fears of dying', *Journal of Personality and Social Psychology*, vol. 91, no. 1, p. 49.
- Gallagher, M. W. 2012, 'Self-Efficacy', in *Encyclopedia of Human Behavior*, 2nd edn, Elsevier Inc., pp. 314-320.
- Garbarino, M., Lai, M., Bender, D., Picard, R. W., Tognetti, S. & Ieee 2014, *Empatica E3-A wearable wireless multi-sensor device for real-time computerized biofeedback and data acquisition*, 2014 EAI 4th International Conference on Wireless Mobile Communication and Healthcare, Ieee, New York.
- Gardner, H. K. 2012, 'Performance Pressure as a Double-edged Sword: Enhancing Team Motivation but Undermining the Use of Team Knowledge', *Administrative science quarterly*, vol. 57, no. 1, pp. 1-46.
- Gartner, W. B. 1988, "'Who is an entrepreneur?' is the wrong question", *American Journal of Small Business*, vol. 12, no. 4, p. 11.
- Gartner, W. B. 1990, 'What are we talking about when we talk about entrepreneurship?', *Journal of Business Venturing*, vol. 5, no. 1, pp. 15-28.
- Gartner, W. B. & Shaver, K. G. 2012, 'Nascent entrepreneurship panel studies: progress and challenges', *Small Business Economics*, vol. 39, no. 3, pp. 659-665.

Gartner, W. B., Shaver, K. G., Carter, N. M. & Reynolds, P. D. 2004, *Handbook of Entrepreneurial Dynamics: The Process of Business Creation*, Sage Publications Inc.

Gast, D. L. 2009, *Single Subject Research Methodology in Behavioral Sciences*, Routledge, New York, NY.

Geisler, F. C. M. & Kubiak, T. 2009, 'Heart rate variability predicts self-control in goal pursuit', *European Journal of Personality*, vol. 23(8), no. 12/2009.

Geisler, F. C. M. & Schröder-Abé, M. 2015, 'Is emotion suppression beneficial or harmful? It depends on self-regulatory strength', *Motivation and Emotion*, vol. 39, no. 4.

Gendron, M. 2004, *Integrating newly merged organizations*, Praeger, Westport, Conn.

George, G., Haas, M. R. & Pentland, A. 2014, 'Big Data and Management', *Academy of Management Journal*, vol. 57, no. 2, pp. 321-326.

George, J. M. & Jones, G. R. 2000, 'The role of time in theory and theory building', *Journal of Management*, vol. 26, no. 4, pp. 657-684.

Gielnik, M. M., Spitzmuller, M., Schmitt, A., Klemann, D. K. & Frese, M. 2015, '"I put in effort, therefore I am passionate": Investigating the path from effort to passion in entrepreneurship', *Academy of Management Journal*, vol. 58, no. 4, pp. 1012-1031.

Gielnik, M. M., Zacher, H. & Frese, M. 2012, 'Focus on opportunities as a mediator of the relationship between business owners' age and venture growth', *Academy of Management Journal*, vol. 27, no. 1, pp. 127-142.

Gish, J. J., Wagner, D. T., Grégoire, D. A. & Barnes, C. M. 2019, 'Sleep and entrepreneurs' abilities to imagine and form initial beliefs about new venture ideas', *Journal of Business Venturing*, vol. 34, no. 6.

Glantz, M. & Johnson, J. 2002, *Resilience and Development: Positive Life Adaptations*, Positive Life Adaptations, Springer, Boston, MA.

Gordon, S. R. 2012, Dimensions of the venture creation process: Amount, dynamics, and sequences of action in nascent entrepreneurship, thesis, Queensland University of Technology.

Gorgievski, M. J., Ascalon, M. E. & Stephan, U. 2011, 'Small Business Owners' Success Criteria, a Values Approach to Personal Differences', *Journal of Small Business Management*, vol. 49, no. 2, pp. 207-232.

Gorgievski, M. J. & Stephan, U. 2016, 'Advancing the Psychology of Entrepreneurship: A Review of the Psychological Literature and an Introduction', *Applied Psychology*, vol. 65, no. 3, pp. 437-468.

Granovetter, M. 2005, 'The Impact of Social Structure on Economic Outcomes', *Journal of Economic Perspectives*, vol. 19, no. 1, pp. 33-50.

Grice, J., Barrett, P., Cota, L., Felix, C., Taylor, Z., Garner, S., Medellin, E. & Vest, A. 2017, 'Four bad habits of modern psychologists', *Behavioral Sciences*, vol. 7, no. 3, p. 53.



Gunia, B. C. 2018, 'The sleep trap: Do sleep problems prompt entrepreneurial motives but undermine entrepreneurial means?', *Academy of Management Perspectives*, vol. 32, no. 2, pp. 228-242.

Gutnick, D., Walter, F., Nijstad, B. A. & De Dreu, C. K. W. 2012, 'Creative performance under pressure: An integrative conceptual framework', *Organizational Psychology Review*, vol. 2, no. 3, pp. 189-207.

Guzzo, R. A., Fink, A. A., King, E., Tonidandel, S. & Landis, R. S. 2015, 'Big Data Recommendations for Industrial–Organizational Psychology', *Industrial and Organizational Psychology*, vol. 8, no. 4, pp. 491-508.

Hagger, M. S., Chatzisarantis, N. L., Alberts, H., Anggono, C. O., Batailler, C., Birt, A. R., Brand, R., Brandt, M. J., Brewer, G. & Bruyneel, S. 2016, 'A multilab preregistered replication of the ego-depletion effect', *Perspectives on Psychological Science*, vol. 11, no. 4, pp. 546-573.

Hagger, M. S., Wood, C., Stiff, C. & Chatzisarantis, N. L. 2010, 'Ego depletion and the strength model of self-control: a meta-analysis', *Psychological Bulletin*, vol. 136, no. 4, p. 495.

Hallebone, E. & Priest, J. 2009, *Business and Management Research : Paradigms & Practices*, Palgrave Macmillan, New York.

Harré, R. & Gillett, G. 1994, *The Discursive Mind*, SAGE Publications, Inc., Thousand Oaks, USA.

Harris, J. A., Saltstone, R. & Fraboni, M. 1999, 'An Evaluation of the Job Stress Questionnaire with a Sample of Entrepreneurs', *Journal of Business Psychology*, vol. 13, no. 3, pp. 447-455.

Haswell, S. & Holmes, S. 1989, 'Estimating the Small Business Failure Rate: A Reappraisal', *Journal of Small Business Management*, vol. 27, no. 3, p. 68.

Haynie, M. & Shepherd, D. A. 2009, 'A Measure of Adaptive Cognition for Entrepreneurship Research', *Entrepreneurship Theory and Practice*, vol. 33, no. 3, pp. 695-714.

Hill, L., Siebenbrock, A., Sollers, J. & Thayer, J. F. 2009, 'Are all measures created equal? Heart rate variability and respiration', *Biomedical Sciences Instrumentation*, vol. 45, pp. 71-76.

Hmieleski, K. M. & Sheppard, L. D. 2019, 'The Yin and Yang of entrepreneurship: Gender differences in the importance of communal and agentic characteristics for entrepreneurs' subjective well-being and performance', *Journal of Business Venturing*, vol. 34, no. 4, pp. 709-730.

Ho, M. W. Y. & Singh, S. 2020, 'The Well-Being Trajectories of Entrepreneurs', *Academy of Management Proceedings*, vol. 2020, no. 1.

Hofmann, W., Schmeichel, B. J. & Baddeley, A. D. 2012, 'Executive Functions and Self-Regulation', *Trends in Cognitive Sciences*, vol. 16, no. 3, pp. 174-180.

Holzman, J. B. & Bridgett, D. J. 2017, 'Heart rate variability indices as bio-markers of top-down self-regulatory mechanisms: A meta-analytic review', *Neuroscience and Biobehavioral Reviews*, vol. 74, no. Pt A, pp. 233-255.

- Hornaday, J. A. & Aboud, J. 1971, 'CHARACTERISTICS OF SUCCESSFUL ENTREPRENEURS', *Personnel Psychology*, vol. 24, no. 2, pp. 141-153.
- Isen, A. M. 1984, 'Toward understanding the role of affect in cognition', in *Handbook of social cognition, Vol 3.*, Lawrence Erlbaum Associates Publishers, Mahwah, NJ, US, pp. 179-236.
- Jayawarna, D., Rouse, J. & Kitching, J. 2013, 'Entrepreneur motivations and life course', *International Small Business Journal: Researching Entrepreneurship*, vol. 31, no. 1, pp. 34-56.
- Judd, C. M., Kenny, D. A. & McClelland, G. H. 2001, 'Estimating and testing mediation and moderation in within-subject designs', *Psychological methods*, vol. 6, no. 2, p. 115.
- Kanfer, R. 1990, 'Motivation theory and industrial and organizational psychology', *Handbook of Industrial Organizational Psychology Review*, vol. 1, no. 2, pp. 75-130.
- Karoly, P. 1993, 'Mechanisms of Self-Regulation: A Systems View', *Annual Review Psychology*, vol. 44, no. 1, pp. 23-52.
- Karoly, P., Boekaerts, M. & Maes, S. 2005, 'Toward Consensus in the Psychology of Self - Regulation: How Far Have We Come? How Far Do We Have Yet to Travel?', *Applied Psychology*, vol. 54, no. 2, pp. 300-311.
- Katz, J. & Gartner, W. B. 1988, 'Properties of Emerging Organizations', *The Academy of Management Review*, vol. 13, no. 3, pp. 429-441.
- Katz, J. A. & Corbett, A. C. 2019, *Seminal ideas for the next twenty-five years of advances*, First edn, Emerald Publishing, Bingley, UK.
- Kauanui, S. K., Thomas, K. D., Rubens, A. & Sherman, C. L. 2010, 'Entrepreneurship and Spirituality: A Comparative Analysis of Entrepreneurs' Motivation', *Journal of Small Business & Entrepreneurship*, vol. 23, no. 4, pp. 621-635.
- Keyes, C. L. 2013, 'Promoting and protecting positive mental health: Early and often throughout the lifespan', in *Mental well-being*, Springer, pp. 3-28.
- Kim, H.-G., Cheon, E.-J., Bai, D.-S., Lee, Y. H. & Koo, B.-H. 2018, 'Stress and Heart Rate Variability: A Meta-Analysis and Review of the Literature', *Psychiatry investigation*, vol. 15, no. 3, pp. 235-245.
- Kirzner, I. M. 1973, *Competition and entrepreneurship*, University of Chicago press.
- Kitchin, R. 2014, 'Big Data, new epistemologies and paradigm shifts', *Big Data and Society*, vol. 1, no. 1.
- Kleiger, R. E., Stein, P. K. & Bigger, J. T. 2005, 'Heart Rate Variability: Measurement and Clinical Utility', *Annals of noninvasive electrocardiology*, vol. 10, no. 1, pp. 88-101.
- Klein, P. G. 2008, 'Opportunity discovery, entrepreneurial action, and economic organization', *Strategic Entrepreneurship Journal*, vol. 2, no. 3, pp. 175-190.

- Koval, P., Ogrinz, B., Kuppens, P., Van Den Bergh, O., Tuerlinckx, F. & Sütterlin, S. 2013, 'Affective Instability in Daily Life Is Predicted by Resting Heart Rate Variability', *PLOS ONE*, vol. 8, no. 11, p. e81536.
- Kraus, S., Meier, F. & Niemand, T. 2016, 'Experimental methods in entrepreneurship research: the status quo', *International Journal of Entrepreneurial Behavior & Research*, vol. 22, no. 6, pp. 958-983.
- Krueger Jr, N. 2005, 'The Cognitive Psychology of Entrepreneurship', in *Handbook of Entrepreneurship Research*, Springer, Switzerland, pp. 105-140.
- Krueger, N. F. & Carsrud, A. L. 1993, 'Entrepreneurial intentions: Applying the theory of planned behaviour', *Entrepreneurship & regional development*, vol. 5, no. 4, pp. 315-330.
- Kuratko, D. F., Hornsby, J. S. & Naffziger, D. W. 1997, 'An examination of owner's goals in sustaining entrepreneurship', *Journal of Small Business Management*, vol. 35, no. 1, p. 24.
- Kwantes, C. T. & Boglarsky, C. A. 2007, 'Perceptions of organizational culture, leadership effectiveness and personal effectiveness across six countries', *Journal of International Management*, vol. 13, no. 2, pp. 204-230.
- Larson, A. & Starr, J. A. 1993, 'A network model of organization formation', *Entrepreneurship Theory and Practice*, vol. 17, no. 2, pp. 5-15.
- Latham, G. P. & Locke, E. A. 1991, 'Self-regulation through goal setting', *Organizational Behavior and Human Decision Processes*, vol. 50, no. 2, pp. 212-247.
- Lazarus, R. S. 1966, *Psychological stress and the coping process*, McGraw-Hill, New York, NY, USA.
- Lazarus, R. S. 2000, 'How emotions influence performance in competitive sports', *Sport Psychologist*, vol. 14, no. 3, pp. 229-252.
- Lerner, D. A., Hunt, R. A. & Verheul, I. 2018, 'Dueling Banjos: Harmony and Discord between ADHD and Entrepreneurship', *Academy of Management Perspectives*, vol. 32, no. 2, pp. 266-286.
- Lévesque, M. & Stephan, U. 2020, 'It's Time We Talk About Time in Entrepreneurship', *Entrepreneurship Theory and Practice*, vol. 44, no. 2, pp. 163-184.
- Liao, J. J. & Welsch, H. 2008, 'Patterns of venture gestation process: Exploring the differences between tech and non-tech nascent entrepreneurs', *The Journal of High Technology Management Research*, vol. 19, no. 2, pp. 103-113.
- Lichtenstein, B. B., Carter, N. M., Dooley, K. J. & Gartner, W. B. 2007, 'Complexity dynamics of nascent entrepreneurship', *Journal of Business Venturing*, vol. 22, no. 2, pp. 236-261.
- Liu, Y., Mo, S., Song, Y. & Wang, M. 2016, 'Longitudinal analysis in occupational health psychology: A review and tutorial of three longitudinal modeling techniques', *Applied Psychology*, vol. 65, no. 2, pp. 379-411.

- Locke, E. A. & Latham, G. P. 1991, 'A theory of goal setting & task performance', *The Academy of Management Review*, vol. 16, no. 2, pp. 480-483.
- Lord, R. G., Diefendorff, J. M., Schmidt, A. M. & Hall, R. J. 2010, 'Self-Regulation at Work', *Annual Review of Psychology*, vol. 61, no. 1, pp. 543-568.
- Lucky, E. O.-I. & Minai, M. S. 2011, 'The conceptual framework of entrepreneur and self management', *International Journal of Business and Social Science*, vol. 2, no. 20.
- Lukes, M. & Stephan, U. 2012, 'Nonprofit Leaders and For-Profit Entrepreneurs: Similar People with Different Motivation', *Ceskoslovenská psychologie*, vol. 56, pp. 45-55.
- Lurquin, J. H., Michaelson, L. E., Barker, J. E., Gustavson, D. E., Von Bastian, C. C., Carruth, N. P. & Miyake, A. 2016, 'No evidence of the ego-depletion effect across task characteristics and individual differences: A pre-registered study', *PLOS ONE*, vol. 11, no. 2.
- Lüthje, C. & Franke, N. 2003, 'the 'making' of an entrepreneur: testing a model of entrepreneurial intent among engineering students at MIT', *R&D Management*, vol. 33, no. 2, pp. 135-147.
- Maddux, J. E. 1995, *Self-Efficacy, Adaptation, and Adjustment Theory, Research, and Application*, Springer, Boston, MA.
- Malhi, G. S., Hamilton, A., Morris, G., Mannie, Z., Das, P. & Outhred, T. 2017, 'The promise of digital mood tracking technologies: are we heading on the right track?', *Evidence-Based Mental Health*, vol. 20, pp. 102-107.
- Maranges, H. M., Schmeichel, B. J. & Baumeister, R. F. 2017, 'Comparing cognitive load and self-regulatory depletion: Effects on emotions and cognitions', *Learning and Instruction*, vol. 51, pp. 74-84.
- Markman, G. 2007, 'Entrepreneurs' Competencies', in J. R. Baum, M. Frese & RA Baron (eds), *The organizational frontiers. The Psychology of Entrepreneurship*, Lawrence Erlbaum Associates Publishers, pp. 67-92.
- Matthews, C. H. & Human, S. E. 'The little engine that could: Uncertainty and growth expectations of nascent entrepreneurs', Babson College, Wellesley, MA,
- Matthews, C. H., Schenkel, M. T., Ford, M. W. & Human, S. E. 2009, 'Comparing nascent entrepreneurs and intrapreneurs and expectations of firm growth', *Journal of Small Business Strategy*, vol. 20, no. 1, pp. 53-80.
- Mauss, I. B. & Robinson, M. D. 2009, 'Measures of emotion: A review', *Cognition & Emotion*, vol. 23, no. 2, pp. 209-237.
- McAfee, A., Brynjolfsson, E., Davenport, T. H., Patil, D. & Barton, D. 2012, 'Big data: the management revolution', *Harvard Business Review*, vol. 90, no. 10, pp. 60-68.
- McArthur, T., Lam-McArthur, J. & Fontaine, L. 2018, *Oxford English Dictionary*, 2nd edn, Oxford University Press.

McCarthy, C., Pradhan, N., Redpath, C. & Adler, A. 'Validation of the Empatica E4 wristband', Ottawa, ON, Canada, IEEE, pp. 1-4.

McCormick, B. W., Reeves, C. J., Downes, P. E., Li, N. & Ilies, R. 2020, 'Scientific contributions of within-person research in management: Making the juice worth the squeeze', *Journal of Management*, vol. 46, no. 2, pp. 321-350.

McCraty, R. & Shaffer, F. 2015, 'Heart Rate Variability: New Perspectives on Physiological Mechanisms, Assessment of Self-regulatory Capacity, and Health risk', *Global advances in health and medicine*, vol. 4, no. 1, p. 46.

McMullen, J. S. & Dimov, D. 2013, 'Time and the entrepreneurial journey: The problems and promise of studying entrepreneurship as a process', *Journal of Management Studies*, vol. 50, no. 8, pp. 1481-1512.

McMullen, J. S. & Shepherd, D. A. 2006, 'Entrepreneurial action and the role of uncertainty in the theory of the entrepreneur', *Academy of Management review*, vol. 31, no. 1, pp. 132-152.

Melnicuk, V., Birrell, S., Crundall, E. & Jennings, P. 'Employing consumer electronic devices in physiological and emotional evaluation of common driving activities', IEEE, pp. 1529-1534.

Milenković, A., Otto, C. & Jovanov, E. 2006, 'Wireless sensor networks for personal health monitoring: Issues and an implementation', *Computer communications*, vol. 29, no. 13-14, pp. 2521-2533.

Miller, C. C. & Cardinal, L. B. 1994, 'Strategic Planning and Firm Performance: A Synthesis of More than Two Decades of Research', *The Academy of Management Journal*, vol. 37, no. 6, pp. 1649-1665.

Milliken, F. J. 1987, 'Three types of perceived uncertainty about the environment: State, effect, and response uncertainty', *Academy of Management review*, vol. 12, no. 1, pp. 133-143.

Mischel, W. & Mendoza-Denton, R. 2003, 'Harnessing willpower and socioemotional intelligence to enhance human agency and potential', vol.

Mitchell, M. S., Greenbaum, R. L., Vogel, R. M., Mawritz, M. B. & Keating, D. J. 2019, 'Can You Handle the Pressure? The Effect of Performance Pressure on Stress Appraisals, Self-regulation, and Behavior', *Academy of Management Journal*, vol. 62, no. 2, pp. 531-552.

Mitchell, R., Randolph-Seng, B. & Mitchell, J. 2011, 'Socially Situated Cognition: Imagining New Opportunities for Entrepreneurship Research', *Academy of Management review*, vol. 36, pp. 774-776.

Mitchell, R. K., Busenitz, L. W., Bird, B., Marie Gaglio, C., McMullen, J. S., Morse, E. A. & Smith, J. B. 2007, 'The Central Question in Entrepreneurial Cognition Research', *Entrepreneurship Theory and Practice*, vol. 31, no. 1, pp. 1-27.

Mueller, S., Volery, T. & von Siemens, B. 2012, 'What Do Entrepreneurs Actually Do? An Observational Study of Entrepreneurs' Everyday Behavior in the Start-Up and Growth Stages', *Entrepreneurship Theory and Practice*, vol. 36, no. 5, pp. 995-1017.

Muraven, M. 2008, 'Prejudice as Self - Control Failure 1', *Journal of Applied Social Psychology*, vol. 38, no. 2, pp. 314-333.

Muraven, M. & Baumeister, R. F. 2000, 'Self-Regulation and Depletion of Limited Resources: Does Self-Control Resemble a Muscle?', *Psychological Bulletin*, vol. 126, no. 2, pp. 247-259.

Muraven, M., Baumeister, R. F. & Tice, D. M. 1999, 'Longitudinal improvement of self-regulation through practice: Building self-control strength through repeated exercise', *The Journal of social psychology*, vol. 139, no. 4, pp. 446-457.

Muraven, M., Collins, R. L. & Neinhuis, K. 2002, 'Self-control and alcohol restraint: an initial application of the self-control strength model', *Psychology of Addictive Behaviors*, vol. 16, no. 2, p. 113.

Muraven, M., Shmueli, D. & Burkley, E. 2006, 'Conserving Self-Control Strength', *Journal of Personality and Social Psychology*, vol. 91, no. 3, pp. 524-537.

Muraven, M., Tice, D. M. & Baumeister, R. F. 1998, 'Self-Control as Limited Resource: Regulatory Depletion Patterns', *Journal of Personality and Social Psychology*, vol. 74, no. 3, pp. 774-789.

Murnieks, C. Y., Mosakowski, E. & Cardon, M. S. 2014, 'Pathways of Passion: Identity Centrality, Passion, and Behavior Among Entrepreneurs', *Journal of Management*, vol. 40, no. 6, pp. 1583-1606.

Nambisan, S. & Baron, R. A. 2013, 'Entrepreneurship in Innovation Ecosystems: Entrepreneurs' Self-Regulatory Processes and Their Implications for New Venture Success', *Entrepreneurship Theory and Practice*, vol. 37, no. 5, pp. 1071-1097.

Nanda, R. & Rhodes-Kropf, M. 2013, 'Investment cycles and startup innovation', *Journal of Financial Economics*, vol. 110, no. 2, pp. 403-418.

Neal, A., Ballard, T. & Vancouver, J. B. 2017, 'Dynamic Self-Regulation and Multiple-Goal Pursuit', *Annual review of organizational psychology and organizational behavior*, vol. 4, no. 1, pp. 401-423.

Newman, A., Obschonka, M., Schwarz, S., Cohen, M. & Nielsen, I. 2018, 'Entrepreneurial self-efficacy: A systematic review of the literature on its theoretical foundations, measurement, antecedents, and outcomes, and an agenda for future research', *Journal of Vocational Behavior*, vol. 110 Part B, pp. 403-419.

Normand, M. P. 2016, 'Less is more: Psychologists can learn more by studying fewer people', *Frontiers in Psychology*, vol. 7, p. 934.

O'Shea, D. 2011, Integrating cognitive, motivational, and emotional self-regulation in early stage entrepreneurs, thesis, ProQuest Dissertations Publishing.

O'Shea, D., Buckley, F. & Halbesleben, J. 2017, 'Self-regulation in entrepreneurs: Integrating action, cognition, motivation, and emotions', *Organizational Psychology Review*, vol. 7, no. 3, pp. 250-278.

Ollander, S., Godin, C., Campagne, A., Charbonnier, S. & Ieee 2016, 'A Comparison of Wearable and Stationary Sensors for Stress Detection', in *2016 Ieee International Conference on Systems, Man, and*

*Cybernetics*, IEEE International Conference on Systems Man and Cybernetics Conference Proceedings, pp. 4362-4366.

Palich, L. E. & Ray Bagby, D. 1995, 'Using cognitive theory to explain entrepreneurial risk-taking: Challenging conventional wisdom', *Journal of Business Venturing*, vol. 10, no. 6, pp. 425-438.

Panksepp, J. 2000, 'Affective consciousness and the instinctual motor system: The neural sources of sadness and joy', in *The caldron of consciousness: Motivation, affect and self-organization—An anthology.*, Advances in consciousness research., John Benjamins Publishing Company, Amsterdam, Netherlands, pp. 27-54.

Parker, S. 2009, 'Why do small firms produce the entrepreneurs?', *Journal of Socio-Economics*, vol. 38, pp. 484-494.

Patzelt, H. & Shepherd, D. A. 2011, 'Negative emotions of an entrepreneurial career: Self-employment and regulatory coping behaviors', *Journal of Business Venturing*, vol. 26, no. 2, pp. 226-238.

Penttilä, J., Helminen, A., Jartti, T., Kuusela, T., Huikuri, H. V., Tulppo, M. P., Coffeng, R. & Scheinin, H. 2001, 'Time domain, geometrical and frequency domain analysis of cardiac vagal outflow: effects of various respiratory patterns', *Clinical Physiology*, vol. 21, no. 3, pp. 365-376.

Peterson, S. J., Reina, C. S., Waldman, D. A. & Becker, W. J. 2015, *Using Physiological Methods to Study Emotions in Organizations*, Emerald Group Publishing Limited.

Phan, P. & Wright, M. 2018, 'Advancing the science of human cognition and behavior', *Academy of Management Perspectives*, vol. 32, no. 3.

Picard, R. W. & Healey, J. 1997, 'Affective wearables', *Personal Technologies*, vol. 1, no. 4, pp. 231-240.

Pihie, Z. & Bagheri, A. 2013, 'Self-Efficacy and Entrepreneurial Intention: The Mediation Effect of Self-Regulation', *Studies in Vocational and Professional Education*, vol. 6, no. 3, pp. 385-401.

Piperopoulos, P. & Dimov, D. 2015, 'Burst bubbles or build steam? Entrepreneurship education, entrepreneurial self - efficacy, and entrepreneurial intentions', *Journal of Small Business Management*, vol. 53, no. 4, pp. 970-985.

Pocheptsova, A., Amir, O., Dhar, R. & Baumeister, R. F. 2009, 'Deciding without resources: Resource depletion and choice in context', *Journal of Marketing Research*, vol. 46, no. 3, pp. 344-355.

Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y. & Podsakoff, N. P. 2003, 'Common method biases in behavioral research: a critical review of the literature and recommended remedies', *Journal of Applied Psychology*, vol. 88, no. 5, p. 879.

Podsakoff, P. M., MacKenzie, S. B. & Podsakoff, N. P. 2012, 'Sources of Method Bias in Social Science Research and Recommendations on How to Control It', *Annual Review of Psychology*, vol. 63, no. 1, pp. 539-569.

- Poh, M.-Z., Swenson, N. C. & Picard, R. W. 2010, 'A Wearable Sensor for Unobtrusive, Long-Term Assessment of Electrodermal Activity', *Biomedical Engineering, IEEE Transactions on*, vol. 57, no. 5, pp. 1243-1252.
- Porath, C. L. & Bateman, T. S. 2006, 'Self-Regulation: From Goal Orientation to Job Performance', *Journal of Applied Psychology*, vol. 91, no. 1, pp. 185-192.
- Porges, S. W. 2001, 'The polyvagal theory: phylogenetic substrates of a social nervous system', *International Journal of Psychophysiology*, vol. 42, no. 2, pp. 123-146.
- Porges, S. W. 2007, 'The polyvagal perspective', *Biological Psychology*, vol. 74, no. 2, pp. 116-143.
- Porges, S. W. 2011, *The polyvagal theory : neurophysiological foundations of emotions, attachment, communication, and self-regulation*, 1st edn, W. W. Norton, New York.
- Price, P., Chiang, I. C. A., Jhangiani, R., Leighton, D. C. & Cuttler, C. 2017, *Research Methods in Psychology*, 3rd American edn.
- Pu, J., Schmeichel, B. J. & Demaree, H. A. 2010, 'Cardiac vagal control predicts spontaneous regulation of negative emotional expression and subsequent cognitive performance', *Biological Psychology*, vol. 84, no. 3, pp. 531-540.
- Putka, D. J. & Oswald, F. L. 2015, 'Implications of the big data movement for the advancement of IO science and practice', in *Big Data at Work*, Routledge, pp. 195-226.
- Ragot, M., Martin, N., Em, S., Pallamin, N. & Diverrez, J.-M. 'Emotion Recognition Using Physiological Signals: Laboratory vs. Wearable Sensors', in T Ahram & C Falcão (eds), Springer International Publishing, pp. 15-22.
- Rahim, M. A. 1995, 'A comparative study of entrepreneurs and managers: Stress, burnout, locus of control, and social support', *Journal of Health and Human Services Administration*, vol. 18, no. 1, pp. 68-89.
- Rauch, A., Fink, M. & Hatak, I. 2018, 'Stress processes: An essential ingredient in the entrepreneurial process', *Academy of Management Perspectives*, vol. 32, no. 3, pp. 340-357.
- Reynard, A., Gevirtz, R., Berlow, R., Brown, M. & Boutelle, K. 2011, 'Heart rate variability as a marker of self-regulation', *Applied Psychophysiology Biofeedback*, vol. 36, no. 3, p. 209.
- Reynolds, P. D. 2016, 'Start-up Actions and Outcomes: What Entrepreneurs Do to Reach Profitability', *Foundations and Trends® in Entrepreneurship*, vol. 12, no. 6, pp. 443-559.
- Reynolds, P. D. & Curtin, R. T. 2008, 'Business Creation in the United States: Panel Study of Entrepreneurial Dynamics II Initial Assessment', *Foundations and Trends® in Entrepreneurship*, vol. 4, no. 3, pp. 155-307.
- Richard, P. J., Devinney, T. M., Yip, G. S. & Johnson, G. 2009, 'Measuring organizational performance: Towards methodological best practice', *Journal of Management*, vol. 35, no. 3, pp. 718-804.



- Robichaud, Y., McGraw, E. & Alain, R. 2001, 'Toward the development of a measuring instrument for entrepreneurial motivation', *Journal of Developmental Entrepreneurship*, vol. 6, no. 2, p. 189.
- Robinson, P., Huefner, J. & Hunt, H. 1991, 'Entrepreneurial Research on Student Subjects Does Not Generalize to Real World Entrepreneurs', *Journal of Small Business Management*, vol. 29, no. 2, p. 42.
- Russo, J. & Schoemaker, P. 1992, 'Managing Overconfidence', *Sloan Management Review*, vol. 33, no. 2, pp. 7-17.
- Ryan, R. M. & Deci, E. L. 2001, 'ON HAPPINESS AND HUMAN POTENTIALS: A Review of Research on Hedonic and Eudaimonic Well-Being', *Annual Review of Psychology*, vol. 52, no. 1, pp. 141-166.
- Ryff, C. 2017, 'Eudaimonic well-being, inequality, and health: Recent findings and future directions', *Journal of Civil Economy*, vol. 64, no. 2, pp. 159-178.
- Ryff, C. D. 2018, 'Well-being with soul: Science in pursuit of human potential', *Perspectives on Psychological Science*, vol. 13, no. 2, pp. 242-248.
- Ryff, C. D. 2019, 'Entrepreneurship and eudaimonic well-being: Five venues for new science', *Journal of Business Venturing*, vol. 34, no. 4, pp. 646-663.
- Sadler-Smith, E. & Badger, B. 1998, 'Cognitive style, learning and innovation', *Technology Analysis & Strategic Management*, vol. 10, no. 2, pp. 247-266.
- Saunders, M. N. K., Lewis, P. & Thornhill, A. 2016, *Research methods for business students*, Seventh edn, Pearson Education Limited, Harlow, Essex, England.
- Schindehutte, M., Morris, M. & Allen, J. 2006, 'Beyond achievement: Entrepreneurship as extreme experience', *Small Business Economics*, vol. 27, no. 4-5, pp. 349-368.
- Schmeichel, B. J. & Tang, D. 2015, 'Individual Differences in Executive Functioning and Their Relationship to Emotional Processes and Responses', *Current Directions in Psychological Science*, vol. 24, no. 2, pp. 93-98.
- Schmeichel, B. J., Vohs, K. D. & Baumeister, R. F. 2003, 'Intellectual performance and ego depletion: role of the self in logical reasoning and other information processing', *Journal of Personality and Social Psychology*, vol. 85, no. 1, p. 33.
- Schulz, R. & Heckhausen, J. 1996, 'A life span model of successful aging', *American Psychologist*, vol. 51, no. 7, p. 702.
- Schwab, A. & Zhang, Z. 2019, 'A New Methodological Frontier in Entrepreneurship Research: Big Data Studies', *Entrepreneurship Theory and Practice*, vol. 43, no. 5, pp. 843-854.
- Scott, B. A. & Judge, T. A. 2006, 'Insomnia, emotions, and job satisfaction: A multilevel study', *Journal of Management*, vol. 32, no. 5, pp. 622-645.
- Seelos, C. & Mair, J. 2005, 'Social entrepreneurship: Creating new business models to serve the poor', *Business Horizons*, vol. 48, no. 3, pp. 241-246.

Segerstrom, S. C. & Nes, L. S. 2007, 'Heart Rate Variability Reflects Self-Regulatory Strength, Effort, and Fatigue', *Psychological Science*, vol. 18, no. 3, pp. 275-281.

Seligman, M. E. 2004, *Authentic happiness: Using the new positive psychology to realize your potential for lasting fulfillment*, Simon and Schuster.

Shaffer, F. & Ginsberg, J. P. 2017, 'An Overview of Heart Rate Variability Metrics and Norms', *Frontiers in public health*, vol. 5, pp. 258-258.

Shane, S. 2003, *A general theory of entrepreneurship : the individual-opportunity nexus*, Edward Elgar Publishing, Northampton, MA.

Shane, S., Locke, E. A. & Collins, C. J. 2003, 'Entrepreneurial motivation', *Human Resource Management Review*, vol. 13, no. 2, pp. 257-279.

Shane, S. & Venkataraman, S. 2000, 'The Promise of Entrepreneurship As a Field of Research', *The Academy of Management Review*, vol. 25, no. 1, p. 217.

Shanteau, J. 1992, 'Competence in experts: The role of task characteristics', *Organizational Behavior and Human Decision Processes*, vol. 53, no. 2, pp. 252-266.

Shepherd, D. A. 2015, 'Party On! A call for entrepreneurship research that is more interactive, activity based, cognitively hot, compassionate, and prosocial', *Journal of Business Venturing*, vol. 30, no. 4, pp. 489-507.

Shepherd, D. A. & Patzelt, H. 2015, 'The "heart" of entrepreneurship: The impact of entrepreneurial action on health and health on entrepreneurial action', *Journal of Business Venturing Insights*, vol. 4, pp. 22-29.

Shepherd, D. A. & Patzelt, H. 2018, *Entrepreneurial cognition : exploring the mindset of entrepreneurs*, Springer International Publishing

Shepherd, D. A., Wiklund, J. & Haynie, J. M. 2009, 'Moving forward: Balancing the financial and emotional costs of business failure', *Journal of Business Venturing*, vol. 24, no. 2, pp. 134-148.

Shir, N., Nikolaev, B. N. & Wincent, J. 2019, 'Entrepreneurship and well-being: The role of psychological autonomy, competence, and relatedness', *Journal of Business Venturing*, vol. 34, no. 5.

Shoval, N., Schvimer, Y. & Tamir, M. 2018, 'Tracking technologies and urban analysis: Adding the emotional dimension', *Cities*, vol. 72, pp. 34-42.

Siirtola, P., Laurinen, P., Haapalainen, E., Roning, J. & Kinnunen, H. 'Clustering-based activity classification with a wrist-worn accelerometer using basic features', *IEEE*, pp. 95-100.

Smith, N. R. 1967, *The Entrepreneur and His Firm: The Relationship Between Type of Man and Type of Company*, Bureau of Business and Economic Research, Division of Research, Graduate School of Business Administration, Michigan State University.

- Smith, P. L. & Little, D. R. 2018, 'Small is beautiful: In defense of the small-N design', *Psychonomic Bulletin & Review*, vol. 25, no. 6, pp. 2083-2101.
- Sonnentag, S. 2015, 'Dynamics of well-being', *Annual review of organizational psychology and organizational behavior*, vol. 2, pp. 261-293.
- Sorrentino, R. & Roney, C. 2000, *Uncertain Mind: Individual Differences in Facing the Unknown* Psychology Press, Philadelphia, USA.
- Staniewski, M. W. & Awruk, K. 2018, 'Questionnaire of entrepreneurial success — Report on the initial stage of method construction', *Journal of Business Research*, vol. 88, pp. 437-442.
- Stephan, U. 2018, 'Entrepreneurs' mental health and well-being: A review and research agenda', *Academy of Management Perspectives*, vol. 32, no. 3, pp. 290-322.
- Stephan, U., Hart, M. & Drews, C.-C. 2015, *Understanding motivations for entrepreneurship: A review of recent research evidence*, IS Department for Business, London, UK.
- Sternberg, R. & Wennekers, S. 2005, 'Determinants and Effects of New Business Creation Using Global Entrepreneurship Monitor Data', *Small Business Economics*, vol. 24, no. 3, pp. 193-203.
- Stone, A. & Shiffman, S. 1994, 'Ecological momentary assessment (EMA) in behavioral medicine', *Annals of Behavioral Medicine*, vol. 16, no. 3, pp. 199-202.
- Stone, A., Shiffman, S., Atienza, A. & Nebeling, L. 2007, *The science of real-time data capture: Self-reports in health research*, Oxford University Press.
- Stryker, S. & Burke, P. J. 2000, 'The Past, Present, and Future of an Identity Theory', *Social Psychology Quarterly*, vol. 63, no. 4, pp. 284-297.
- Sütterlin, S., Herbert, C., Schmitt, M., Kübler, A. & Vögele, C. 2011, 'Frames, decisions, and cardiac-autonomic control', *Social Neuroscience*, vol. 6, no. 2, pp. 169-177.
- Swayne, C. B. & Tucker, W. R. 1973, *The Effective Entrepreneur*, General Learning Press, Morristown, N.J.
- Tangney, J. P., Baumeister, R. & Boone, A. L. 2004, 'High self-control predicts good adjustment, less pathology, better grades, and interpersonal success', *Journal of Personality*, vol. 72, no. 2, pp. 271-324.
- Tarvainen, M. P., Lipponen, J. A., Niskanen, J.-P. & Ranta-Aho, P. O. 2019, *Kubios HRV (ver3.3) USER'S GUIDE*, <[https://www.kubios.com/downloads/Kubios\\_HRV\\_Users\\_Guide.pdf](https://www.kubios.com/downloads/Kubios_HRV_Users_Guide.pdf)>.
- Tarvainen, M. P., Niskanen, J.-P., Lipponen, J. A., Ranta-Aho, P. O. & Karjalainen, P. A. 2014, 'Kubios HRV – Heart rate variability analysis software', *Computer Methods and Programs in Biomedicine*, vol. 113, no. 1, pp. 210-220.

Task Force, o. T. E. S. o. C. a. T. N. A. S. o. P. a. E. 1996, 'Heart rate variability. Standards of measurement, physiological interpretation, and clinical use', *European Heart Journal*, vol. 17, no. 3, pp. 354-381.

Teoh, H. Y. & Foo, S. L. 1997, 'Moderating effects of tolerance for ambiguity and risktaking propensity on the role conflict-perceived performance relationship: Evidence from Singaporean entrepreneurs', *Journal of Business Venturing*, vol. 12, no. 1, pp. 67-81.

Thayer, J., Hansen, A., Saus-Rose, E. & Johnsen, B. 2009, 'Heart Rate Variability, Prefrontal Neural Function, and Cognitive Performance: The Neurovisceral Integration Perspective on Self-regulation, Adaptation, and Health', *Annals of Behavioral Medicine*, vol. 37, no. 2, pp. 141-153.

Thayer, J. F. & Lane, R. D. 2000, 'A model of neurovisceral integration in emotion regulation and dysregulation', *Journal of Affective Disorders*, vol. 61, no. 3, pp. 201-216.

Thompson, C. A., Kopelman, R. E. & Schriesheim, C. A. 1992, 'Putting all one's eggs in the same basket: A comparison of commitment and satisfaction among self-and organizationally employed men', *Journal of Applied Psychology*, vol. 77, no. 5, p. 738.

Thompson, J. & Downing, R. 'Effective Entrepreneur Enabling-Increasing the Effectiveness of Advising, Coaching and Mentoring Support', *Local Economy: The Journal of the Local Economy Policy Unit*,

Tice, D. M., Baumeister, R. F., Shmueli, D. & Muraven, M. 2007, 'Restoring the self: Positive affect helps improve self-regulation following ego depletion', *Journal of Experimental Social Psychology*, vol. 43, no. 3, pp. 379-384.

Tonidandel, S., King, E. B. & Cortina, J. M. 2018, 'Big data methods: Leveraging modern data analytic techniques to build organizational science', *Organizational Research Methods*, vol. 21, no. 3, pp. 525-547.

Totterdell, P., Wood, S. & Wall, T. 2006, 'An intra - individual test of the demands - control model: A weekly diary study of psychological strain in portfolio workers', *Journal of Occupational Organizational Psychology Review*, vol. 79, no. 1, pp. 63-84.

Trevelyan, R. 2011, 'Self-regulation and effort in entrepreneurial tasks', *International Journal of Entrepreneurial Behaviour & Research*, vol. 17, no. 1, pp. 39-63.

Tsui, A. & Ashford, S. J. 1994, 'Adaptive Self-Regulation - A Process View of Managerial Effectiveness', *Journal of Management*, vol. 20, no. 1, pp. 93-121.

Tumasjan, A. & Braun, R. 2012, 'In the eye of the beholder: How regulatory focus and self-efficacy interact in influencing opportunity recognition', *Journal of Business Venturing*, vol. 27, no. 6, pp. 622-636.

Uy, M. A., Foo, M.-D. & Aguinis, H. 2010, 'Using Experience Sampling Methodology to Advance Entrepreneurship Theory and Research', *Organizational Research Methods*, vol. 13, no. 1, pp. 31-54.

Uy, M. A., Foo, M.-D. & Song, Z. 2013, 'Joint effects of prior start-up experience and coping strategies on entrepreneurs' psychological well-being', *Journal of Business Venturing*, vol. 28, no. 5, pp. 583-597.

- Uy, M. A., Sun, S. & Foo, M.-D. 2017, 'Affect spin, entrepreneurs' well-being, and venture goal progress: The moderating role of goal orientation', *Journal of Business Venturing*, vol. 32, no. 4, pp. 443-460.
- Van Gelderen, M., Kautonen, T. & Fink, M. 2015, 'From entrepreneurial intentions to actions: Self-control and action-related doubt, fear, and aversion', *Journal of Business Venturing*, vol. 30, no. 5, pp. 655-673.
- van Gelderen, M., Kautonen, T., Wincent, J. & Biniari, M. 2018, 'Implementation intentions in the entrepreneurial process: concept, empirical findings, and research agenda', *Small Business Economics*, vol. 51, no. 4, pp. 923-941.
- van Lier, H. G., Pieterse, M. E., Garde, A., Postel, M. G., de Haan, H. A., Vollenbroek-Hutten, M. M. R., Schraagen, J. M. & Noordzij, M. L. 2020, 'A standardized validity assessment protocol for physiological signals from wearable technology: Methodological underpinnings and an application to the E4 biosensor', *Behavior Research Methods*, vol. 52, no. 2, pp. 607-629.
- van Praag, C. M. & Versloot, P. H. 2007, 'What is the value of entrepreneurship? A review of recent research', *Small Business Economics*, vol. 29, no. 4, pp. 351-382.
- Vancouver, J. B. 2008, 'Integrating self-regulation theories of work motivation into a dynamic process theory', *Human Resource Management Review*, vol. 18, no. 1, pp. 1-18.
- Vandewalle, D. & Cummings, L. L. 1997, 'A Test of the Influence of Goal Orientation on the Feedback-Seeking Process', *Journal of Applied Psychology*, vol. 82, no. 3, pp. 390-400.
- Venkataraman, S. 1997, 'The distinctive domain of entrepreneurship research', *Advances in entrepreneurship, firm emergence and growth*, vol. 3, no. 1, pp. 119-138.
- Vohs, K., Baumeister, R., Ramanan, S., Mead, N., Schmeichel, B. & Hofmann, W. 2014, *Depletion enhances urges and feelings*.
- Vohs, K. D. & Baumeister, R. F. 2016, *Handbook of self-regulation : research, theory, and applications*, Third edn, The Guilford Press, New York.
- Vohs, K. D., Baumeister, R. F. & Schmeichel, B. J. 2012, 'Motivation, personal beliefs, and limited resources all contribute to self-control', *Journal of Experimental Social Psychology*, vol. 48, no. 4, pp. 943-947.
- Vohs, K. D. & Faber, R. J. 2007, 'Spent resources: Self-regulatory resource availability affects impulse buying', *Journal of Consumer Research*, vol. 33, no. 4, pp. 537-547.
- Vohs, K. D. & Heatherton, T. F. 2000, 'Self-regulatory failure: A resource-depletion approach', *Psychological Science*, vol. 11, no. 3, pp. 249-254.
- Wach, D., Stephan, U. & Gorgievski, M. 2016, 'More than money: Developing an integrative multi-factorial measure of entrepreneurial success', *International Small Business Journal*, vol. 34, no. 8, pp. 1098-1121.

- Wach, D., Stephan, U., Gorgievski, M. J. & Wegge, J. 2018, 'Entrepreneurs' achieved success: developing a multi-faceted measure', *International Entrepreneurship and Management Journal*, vol., pp. 1-29.
- Wach, D., Stephan, U., Weinberger, E. & Wegge, J. 2020, 'Entrepreneurs' stressors and well-being: A recovery perspective and diary study', *Journal of Business Venturing*, vol.
- Wagner, D. T., Barnes, C. M., Lim, V. K. & Ferris, D. L. 2012, 'Lost sleep and cyberloafing: Evidence from the laboratory and a daylight saving time quasi-experiment', *Journal of Applied Psychology*, vol. 97, no. 5, p. 1068.
- Walker, E. & Brown, A. 2004, 'What success factors are important to small business owners?', *International Small Business Journal*, vol. 22, no. 6, pp. 577-594.
- Walker, M. P. 2008, 'Cognitive consequences of sleep and sleep loss', *Sleep Medicine*, vol. 9, pp. S29-S34.
- Waller, M. A. & Fawcett, S. E. 2013, 'Data science, predictive analytics, and big data: a revolution that will transform supply chain design and management', *Journal of Business Logistics*, vol. 34, no. 2, pp. 77-84.
- Warr, P., Bindl, U., Parker, S. & Inceoglu, I. 2014, 'Four-quadrant investigation of job-related affects and behaviours', *European Journal of Work and Organizational Psychology*, vol. 23, no. 3, pp. 342-363.
- Wartiovaara, M., Lahti, T. & Wincent, J. 2019, 'The role of inspiration in entrepreneurship: Theory and the future research agenda', *Journal of Business Research*, vol. 101, pp. 548-554.
- Webster, F. A. 1977, 'Entrepreneurs and Ventures: An Attempt at Classification and Clarification', *The Academy of Management Review*, vol. 2, no. 1, pp. 54-61.
- Weinberger, E., Wach, D., Stephan, U. & Wegge, J. 2018, 'Having a creative day: Understanding entrepreneurs' daily idea generation through a recovery lens', *Journal of Business Venturing*, vol. 33, no. 1, pp. 1-19.
- Westerink, J., Krans, M. & Ouwerkerk, M. 2011, *Sensing Emotions: The Impact of Context on Experience Measurements*, Springer, Dordrecht.
- Westerlund, H., Alexanderson, K., Åkerstedt, T., Hanson, L. M., Theorell, T. & Kivimäki, M. 2008, 'Work-related sleep disturbances and sickness absence in the Swedish working population, 1993–1999', *Sleep*, vol. 31, no. 8, pp. 1169-1177.
- Wiklund, J., Nikolaev, B., Shir, N., Foo, M.-D. & Bradley, S. 2019, 'Entrepreneurship and well-being: Past, present, and future', *Journal of Business Venturing*, vol. 34, no. 4, pp. 579-588.
- Wiklund, J., Yu, W., Tucker, R. & Marino, L. D. 2017, 'ADHD, impulsivity and entrepreneurship', *Journal of Business Venturing*, vol. 32, no. 6, pp. 627-656.

Williamson, A. J., Battisti, M., Leatherbee, M. & Gish, J. J. 2019, 'Rest, zest, and my innovative best: Sleep and mood as drivers of entrepreneurs' innovative behavior', *Entrepreneurship Theory & Practice*, vol. 43, no. 3, pp. 582-610.

Wincent, J. & Örtqvist, D. 2009, 'Role stress and entrepreneurship research', *International Entrepreneurship Management Journal*, vol. 5, no. 1, pp. 1-22.

Wincent, J., Örtqvist, D. & Drnovsek, M. 2008, 'The entrepreneur's role stressors and proclivity for a venture withdrawal', *Scandinavian Journal of Management*, vol. 24, no. 3, pp. 232-246.

Wood, R. 2005, 'New Frontiers for Self - Regulation Research in IO Psychology', *Applied Psychology*, vol. 54, no. 2, pp. 192-198.

Xanthopoulou, D., Bakker, A. B. & Ilies, R. J. H. r. 2012, 'Everyday working life: Explaining within-person fluctuations in employee well-being', *Human Relations*, vol. 65, no. 9, pp. 1051-1069.

Yin, R. K. 2014, *Case study research : design and methods*, Fifth edn, SAGE, Los Angeles.

Zahn, D., Adams, J., Krohn, J., Wenzel, M., Mann, C. G., Gomille, L. K., Jacobi-Scherbenig, V. & Kubiak, T. 2016, 'Heart rate variability and self-control—A meta-analysis', *Biological Psychology*, vol. 115, pp. 9-26.

Zeidner, M., Boekaerts, M. & Pintrich, P. R. 2000, 'Chapter 23 - Self-Regulation: Directions and Challenges for Future Research', in M Boekaerts, PR Pintrich & M Zeidner (eds), *Handbook of Self-Regulation*, Academic Press, San Diego, pp. 749-768.

Zhou, Q., Chen, S. H. & Main, A. 2012, 'Commonalities and Differences in the Research on Children's Effortful Control and Executive Function: A Call for an Integrated Model of Self - Regulation', *Child Development Perspectives*, vol. 6, no. 2, pp. 112-121.

Zimmerman, B. J. 2000, 'Chapter 2 - Attaining Self-Regulation: A Social Cognitive Perspective', in M Boekaerts, PR Pintrich & M Zeidner (eds), *Handbook of Self-Regulation*, Academic Press, San Diego, pp. 13-39.

## 8. Appendix

*“If you want to be an entrepreneur, it’s not a job, it’s a lifestyle. It defines you. Forget about vacations, about going home at 6 pm – last thing at night you’ll send emails, first thing in the morning you’ll read emails, and you’ll wake up in the middle of the night. But it’s hugely rewarding as you’re fulfilling something for yourself.”-Niklas Zennstrom, founder of Skype*



## 8.1. E4 Wearable Instructions to Participants

### HOW TO Wearables Study - Entrepreneurship and Emotions

PARTICIPANT ID: XXXXXX

E4 WEARABLE DEVICE NUMBER: XXXXXX

EXPIMETRICS EXPERIENCE CODE: XXXXXX

DATA UPLOAD: id/pw

uploader\_XXXXX

XXXXXXXXXXXXXX

Researchers contact:

#### SETUP

- 1) Complete Background Survey (emailed to you from Qualtrics)
- 2) Download E4 Manager
- 3) Download Expimetrics app and enter experience code
- 4) Put on E4 wearable and turn on for daily usage
  - Make sure E4 is charged and wear on your NON-DOMINANT HAND and turn on (press button 2secs). See below for diagrams
    - o Line up snaps between middle and ring finger
    - o Secure snugly on wrist joint –comfortable but not loose
  - After 40 secs green light underneath device should be on >>> device recording.

#### E4 MANAGER - UPLOAD DATA AND RECHARGE E4

See the following link for all info on how to setup and use the E4

- <https://www.empatica.com/get-started-e4>

Battery life > Recording mode: 48+ h / Charging time: < 2 h

- You will need to sync and charge the E4 data either daily or at maximum after 48 hours. Syncing and charging of 24hours of data will take ~30+mins
- Previous participants have developed habit of syncing and recharging device as part of morning routine (eg shower/breakfast) but timing is up to you.

Research Syncing -Download and install the Empatica Manager on your laptop

1. [Download and install the E4 manager on your Mac OS X computer.](#)
2. [Download and install the E4 manager on your Windows computer.](#)

Log in to study (Data upload) with provided ID and password

- Start E4 manager on your laptop (logged in with upload id and password)
- Connect the E4 wristband in the cradle/usb to your laptop/Mac to start autosync
- Follow instructions on the screen

- The E4 connect manager should show the data for the day being uploaded. If the sync status doesn't change to show % upload after a few minutes, then restart E4 manager and then reconnect E4 to cradle.
- The yellow light on shows that E4 is still being charged. The device is fully charged when yellow light goes off

## Daily Use

- The E4 is water and shock resistant (eg sweat, rain..etc) but is not water proof (don't wear in the shower/bath..etc). Please treat with care.
- Put E4 on non-dominant hand & turn ON (Press button 2sec)
- A short tap on the E4 button will tag an event while recording. For this study you can tag activities where there has been something significant at stake (the outcome could be positive or negative)
- Periodically check under device green light on (recording). If not on then power on (button 2 sec)

### Battery life

Streaming Mode: 20+hrs  
Memory mode: 36+ hrs

### Data Management

Flash memory

Bluetooth LE  
(Smart)

### Form Factor

Small and comfortable

Case: 44 mm x 40 mm, height 16 mm  
Weight: 25 gr

### Certification

CE certification  
FCC certification

### Sensors

 **Photoplethysmography (PPG)**  
Continuous Heart Rate (HRV, Stress, Relaxation)

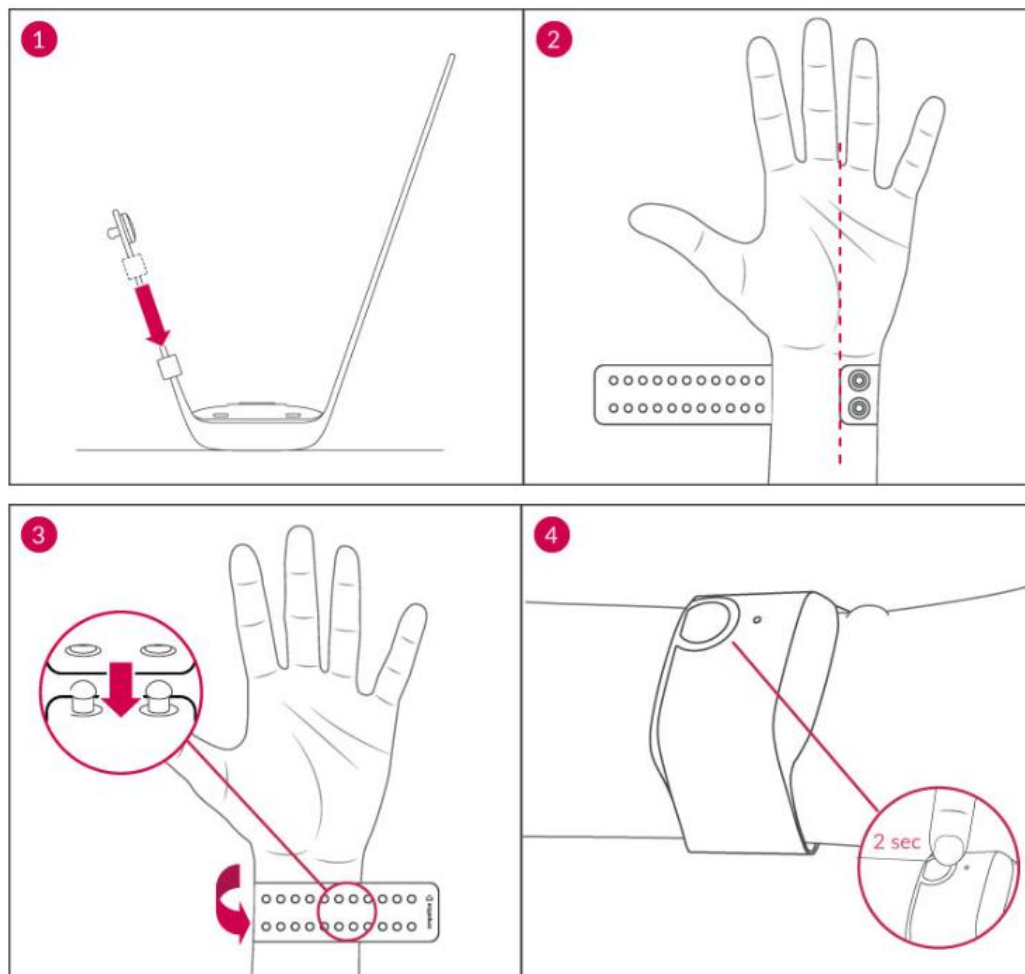
 **3-axis Accelerometer**  
Movement, Activity

 **Temperature + Heat flux**  
Activity, Context Info

 **Electrodermal Activity (EDA)**  
Skin Conductance (Arousal, Excitement)



## WEAR AND USE – E4 by Empatica



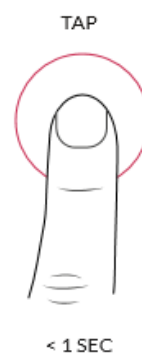
- Line up snaps between middle and ring finger
- Wear on non-dominant hand
- Secure snugly on wrist joint –comfortable but not loose
- Press button (2sec) to power on

### E4 USAGE, Button, Lights

**LED status interactions**  
The E4's LED light will generally appear BLACK.



- Yellow light indicates the battery is charging (connected) or low.
- Green light indicates device start-up and Bluetooth discovery mode.
- Purple light indicates recording has started\*.
- Blue light indicates data streaming has started\*.



Tap the button to tag an event while recording.  
The light will come on for 1 second indicating a tag has been registered



Press the E4 button to power on/off.  
The E4 records automatically 40s after powering on.

## 8.2. ESM Instructions to Participants and Survey Questions

### DOWNLOAD EXPIMETRICS APP + USAGE

#### Expimetrics Mobile Survey App

- Go to app store (Apple/Android) on your phone, search for and install “**expimetrics**” app
- Register an Expimetrics account and sign in
- Click on Enter Experience Code (orange background) and enter the **EXPIMETRICS EXPERIENCE CODE** you have been given.
- You should see the **ACTIVITY** survey available

You must go into the app regularly to complete the Activity surveys.

#### Expimetrics Usage

- Approximately every hour or as frequently as related to changes in work activity go to the Expimetrics app and complete the **ACTIVITY** survey. These surveys can be completed anytime you are working on your startup. Choose a moment when engaged in an entrepreneur related activity and complete throughout the day. See survey questions following for description of activities for reference.
- **At or near the END of your work day** within the **ACTIVITY** survey answer **YES to End of Work Day question** and complete the **CRITICAL** end of day summary questions. Please answer as honestly as possible based on the day, it also asks for information on your sleep from the night. You must complete these End of Day questions once per day.

\*\*\* You must have a data/WIFI connection to complete surveys via the app. \*\*\*

### SURVEY QUESTIONS

#### ACTIVITY – complete approximately hourly throughout work day

>Do you feel.....? - slider 100 point scale

Not at all		<b>HAPPY</b>		Very
Not at all		<b>STRESSED</b>		Very
Not at all		<b>ALERT</b>		Very

>What are you doing right now? – Drop down list (select only one response)

Activity	Meaning	Examples
<b>Exchange information and opinion</b>	General exchange/discussion of information to keep up to date, or inform others about current tasks, issues, project status..etc	Reading incoming email, sending emails, sharing updates with a cofounder/team member by phone or conversation/meeting....etc
<b>Work analytically and conceptually</b>	Actions related to conceptual or analytical work (alone or with others) as well as executing a task (creating work product).	Updating the business plan, creating a presentation or work document, writing a proposal, conducting internet research, placing an order,...etc
<b>Organise and coordinate</b>	Organisation and coordination of meetings, tasks and work for self or team.	Updating to do list, organising folders or documents, scheduling a meeting, printing docs, capacity planning,...etc
<b>Network and maintain relationships</b>	Actions related to the development and nurturing of relationships with colleagues and business partners	Having a coffee with employees, having lunch with other entrepreneurs, attending network event, socialising via Facebook or LinkedIn..etc

<b>Direct and Lead</b>	Actions related to leading and directing activity with the team (incl. employees / contractors / external service providers..etc)	Delegating a task(s), directing activity in the team, telling external service provider what needs to be done,...etc
<b>Learn and Develop</b>	Actions relating to learning, training or development for self or team	Attending a seminar, formal team or individual training, self directed learning online,...etc
<b>Monitor and Control</b>	Activities related to monitoring and controlling work processes and result with team or external	Asking employees about status of their work, testing functionality of product /website, reviewing finances,...etc
<b>Consult and Sell</b>	Actions related to consulting or selling to (potential) customers, partners, or investors.	Calls a (potential) customer; sends an e-mail to a potential customer or investor. Sales or investor meeting...etc
<b>Travel</b>	Travel time that is not used for any other purpose	
<b>Personal</b>	Private actions not related to entrepreneurial activity	
<b>Non Entrepreneur work or study</b>	Any other work or study activity not connected to your venture/entrepreneurial activity	Eg part or full time other work or study commitments

- >Is this a normal routine activity – Yes/No?
- >Is this activity a challenge for you – Yes/No?
- >Does this activity have an uncertain outcome – Yes/No?
- >Did you have any setbacks? – Yes/No?
- >Are you interacting with others? (Were you alone?) – Yes/No?

>Are you near or at the end of the work day? You must answer YES once at the end of your day for CRITICAL summary questions. – Yes/No?

**END of DAY questions! Answer YES near or at END of work day in ACTIVITY survey to access. These questions are CRITICAL and must be completed at the end of your work day. If these questions are not answered you will be sent a reminder**

- >How much effort did you put into your work as an entrepreneur today? (0 none at all -100 very much)
- >How satisfied were you today with being an entrepreneur? (0 not at all -100 very much)
- >How excited were you today with being an entrepreneur? (0 not at all – 100 very much)
- >How stressful was your work as an entrepreneur today? (0 not at all – 100 very much)
- >Do you feel you made progress towards your goals today? (0 not at all – 100 very much)

REST

- >Were you fully rested when you woke up this morning? (0 very tired – 100 completely rested)

- >How many hours of sleep did you have last night? (6 or less, 7, 8, 9, 10 or more)

SUMMARY – DAILY DIARY

- > Describe “how was your day” being as specific as possible with timing of any significant positive or negative moments from the day? What have you learned from your progress today?

### 8.3. Background Survey Protocol for Participants

#### Outline protocol

<b>Pre Study Background Questionnaire</b>
PISCF – Participant Information and Consent Form
Demographics
Entrepreneurship questions
Big 6 Personality Tests
Appraisal inventory
Domains of entrepreneurial passion
Effectuation scale

## **Demographics**

Age

Gender

Education

What is the highest year of school you have completed?

7 - 8 - 9 - 10 - 11 -12

What qualifications have you completed? (Source of question: HILDA Household survey)

Secondary school qualification - lower level

Secondary school qualification - higher level

Nursing qualification

Teaching qualification

Trade certificate or apprenticeship

Technical certificate / advanced certificate

Other certificate, level I

Other certificate, level II

Other certificate, level III

Other certificate, level IV

Other certificate, I do not know

Associate diploma

Undergraduate diploma

Bachelor degree but not honours

Honours bachelor degree

Post-graduate diploma

Masters degree

Doctorate

Other, specify

**Entrepreneurship questions** (Entrepreneurial experience and Vicarious experience)

Do/Did you father or mother run his or her own business? Father - Mother - both

Do you have friends who run their own businesses? Yes/No

Own startup experience, serial entrepreneur

How many times have you founded a new firm or been part of a team founding a new firm?

XX times

Exit experience

Have you ever sold or otherwise exited a business you have started? Yes/No

If Yes, which of the following best describes your exit

A: I sold an operating business

B: I closed an operating business voluntarily

C: I passed a business to my children

E: The business failed (owing to insolvency or bankruptcy)

E: Something else

Hybrid entrepreneur

Do you currently own and run more than one business?

Yes/No

If Yes, how many?

Current business

Age of the business

Which year did you start this business?

Size of the business

How many employees do you have at the moment , including exclusive contractors?

What is the revenue of the business? (Give categories)

Profitability

Last fiscal year, did your business make a profit? Yes/No

Has your business been profitable every year for the past three years? Yes/No

Profitability compared to others

Compared to the other businesses operating in your line of business/industry, how is your business performing in terms of (7-point Likert scale, 1 Much lower than others, 7 much higher than others

Profitability

Sales growth



Subjective satisfaction with the business performance

How satisfied are you with the performance/success of your business (7-point Likert scale)

Industry

In which industry does the business operate? (OPEN ENDED)

How many years of working experience do you have from the industry of your business?  
(Prior to starting the current venture) XX years

Product or service

Would you categorise the business as product or service business? Product / service

Team size and ownership share

How many owners in total, including yourself, does your business have? XX individuals

How large is your ownership of the business? XX%

Are you the owner who carries currently mostly of the responsibilities for making decisions running the business? Yes/No

Hybrid entrepreneur

Do you work full time for this business? Yes/No

If not, what percentage of your regular working hours do you work on the business? XX%

## Big 6 Personality Tests (Source: HEXACO)

On the following, you will find a series of statements about you. Please read each statement and decide how much you agree or disagree with that statement. Then write your response in the space next to the statement using the following scale:

5=strongly agree

4=agree

3=neutral (neither agree nor disagree)

2=disagree

1=strongly disagree

Please answer every statement even if you are not completely sure of your response.

I would be quite bored by a visit to an art gallery.

I plan ahead and organize things, to avoid scrambling at the last minute.

I rarely hold a grudge, even against people who have badly wronged me.

I feel reasonably satisfied with myself overall.

I would feel afraid if I had to travel in bad weather conditions.

I wouldn't use flattery to get a raise or promotion at work, even if I thought it would succeed.

I'm interested in learning about the history and politics of other countries.

I often push myself very hard when trying to achieve a goal.

People sometimes tell me that I am too critical of others.

I rarely express my opinions in group meetings.

I sometimes can't help worrying about little things.

If I knew that I could never get caught, I would be willing to steal a million dollars.

I would enjoy creating a work of art, such as a novel, a song, or a painting.

When working on something, I don't pay much attention to small details.

People sometimes tell me that I'm too stubborn.

I prefer jobs that involve active social interaction to those that involve working alone.

When I suffer from a painful experience, I need someone to make me feel comfortable.

Having a lot of money is not especially important to me.

I think that paying attention to radical ideas is a waste of time.

I make decisions based on the feeling of the moment rather than on careful thought.

People think of me as someone who has a quick temper.

On most days, I feel cheerful and optimistic.

I feel like crying when I see other people crying.

I think that I am entitled to more respect than the average person is.

If I had the opportunity, I would like to attend a classical music concert.

When working, I sometimes have difficulties due to being disorganized.

My attitude toward people who have treated me badly is "forgive and forget".

I feel that I am an unpopular person.

When it comes to physical danger, I am very fearful.

If I want something from someone, I will laugh at that person's worst jokes.

I've never really enjoyed looking through an encyclopedia.

I do only the minimum amount of work needed to get by.

I tend to be lenient in judging other people.  
In social situations, I'm usually the one who makes the first move.  
I worry a lot less than most people do.  
I would never accept a bribe, even if it were very large.  
People have often told me that I have a good imagination.  
I always try to be accurate in my work, even at the expense of time.  
I am usually quite flexible in my opinions when people disagree with me.  
The first thing that I always do in a new place is to make friends.  
I can handle difficult situations without needing emotional support from anyone else.  
I would get a lot of pleasure from owning expensive luxury goods.  
I like people who have unconventional views.  
I make a lot of mistakes because I don't think before I act.  
Most people tend to get angry more quickly than I do.  
Most people are more upbeat and dynamic than I generally am.  
I feel strong emotions when someone close to me is going away for a long time.  
I want people to know that I am an important person of high status.  
I don't think of myself as the artistic or creative type.  
People often call me a perfectionist.  
Even when people make a lot of mistakes, I rarely say anything negative.  
I sometimes feel that I am a worthless person.  
Even in an emergency I wouldn't feel like panicking.  
I wouldn't pretend to like someone just to get that person to do favors for me.  
I find it boring to discuss philosophy.  
I prefer to do whatever comes to mind, rather than stick to a plan.  
When people tell me that I'm wrong, my first reaction is to argue with them.  
When I'm in a group of people, I'm often the one who speaks on behalf of the group.  
I remain unemotional even in situations where most people get very sentimental.  
I'd be tempted to use counterfeit money, if I were sure I could get away with it.

Source: Ashton, M. C., & Lee, K. (2009). The HEXACO-60: A short measure of the major dimensions of personality. *Journal of Personality Assessment*, 91, 340-345.

## Appraisal inventory

Please rate how certain you are that you can do the things discussed below by writing the appropriate number. Rate your degree of confidence by recording a number from 0 to 100 using the scale given below:

0 cannot do at all

50 moderately certain can do

100 highly certain can do

How well can you..

Keep tough problems from getting you down

Bounce back after you have tried your best and failed

Get yourself to keep trying when things are going really badly

Keep up your spirit when you suffer hardship

Get rid of self-doubts after you have had tough setbacks.

Keep from being easily rattled.

Overcome discouragement when nothing you try seems to work.

Remain confident in during difficult times

This questionnaire is designed to help us to gain better understanding of the kinds of things that create difficulties for people when working on a business idea. Please rate how certain you are that you can do the things discussed below by writing the appropriate number. Rate your degree of confidence by recording a number from 0 to 100 using the scale given below:

0 cannot do at all

50 moderately certain can do

100 highly certain can do

Exploration self-efficacy (ideation and building legitimacy and resources)

Come up with a new idea for a product or service

Identify the need for a new product or service

Acquire new customers and markets

Design a product or service that will satisfy customer needs and want

Get others to identify with and believe in the vision and plans for the business

Exploitation self-efficacy (more about managing people and processes)

Take action to increase efficiency

Maintain good relationship with employees

Coordinate the work of employees

Organise your own work effectively

Delegate tasks and responsibilities to employees of your business

Deal effectively with day-to-day problems and crises

Inspire, encourage and motivate employees

Source: Bandura, A. 2006. Guide for Constructing Self-Efficacy Scales. In Pajares, F., Urdan, T. (Eds). Self-Efficacy Beliefs of Adolescents. Information Age Publishing. Pp. 307-337.

## Domains of entrepreneurial passion

Please indicate the extent to which you agree or disagree with the following statements (7-point Likert scale from Strongly disagree to Strongly agree)

Innovator domain:

It is exciting to figure out new ways to solve unmet market needs that can be commercialized.

Searching for new ideas for product/services to offer is enjoyable to me.

I am motivated to figure out how to make existing products/services better.

Scanning the environment for new opportunities really excites me.

Inventing new solutions to problems is an important part of who I am. (identity centrality measure)

Founding domain:

Establishing a new company excites me.

Owning my own company energizes me.

Nurturing a new business through its emerging success is enjoyable.

Being a founder of a business is an important part of who I am. (identity centrality measure)

Developing domain:

I really like finding the right people to market my product/service to.

Assembling the right people to work for my business is exciting.

Pushing my employees and myself to make our company better motivates me.

Nurturing and growing companies is an important part of who I am. (identity centrality measure)

Source: Cardon, Melissa S., Denis A. Gregoire, Christopher E. Stevens, and Pankaj C. Patel. 2013. "Measuring Entrepreneurial Passion: Conceptual Foundations and Scale Validation." *Journal of Business Venturing* 28 (3): 373–96. doi:10.1016/j.jbusvent.2012.03.003.

Emotion as trait (this to be able to caliber E4)

This scale consists of a number of words that describe different feelings and emotions. Read each item and then mark the appropriate answer in the space next to that word. Indicate to what extent you generally feel this way, how you feel on the average. Use the following scale to record your answer.

1 very slightly or not all all

2 a little

3 moderately

4 quite a bit

5 extremely

interested

distressed

excited (high activated positive)

upset  
strong  
guilty  
scared  
hostile  
enthusiastic (high activated positive)  
proud  
irritable  
alert  
ashamed  
inspired (high activated positive)  
nervous  
determined  
attentive  
jittery  
active  
afraid.

Source: Watson, D., Clark, L.A., Tellegen, A. 1988.. Development and validation of the brief measure of positive and negative affect: The PANAS scale. *Journal of Personality and Social Psychology*, 54(6), 1063-1070.

## Effectuation scale

Thinking about your decision-making practice/logic in your business, how well do the following statements describe you:

### Causation

I analyse long run opportunities and select what I think will provide the best returns.  
I develop a strategy to best take the advantage of resources and capabilities.  
I design and plan business strategies.  
I organise and implement control processes to make sure we meet objectives.  
I research and select target markets and do meaningful competitive analysis.  
I have a clear and consistent vision for where I want (my business) to end up.  
I design and plan marketing and production efforts.

### Experimentation

I experiment with different product, services and business models.  
The product/service that my business now provides is essentially the same as originally conceptualised.  
The product/service that my business now provides is substantially different than what I first imagined.  
I have tried a number of different approaches until I found a business model that worked.

### Affordable loss

I am careful not to commit more resources than I could afford to lose.  
I am careful not to risk more money than I am willing to lose with my initial idea.  
I am careful not to risk so much money that my business would be in real trouble financially if things wouldn't work out.

### Flexibility

I allow the business to evolve as opportunities emerge.  
I adapt what my business is doing to the resources we have.  
I am flexible and take advantage of opportunities as they arise.  
I avoid courses of action that restrict my flexibility and adaptability.

### Pre-commitments

We use a substantial number of agreements with customers, suppliers and other organisations and people to reduce the amount of uncertainty.  
We use pre-commitments from customers and suppliers as often as possible.

Source: Chandler, Gaylen N., Dawn R. DeTienne, Alexander McKelvie, and Troy V. Mumford. 2011. "Causation and Effectuation Processes: A Validation Study." *Journal of Business Venturing* 26 (3): 375–90. doi:10.1016/j.jbusvent.2009.10.006.

#### **8.4. Wearable Accuracy, Errors and Artefact Correction**

Accuracy of wearable technologies' PPG sensors has been a hotly debated topic in both the research and popular science literature where potential inaccuracies in PPG stem from three major areas, including (1) diverse skin types, (2) motion artefacts, and (3) signal crossover (Bent et al. 2020). There can be significant differences between devices, and between activity types, notably for example, that absolute error during activity is, on average, 30% higher than during rest (Bent et al. 2020) which indicate that different wearables are all reasonably accurate at resting and prolonged elevated heart rate, but that differences exist between devices in responding to changes in activity or movement as well as inadvertent knocking or bumping of the device. The use of the Empatica E4 wearable reduces some of these issues compared to the majority of consumer wearable devices due to its high sampling rate and error detection algorithms and has been validated for scientific and medical purposes (Garbarino et al. 2014; Ollander et al. 2016; van Lier et al. 2020), however it is a source of potential error and inconsistency in the data particularly for data collected in real life settings. Wearable sensors vary widely in terms of release year, data accessibility, and cost but devices with higher cost, a more recent release date, and a larger market will generally have higher accuracy as wearable sensor technology continues to evolve and improve (van Lier et al. 2020).

While some measurement circumstances can prevent data acquisition altogether, such as when a device is not making adequate contact with the skin in other cases the wearables algorithms will remove data that fails internal quality control, for example, when there is a large motion artefact indicated by high accelerometry sensor values in the wearable. Research-grade wearables such as the Empatica E4 down-sample and/or interpolate to have exactly a 64 Hz sampling rate where consumer wearables may exclude samples due to data loss. The main measurement error in wrist worn wearable devices including the E4 is motion artefacts, which is typically caused by displacement of the PPG sensor over the skin, changes in skin deformation, blood flow dynamics, and ambient temperature (Castaneda et al. 2018). Motion artefacts may manifest as missing or false beats particularly during physical activity or cyclic wrist motions where the "signal crossover" effect causes the sensors to lock onto a repeated periodic signal stemming from the repetitive motion (e.g., walking and jogging) and



mistake that signal as the cardiovascular cycle (van Lier et al. 2020). As participants in this study are engaged in their day to day work and life this includes the spectrum of activity from sleep to working sitting down at their desk or in meetings through to activity such as walking or exercise, networking and managing team members or partners where motion artefacts will impact the data.

The HRV calculations made from PPG data collected require access to raw, sample-level data that is not currently provided by most consumer wearables except research grade wearables such as the Empatica E4 that are validated for time domain HRV calculation (Bent et al. 2020; van Lier et al. 2020). The E4's wristband-integrated processing algorithm removes incorrect peaks due to noise in the raw PPG signal. Kubios HRV Premium software (version 3.3.1) is then used to calculate the HRV values where additional artefact correction filter options can be applied to further correct motion artefacts. In this study the data was processed with both medium and Kubios's proprietary automatic correction levels. And though it is clear that HRV calculations are much more accurate at rest, the value of exploration of the calculations during day-to-day activity are of particular relevance to this study as exploring the direction, intensity, and duration of the change of HRV and not the absolute numbers themselves can provide insights into interactive and cumulative effects of the entrepreneur journey on their self-regulation strength.

The application of both automatic and medium correction levels in the HRV calculations were applied for comparison in order to highlight methodological and practical learnings in this study. Figure 8-1 shows a comparison of automatic vs medium artefact correction for the daily resting RMSSD calculations for participant A during the 30-day data collection of Period 1. The automatic correction method provides greater detail in the direction, intensity and duration of the change of resting HRV. Kubios's automatic correction, available in their premium edition is a robust algorithm for detecting artefacts (missed beat detections, misplaced beats etc.) and ectopic beats (e.g. premature ventricular beats) while the medium correction threshold simply compares every beat interval against a local mean RR, and identifies the beat as an artefact if it exceeds the specified threshold which in the medium case is any RR intervals

identified that are larger/smaller than 0.25 seconds compared to the local average (Tarvainen et al. 2019).

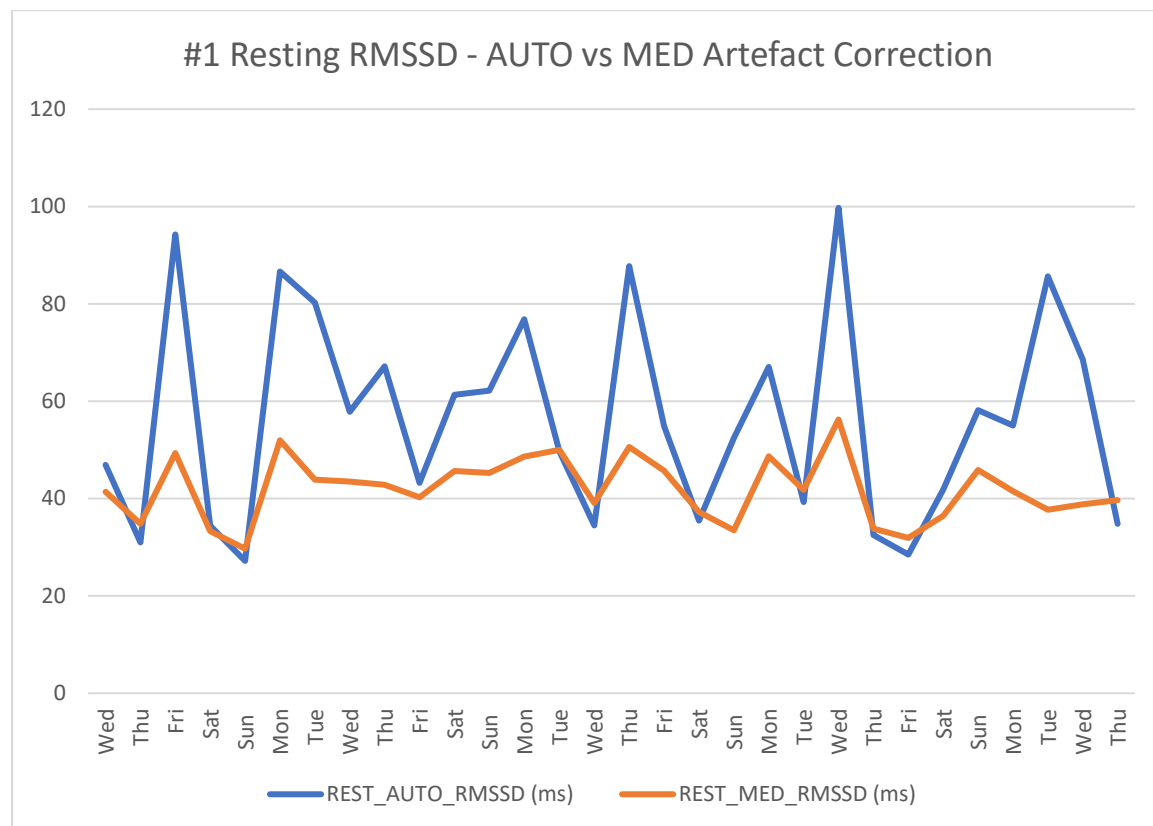


Figure 8-1: Comparison of Automatic vs Medium Artefact Correction

The threshold-based artefact correction algorithm can be set to different levels from very low (0.45 seconds) to very strong (0.05 seconds) which progressively removes more artefacts from the calculations reducing the variability in the HRV calculations. And because the artefacts are identified by simple thresholding, this correction method should not be duplicated between subjects because normal variability is highly individual and instead must be adjusted individually by first identifying if there are any artefacts in the data and then then selecting the lowest possible correction level, which identifies the artefacts but does not identify too many normal RR intervals as artefacts. Using the automatic artefact correction provides for more robust and complete results that can be applied to any subject by detecting artefacts from the dRR, which is a time series consisting of differences between successive RR intervals.

The use of the dRR series provides a robust way to separate ectopic and misplaced beats from the normal sinus rhythm.

Using the same collection period Figure 8-2 shows the percentage of artefacts that were corrected for the RMSSD calculation at rest for both automatic and medium artefact correction. The figure shows a consistent pattern between the two methods however the medium correction method removes more artefacts from the calculation due to the threshold approach than the automatic correction method which for some calculations can reduce its value for exploring the direction, intensity, and duration of the change of HRV.

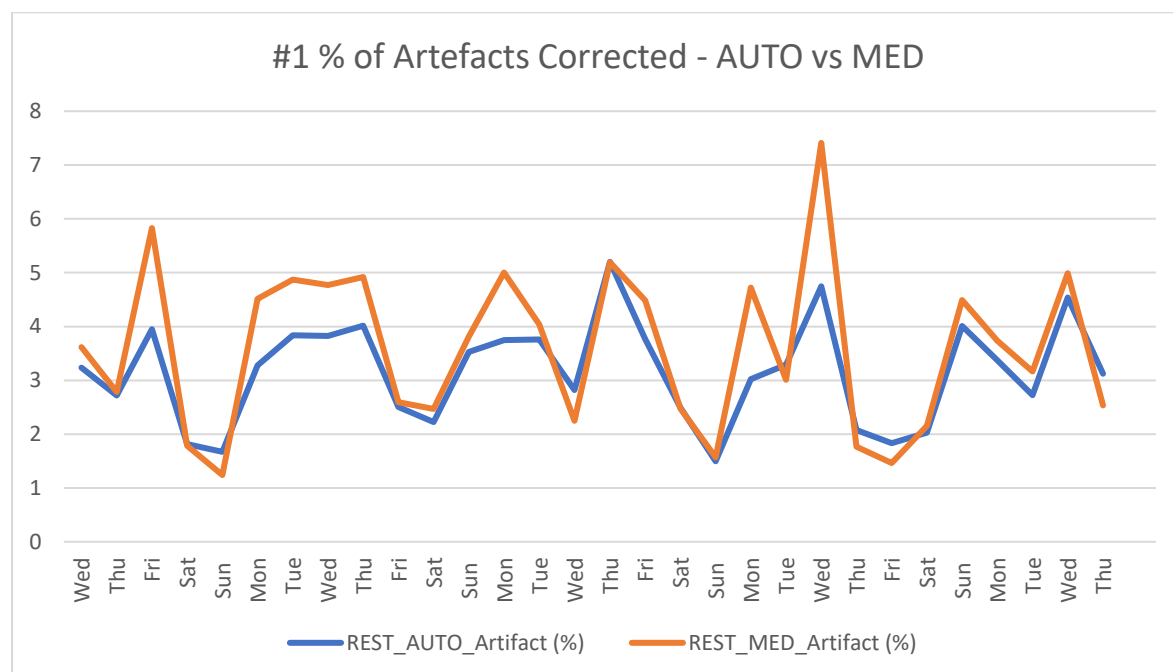


Figure 8-2: Percentage of Artefacts Corrected

## 8.5. Ethics Approval



GPO Box 2476  
Melbourne VIC 3001 Australia  
Tel. +61 3 9925 xxxx  
Fax +61 3 9925 xxxx  
[www.rmit.edu.au](http://www.rmit.edu.au)

### Notice of Approval

**Date:** 4 July 2018

**Project Number:** 21428

**Project Title:** *Using wearable sensor technology to advance entrepreneurship research, study 2*

**Risk Classification:** Low Risk

**Chief Investigator:** Prof Pia Arenius  
**Student Investigators:** Andrew Paul Brough, Nauman Aslam  
**Other Investigators:** Dr Afreen Huq

**Project Approved:** **From:** 27 April 2018 **To:** 3 June 2022

#### Terms of Approval:

##### *Responsibilities of the Principal Investigator*

It is the responsibility of the principal investigator to ensure that all other investigators and staff on a project are aware of the terms of approval and to ensure that the project is conducted as approved by BCHEAN. Approval is only valid while the investigator holds a position at RMIT University.

- 1. Amendments**  
Approval must be sought from BCHEAN to amend any aspect of a project including approved documents. To apply for an amendment submit a request for amendment form to the BCHEAN secretary. This form is available on the Human Research Ethics Committee (HREC) website. Amendments must not be implemented without first gaining approval from BCHEAN.
- 2. Adverse Events**  
You should notify BCHEAN immediately of any serious or unexpected adverse effects on participants or unforeseen events affecting the ethical acceptability of the project.
- 3. Participant Information and Consent Form (PICF)**  
The PICF must be distributed to all research participants, where relevant, and the consent form is to be retained and stored by the investigator. The PICF must contain the RMIT University logo and a complaints clause including the above project number.
- 4. Annual Reports**  
Continued approval of this project is dependent on the submission of an annual report.
- 5. Final Report**  
A final report must be provided at the conclusion of the project. BCHEAN must be notified if the project is discontinued before the expected date of completion.
- 6. Monitoring**  
Projects may be subject to an audit or any other form of monitoring by BCHEAN at any time.
- 7. Retention and Storage of Data**  
The investigator is responsible for the storage and retention of original data pertaining to a project for a minimum period of five years.

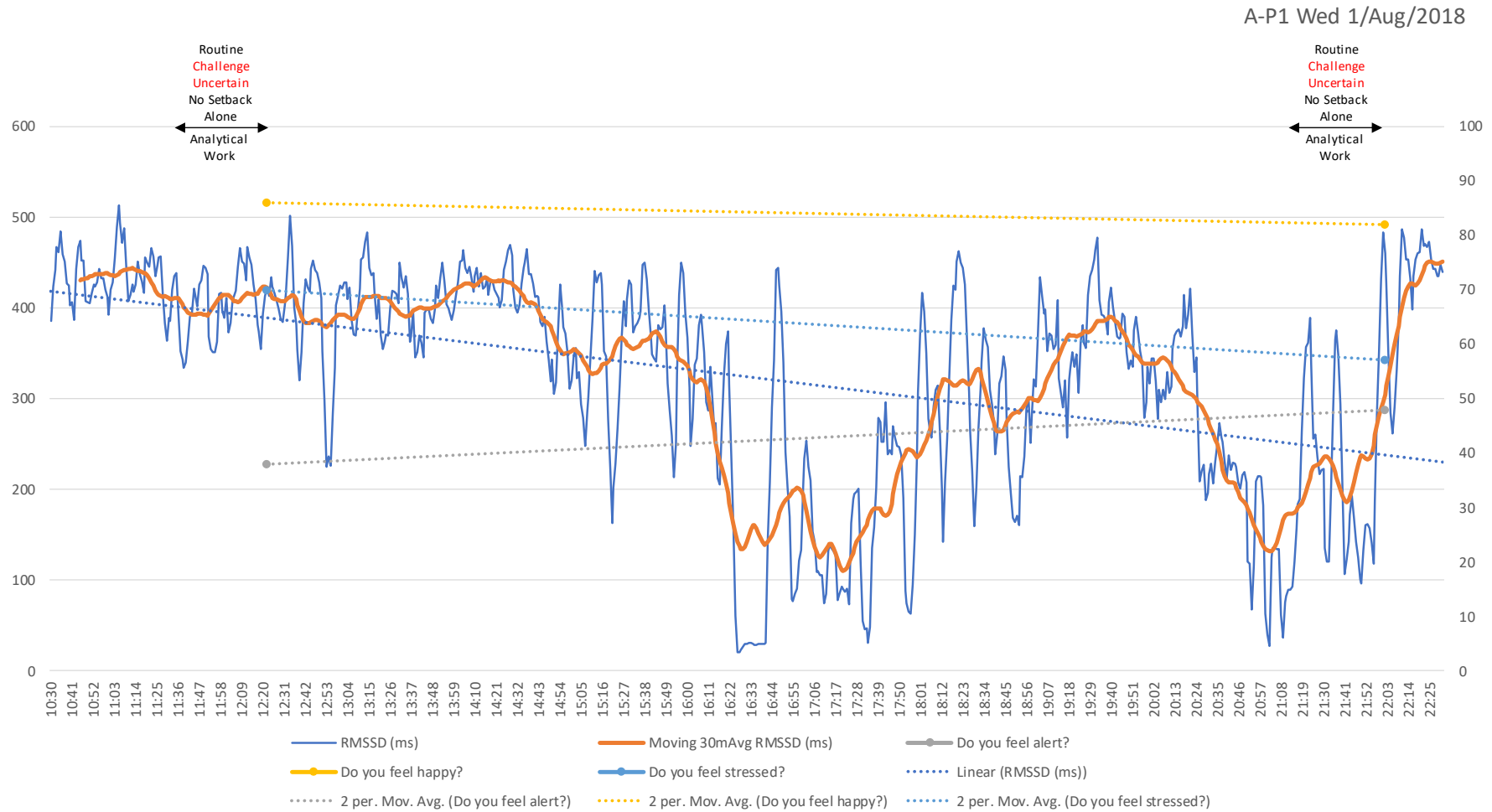
Regards,

Image redacted

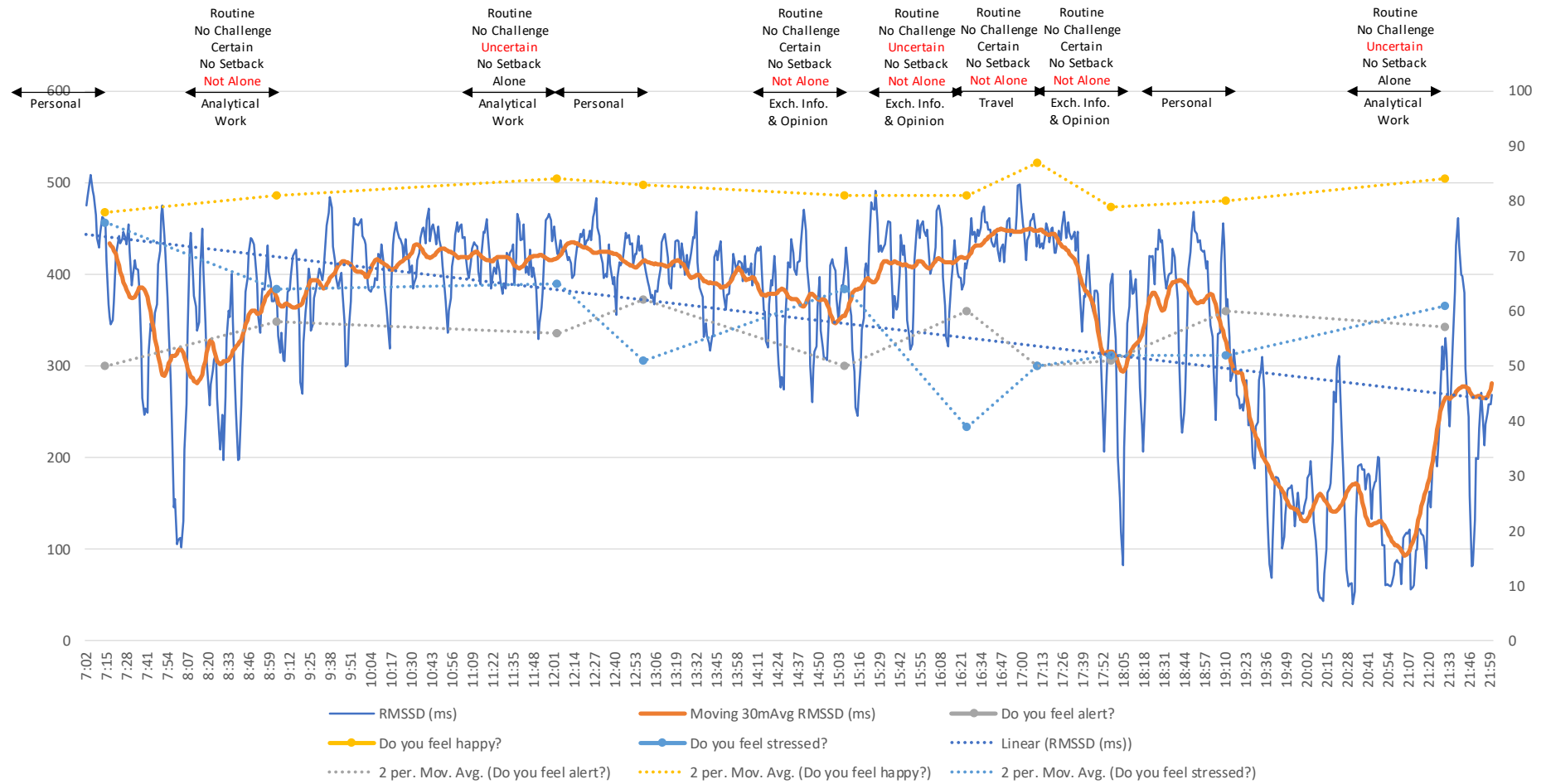
Dr Christopher Cheong  
Chairperson  
RMIT BCHEAN

## 8.6. Participant A – Chart Examples

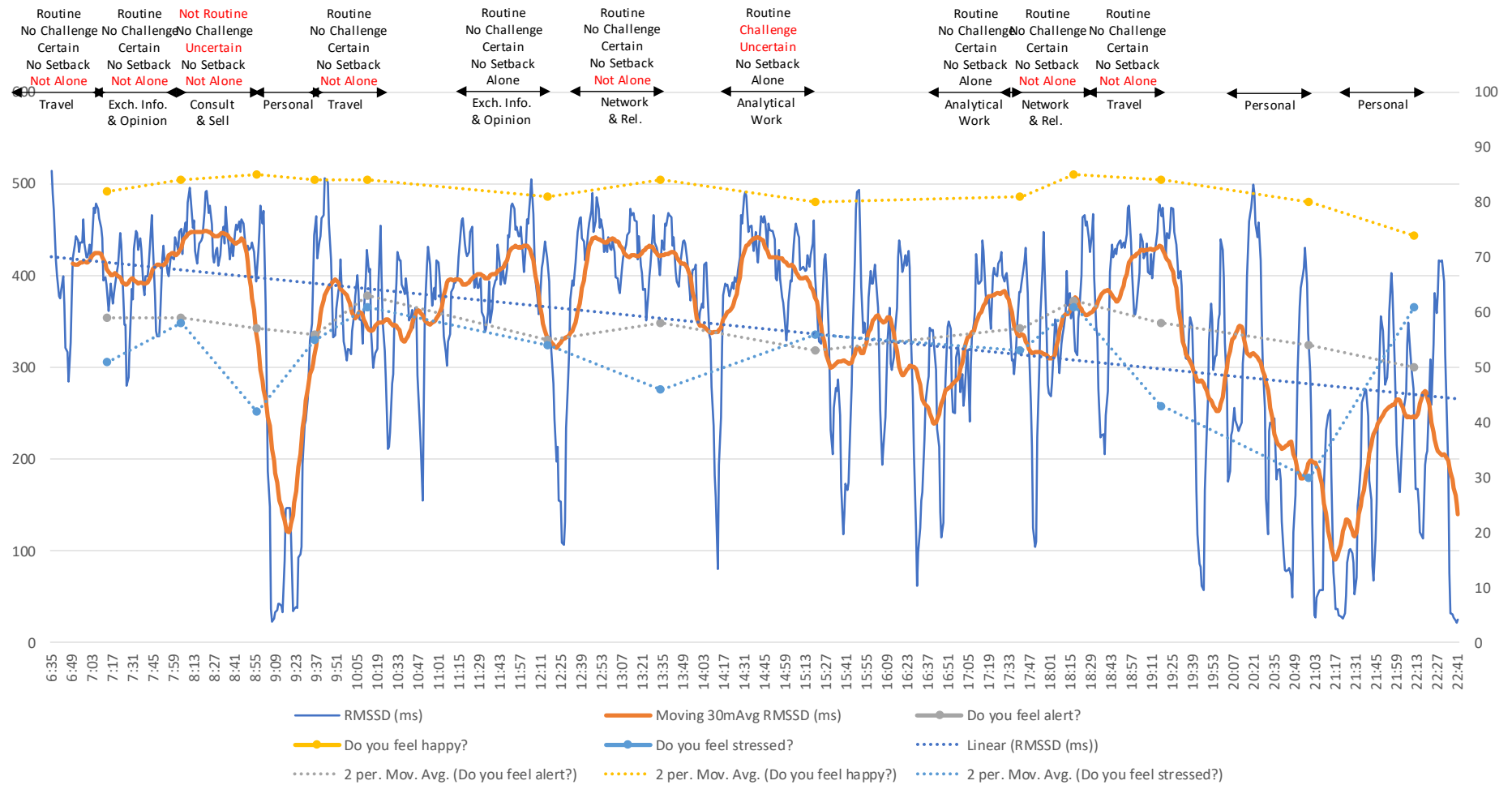
### 8.6.1. Momentary Charts for 30 Days of Period 1



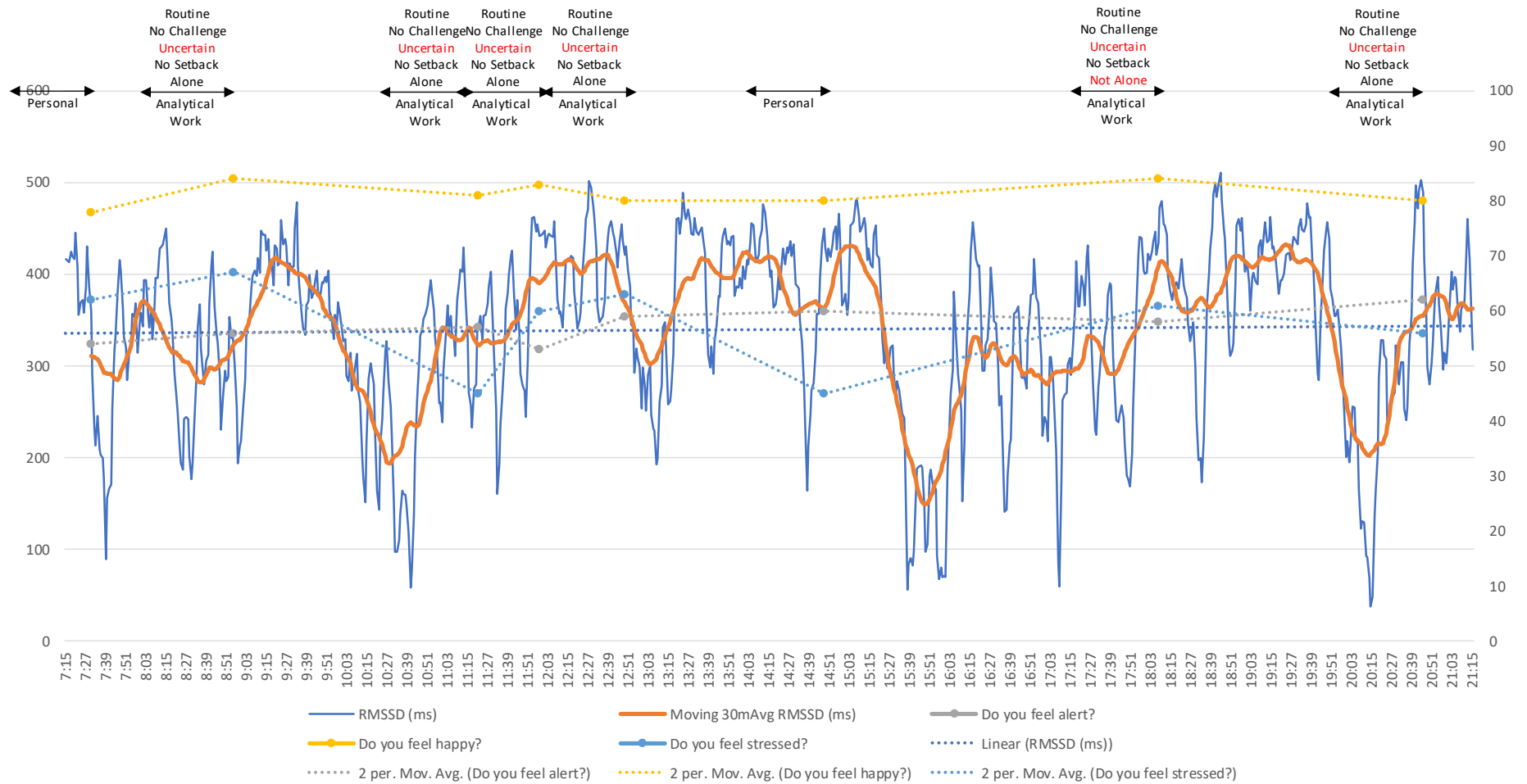
A-P1 Thu 2/Aug/2018



A-P1 Fri 3/Aug/2018

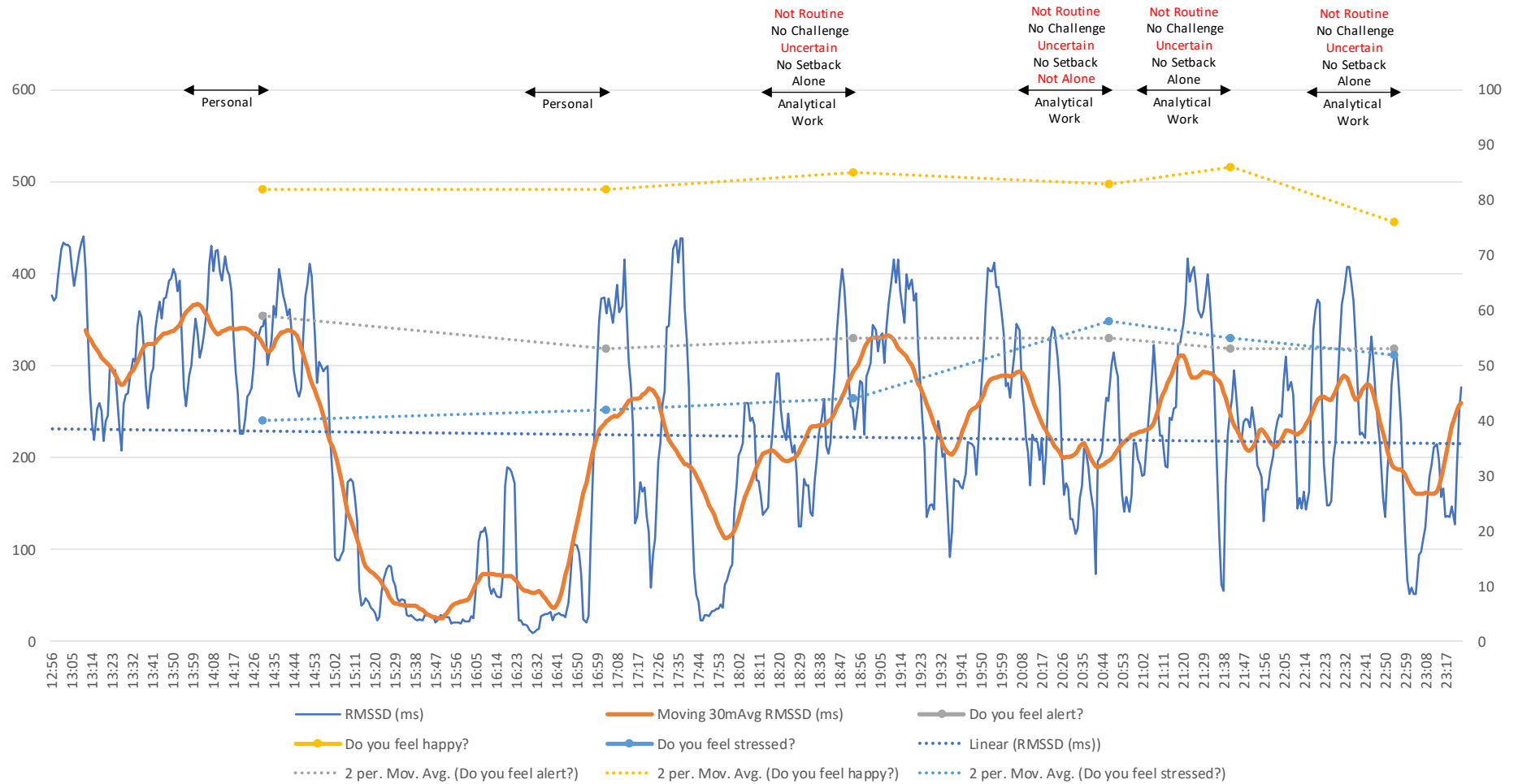


A-P1 Sat 4/Aug/2018

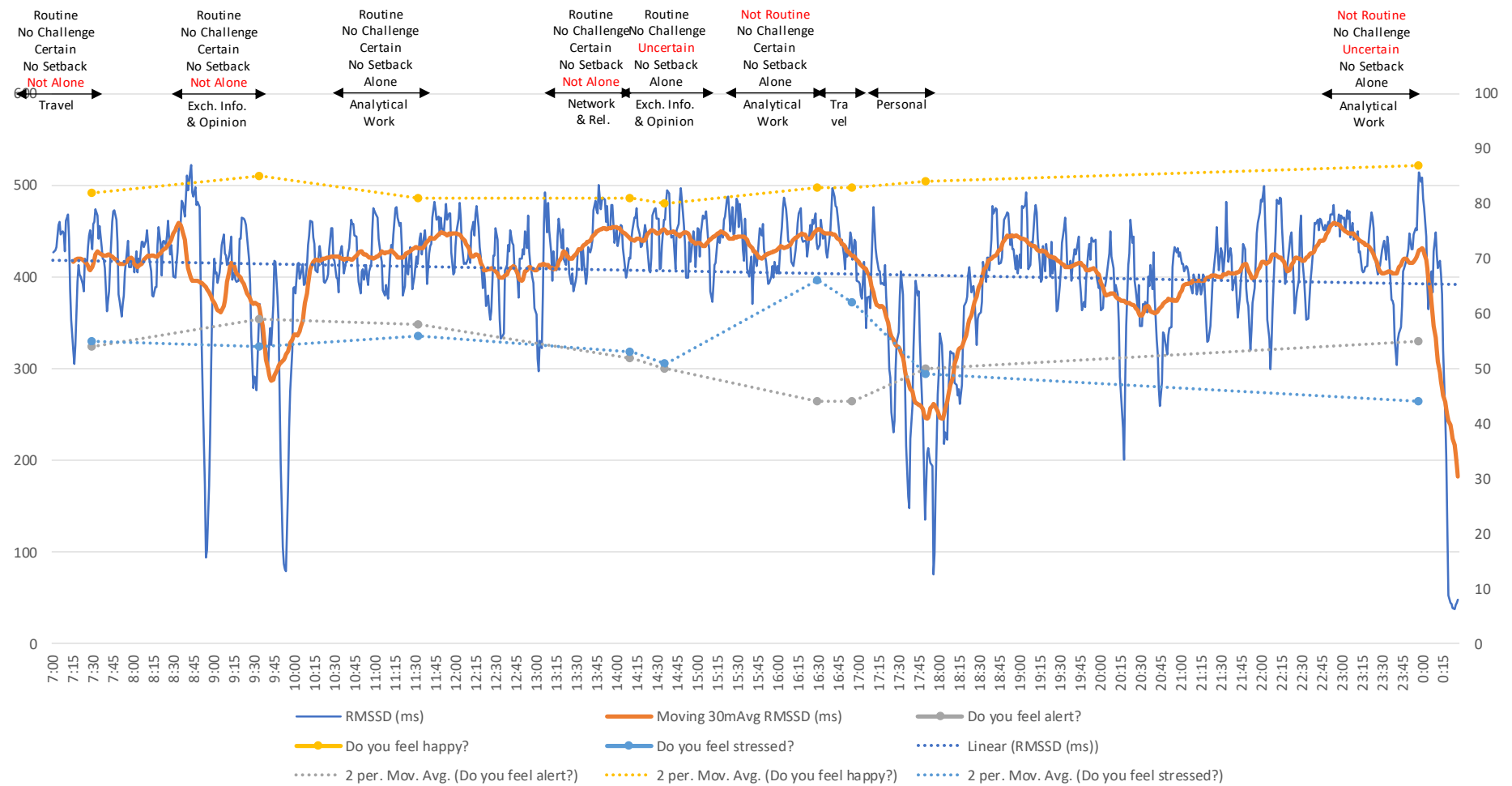




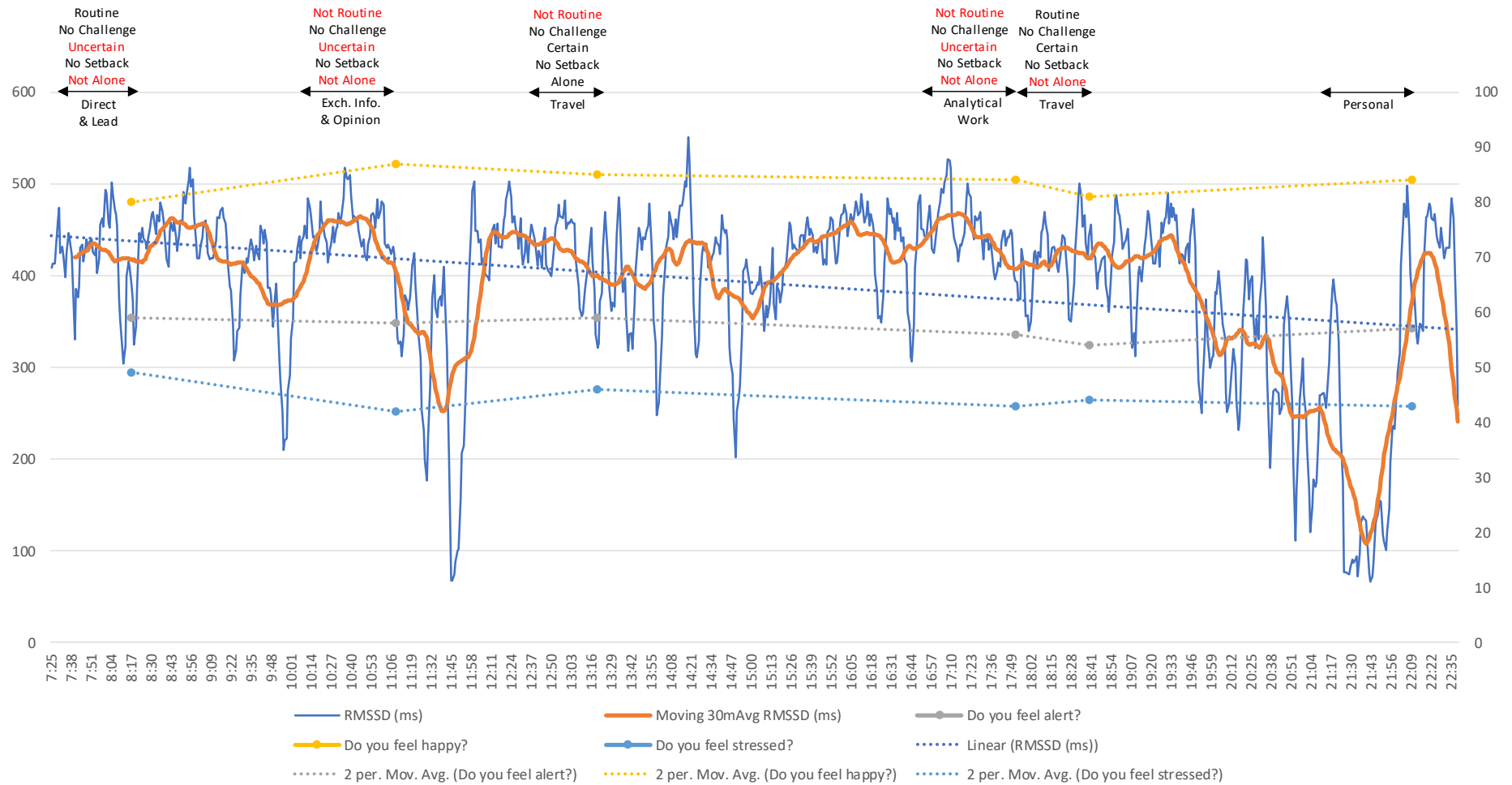
A-P1 Sun 5/Aug/2018



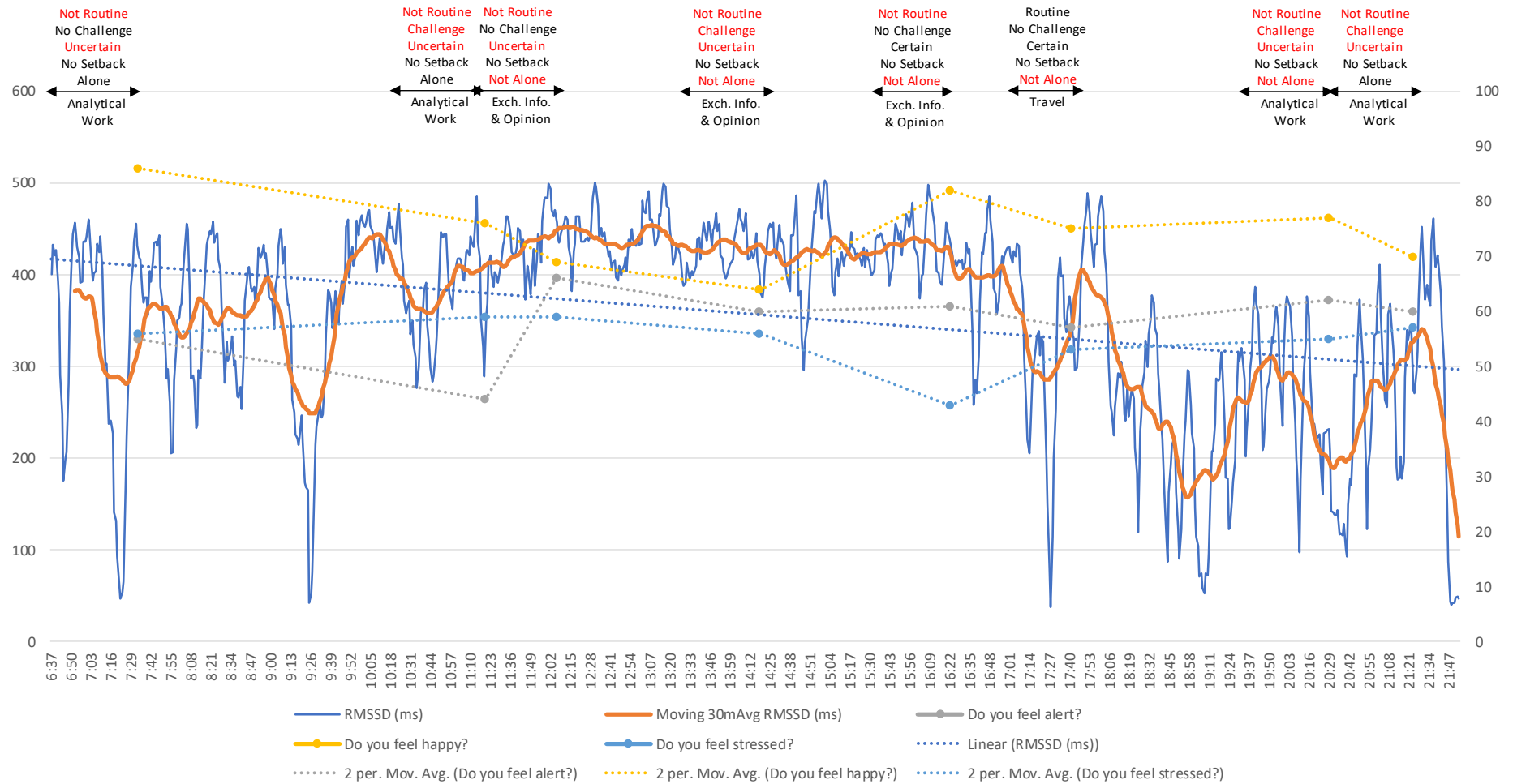
A-P1 Mon 6/Aug/2018



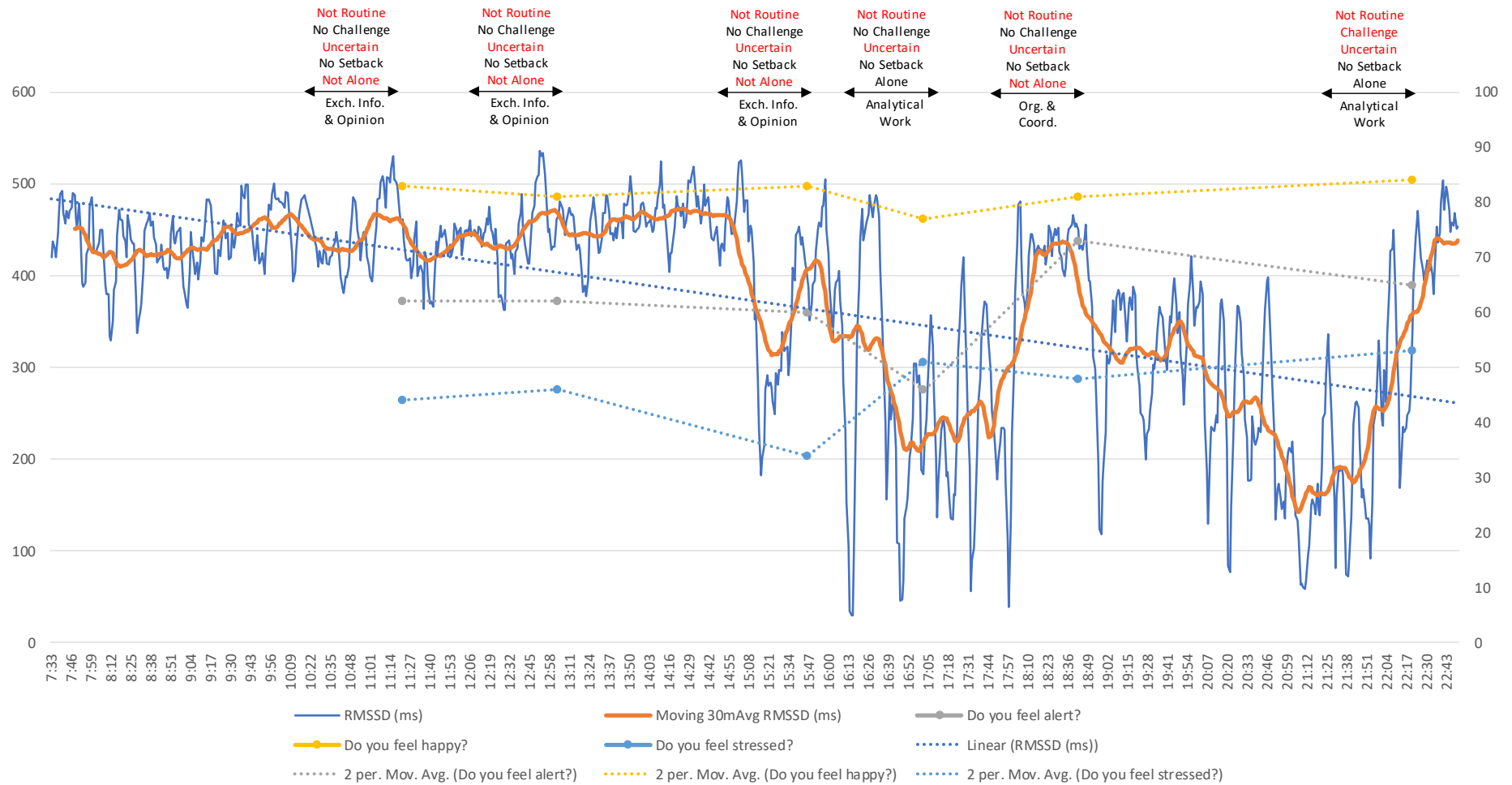
A-P1 Tue 7/Aug/2018



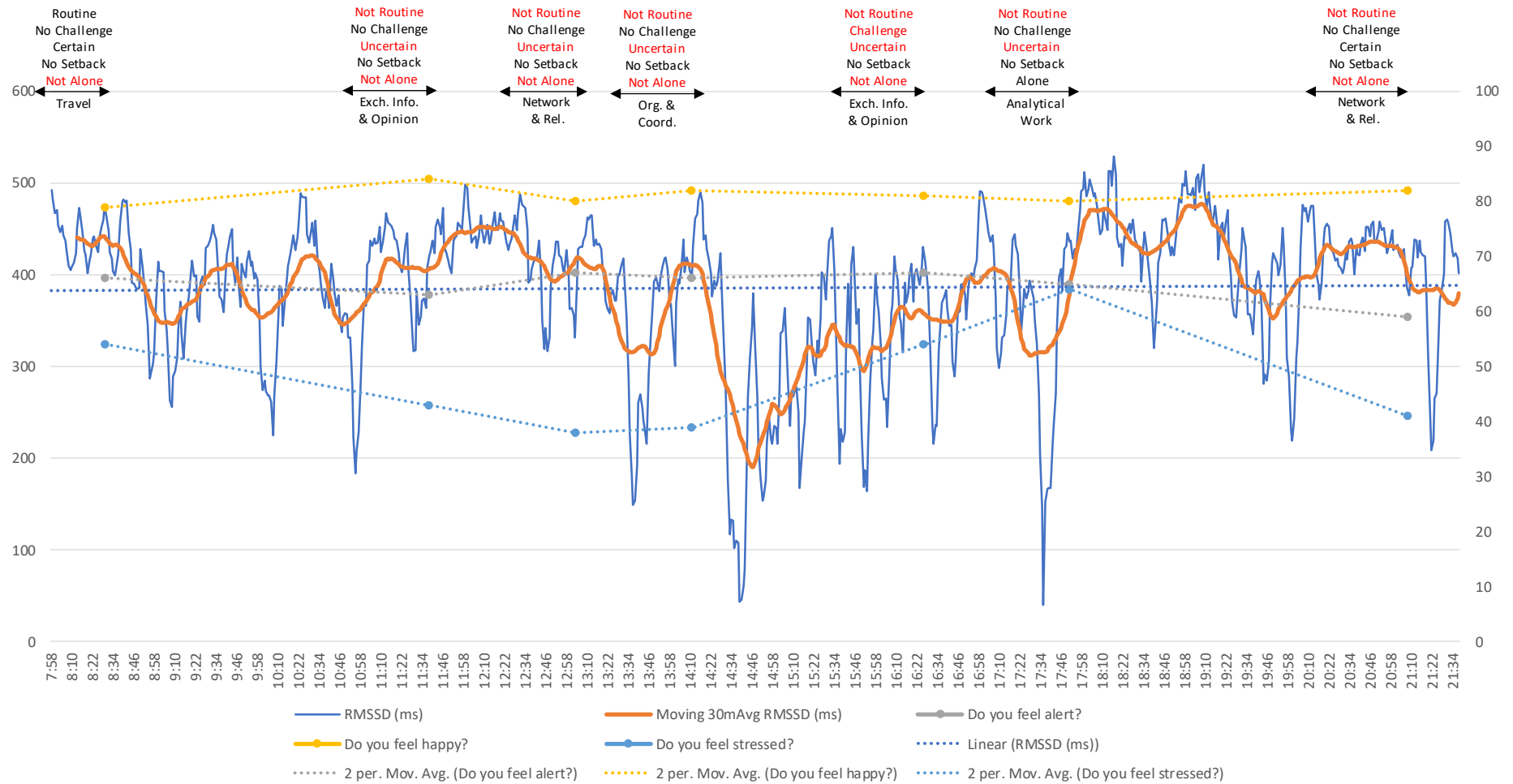
A-P1 Wed 8/Aug/2018



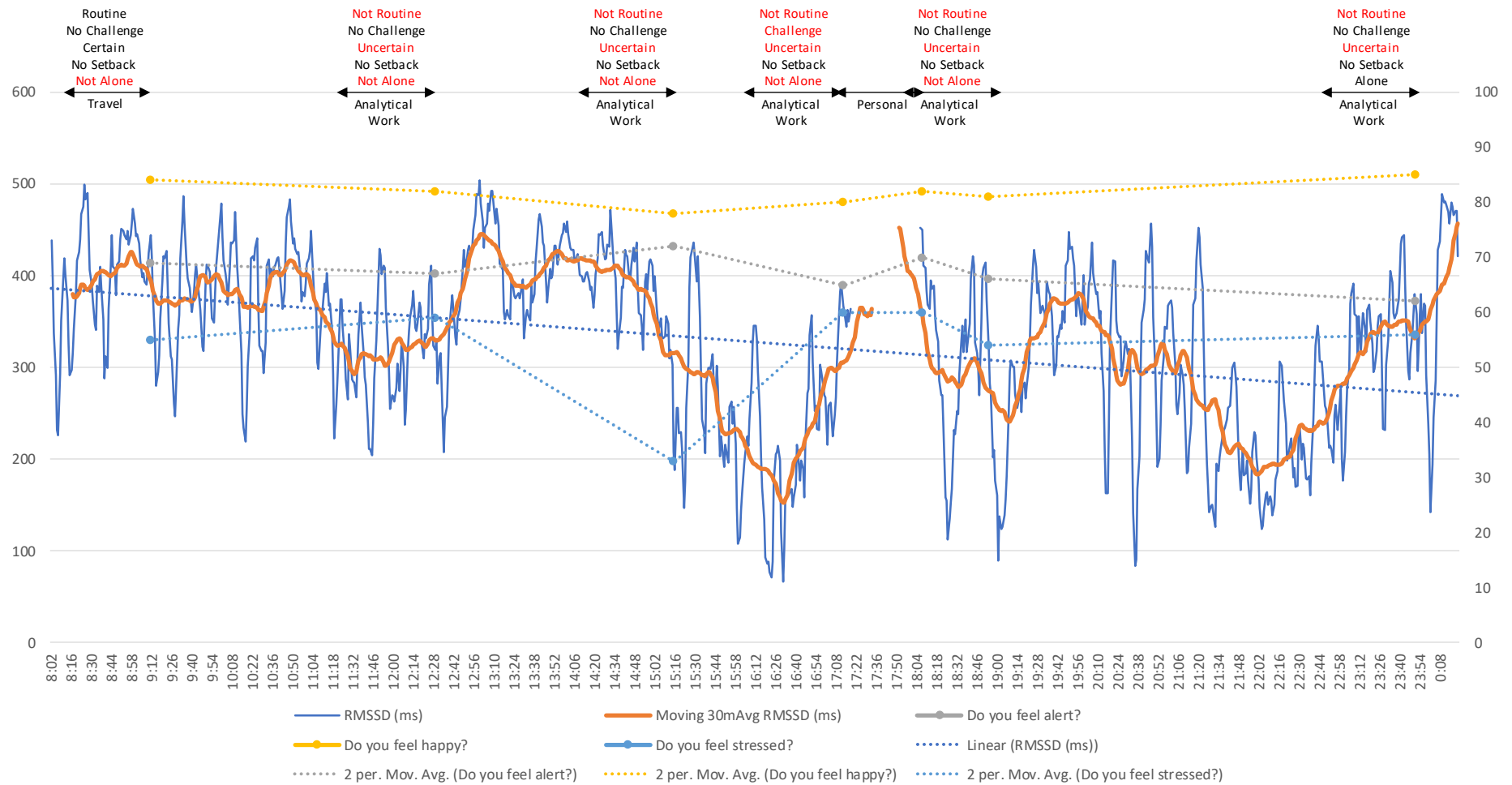
A-P1 Thu 9/Aug/2018



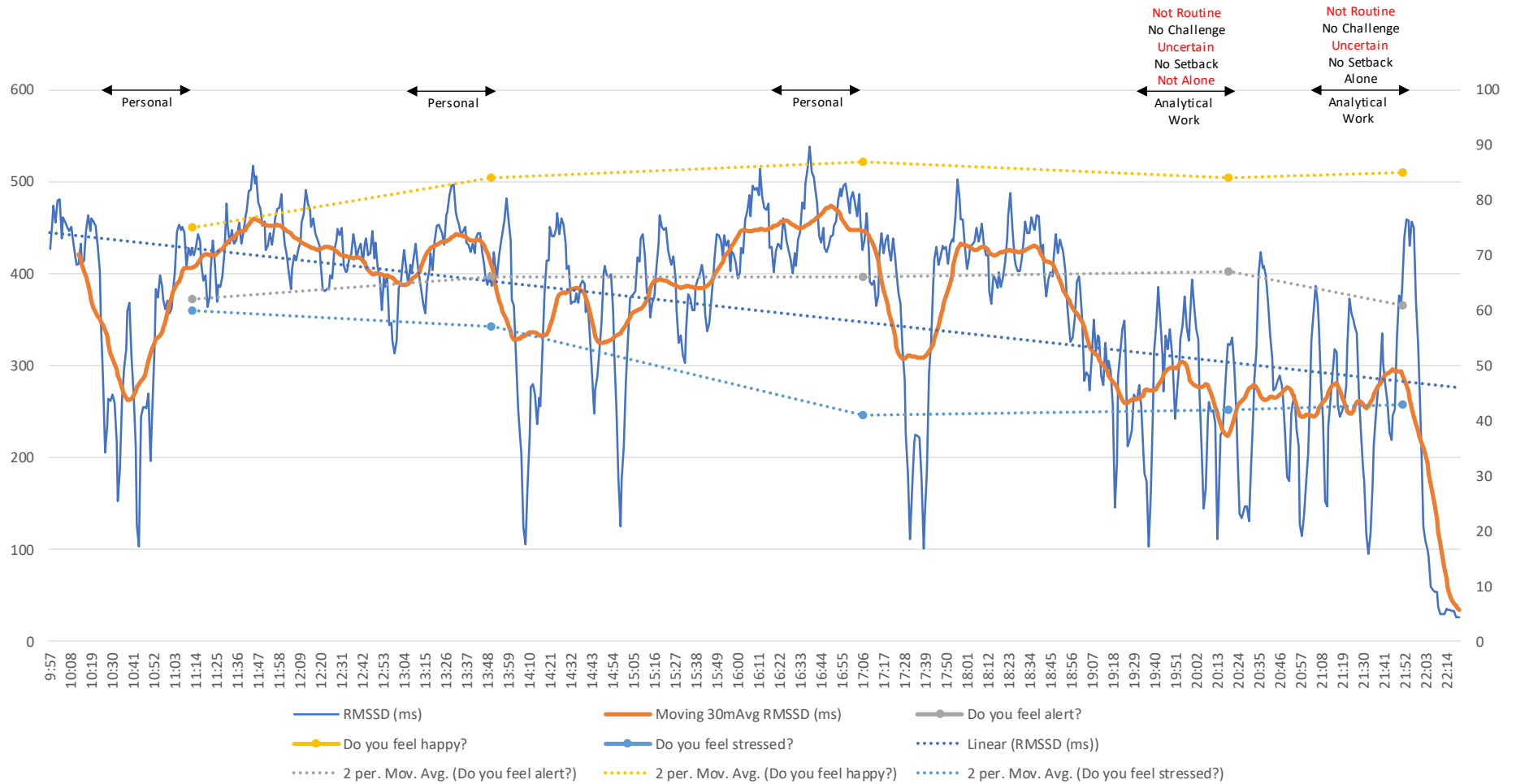
A-P1 Fri 10/Aug/2018



A-P1 Sat 11/Aug/2018

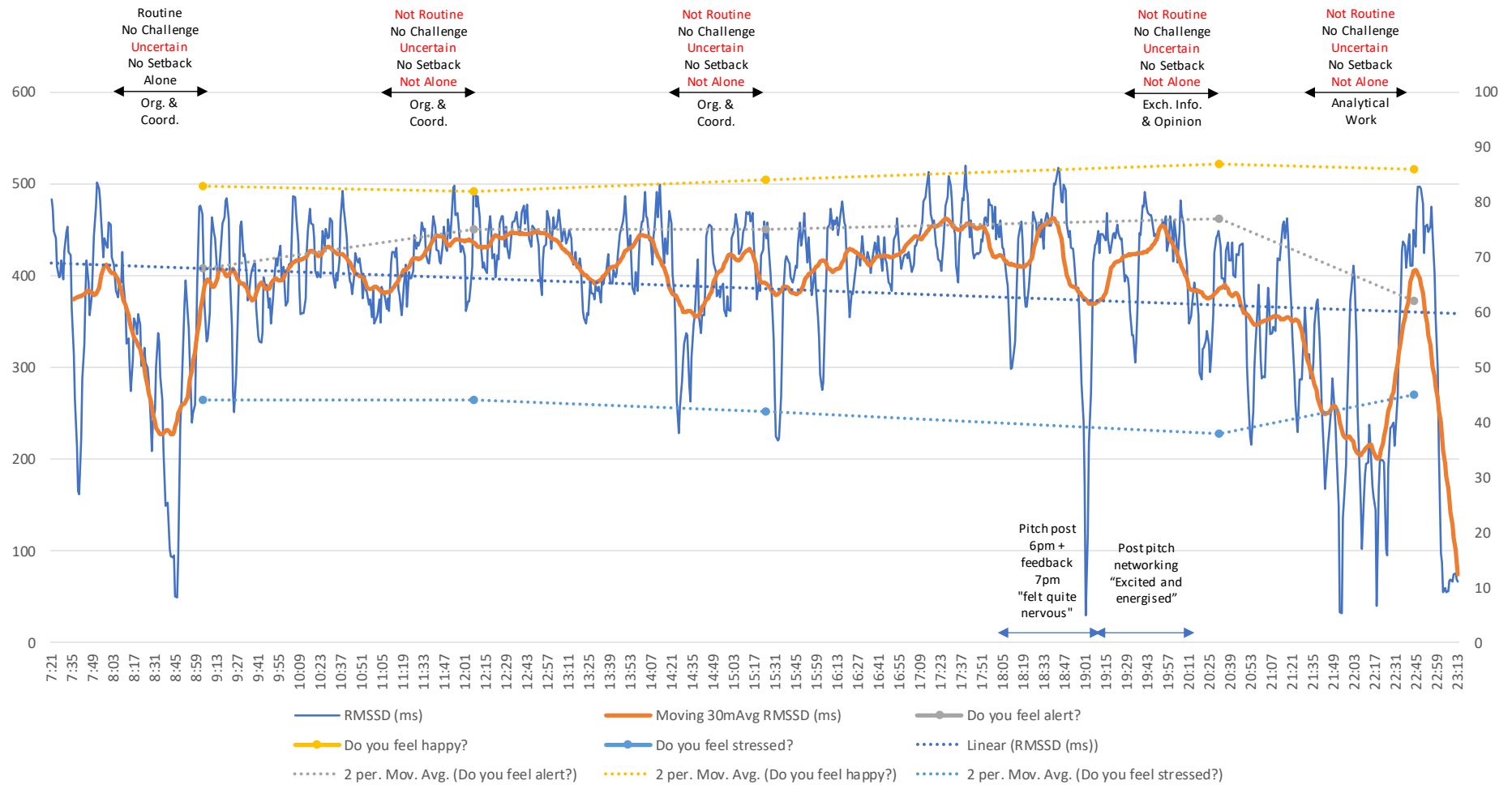


A-P1 Sun 12/Aug/2018

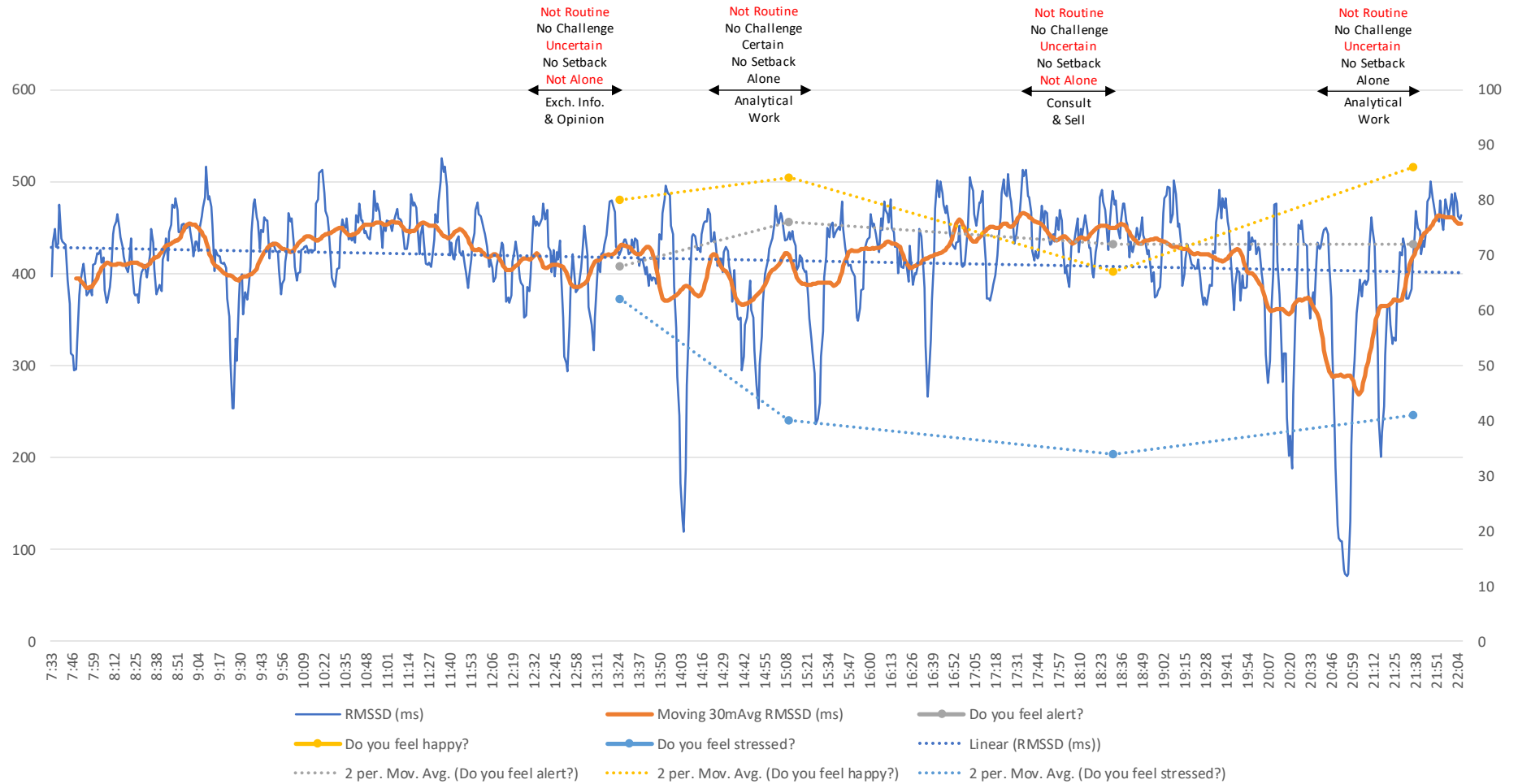




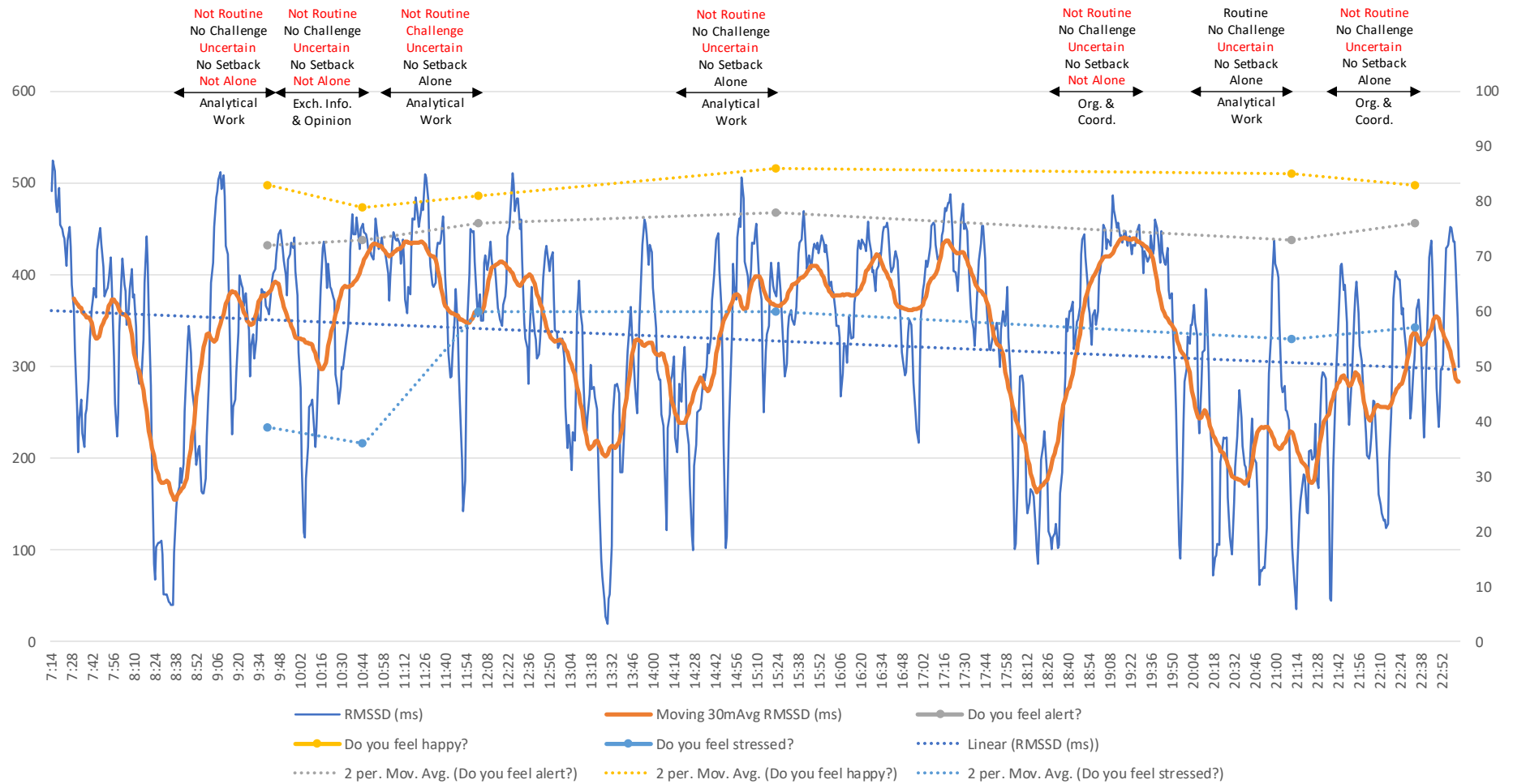
A-P1 Mon 13/Aug/2018



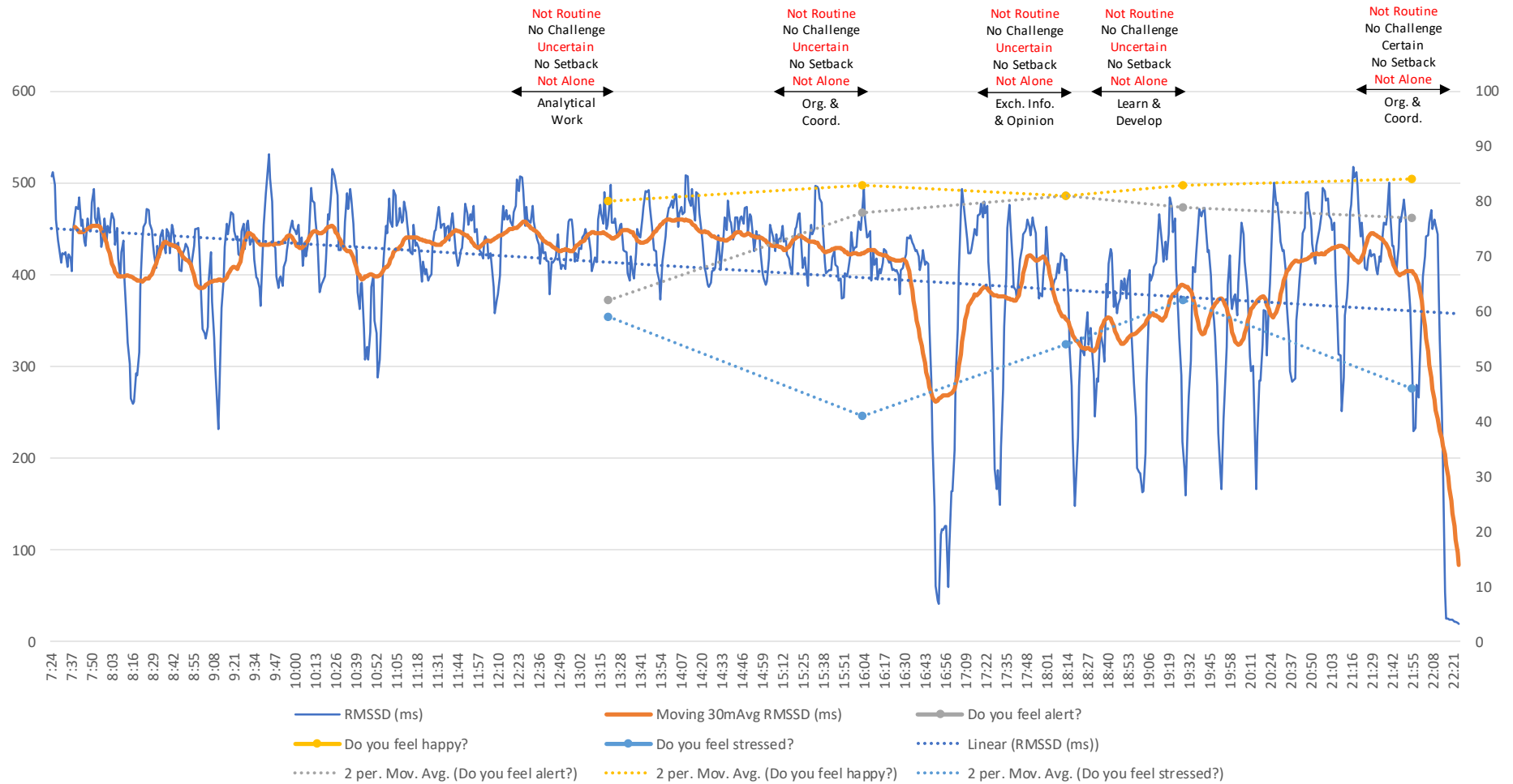
A-P1 Tue 14/Aug/2018



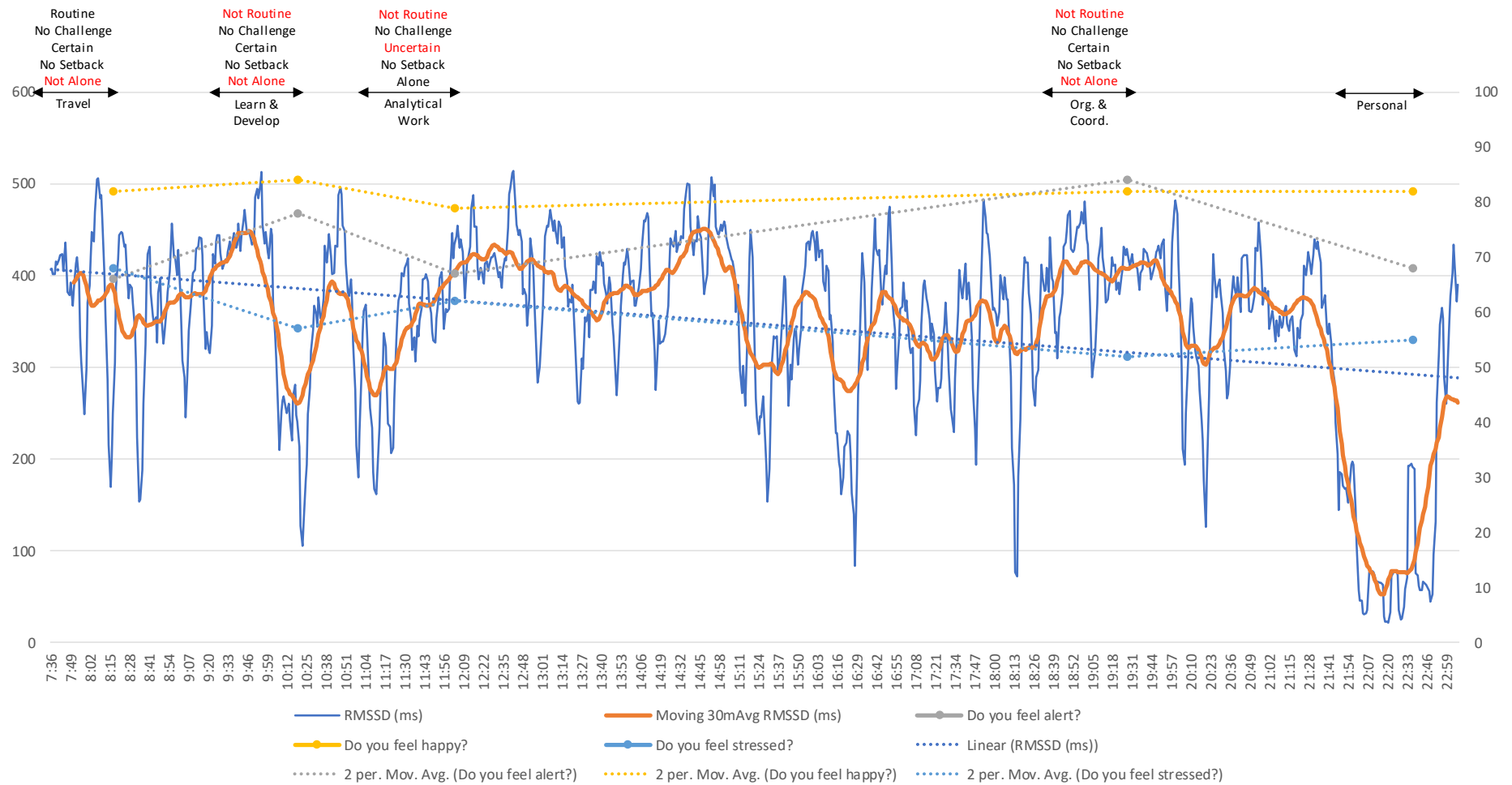
A-P1 Wed 15/Aug/2018



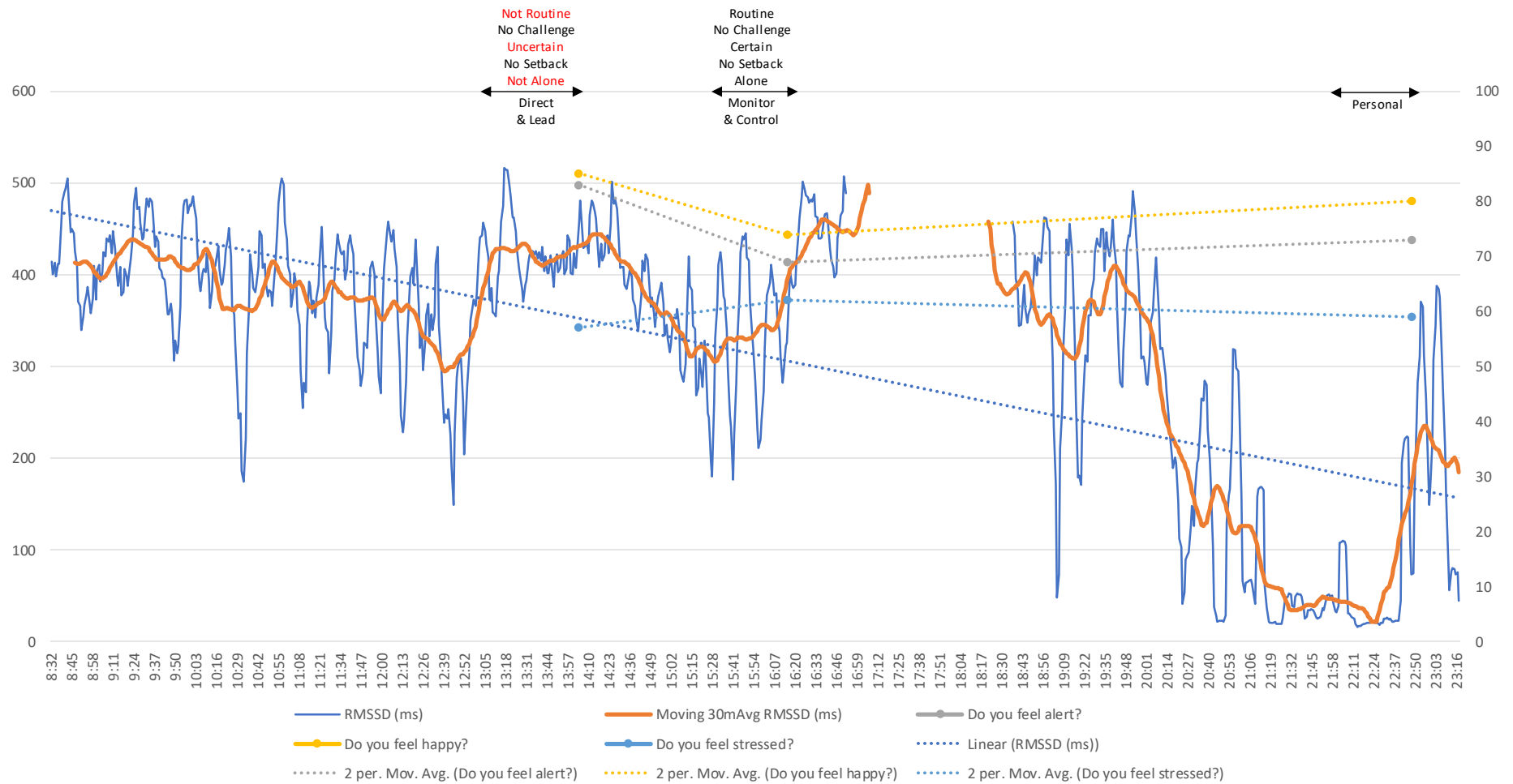
A-P1 Thu 16/Aug/2018



A-P1 Fri 17/Aug/2018

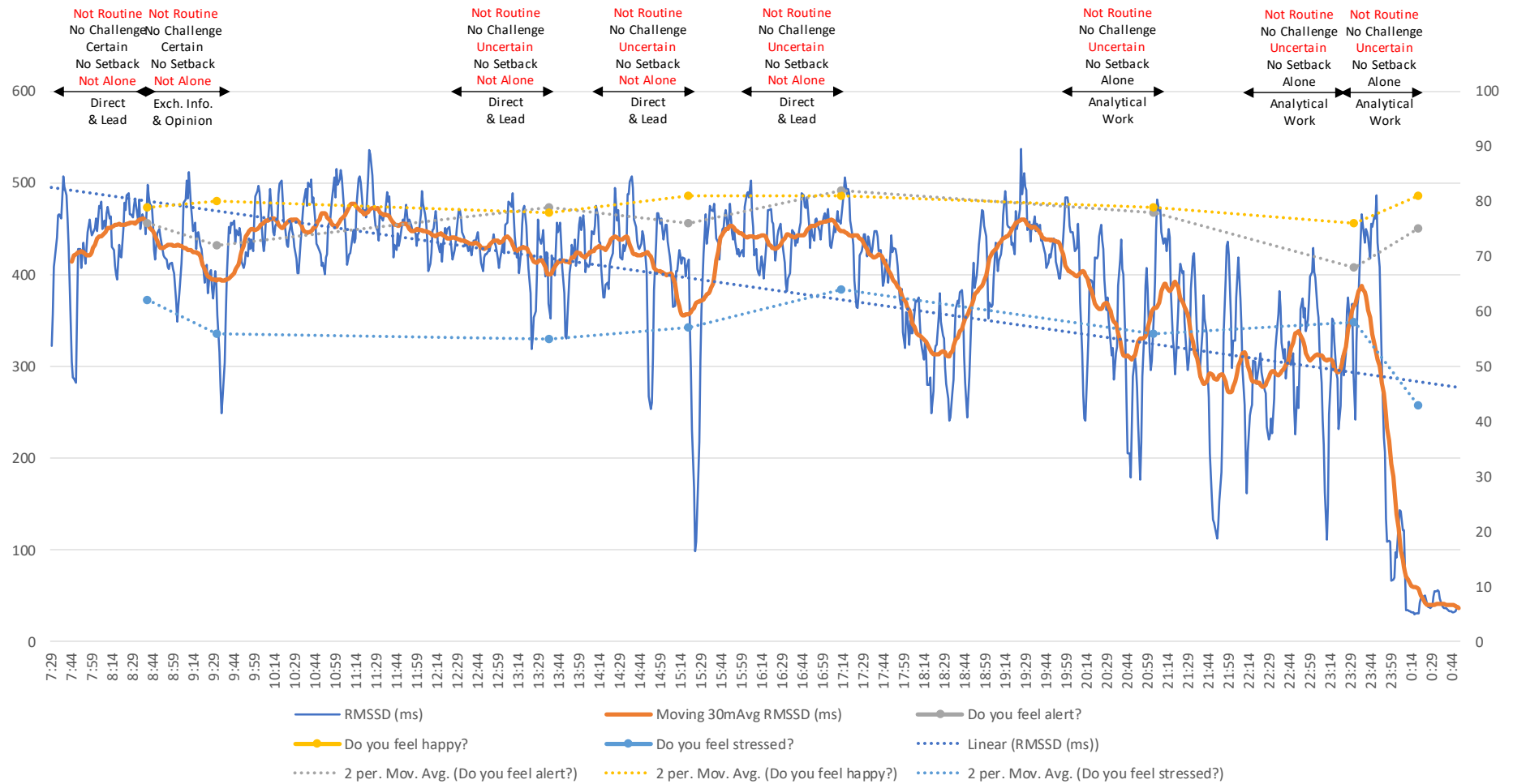


A-P1 Sat 18/Aug/2018



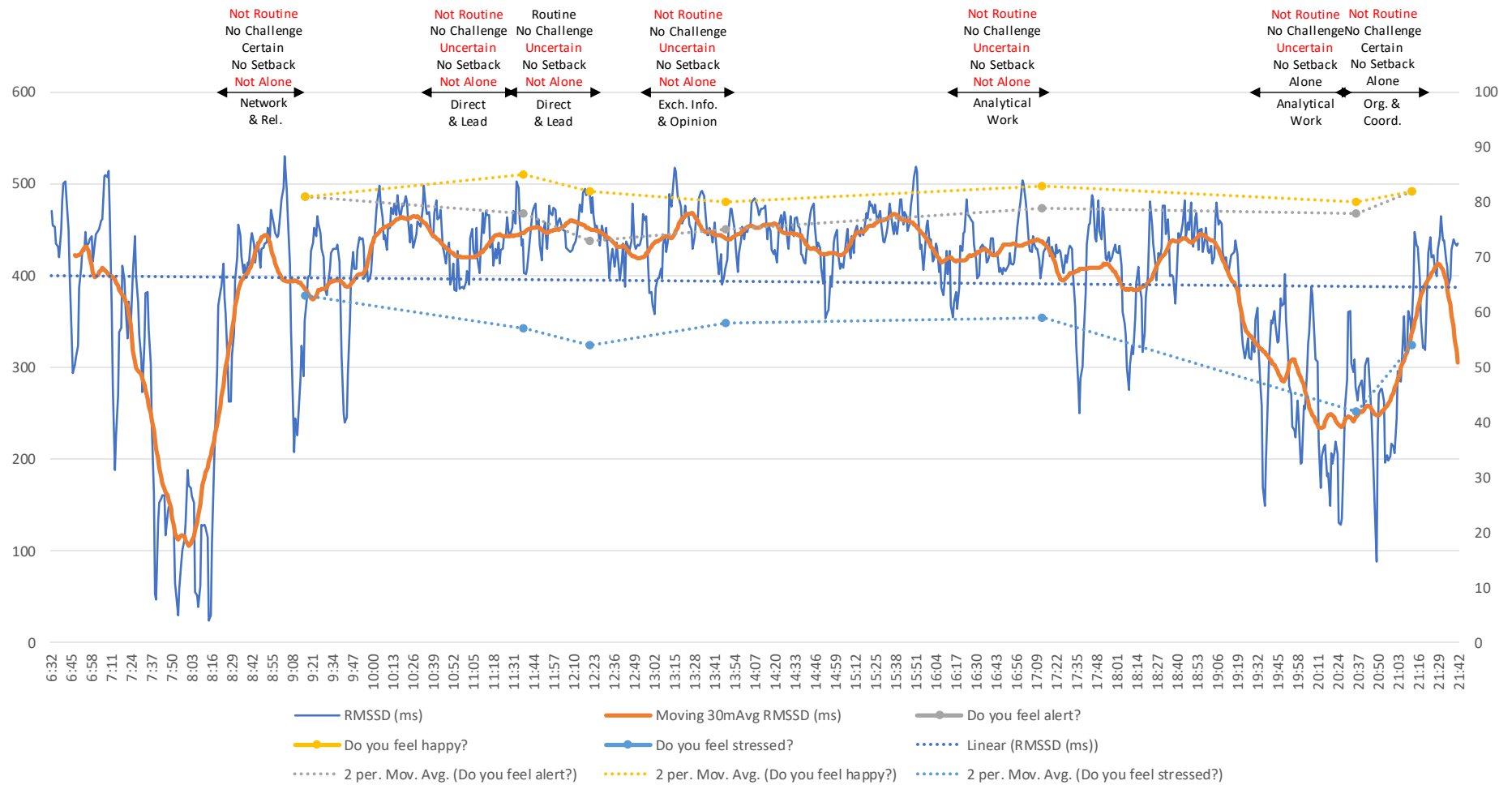
Only 12 minutes of E4 data with no overlap with  
3 x expi activity surveys

Worked the previous day until 4pm then relaxed with wife until late/11pm. Participant took Sunday off from using the E4 for data collection

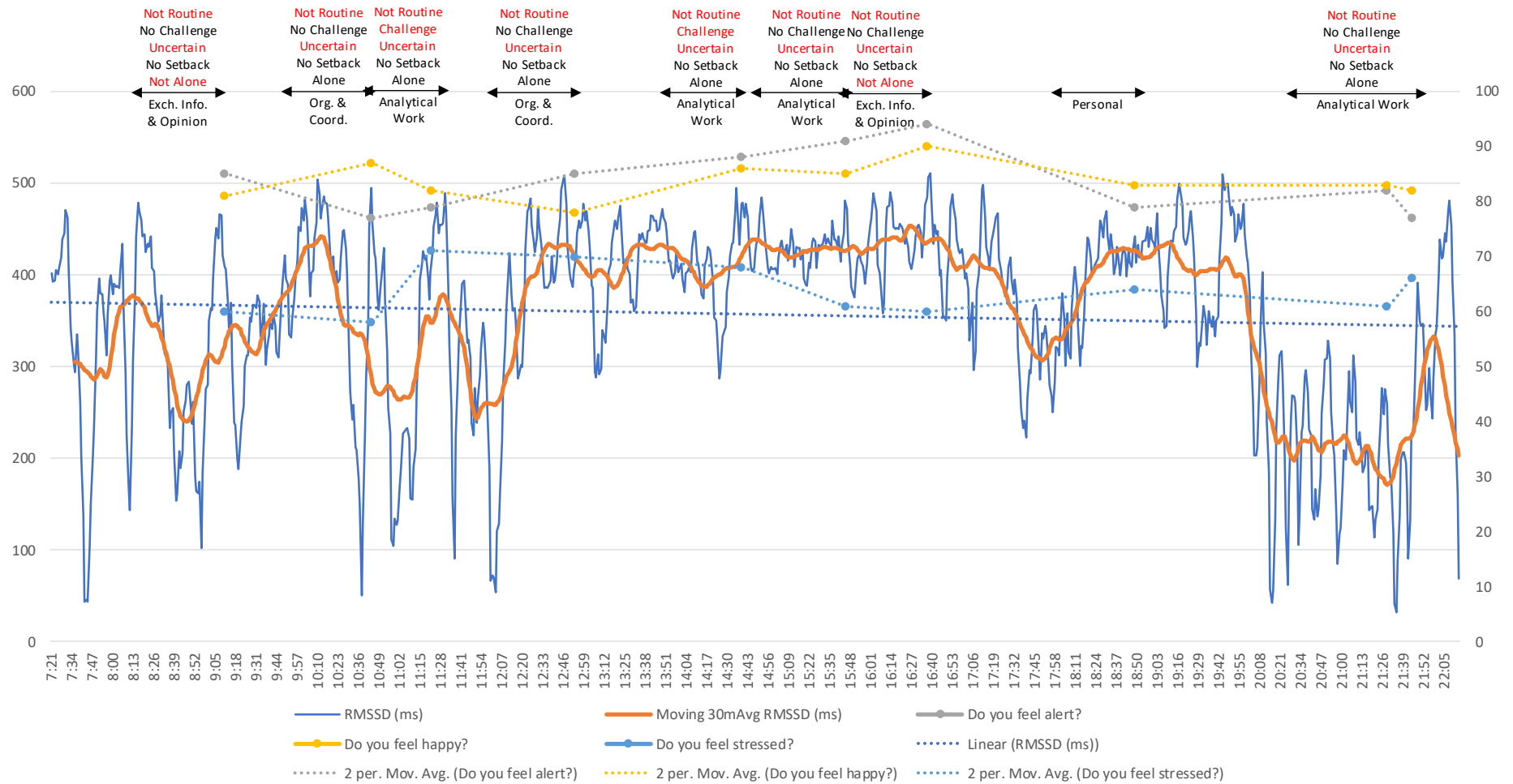




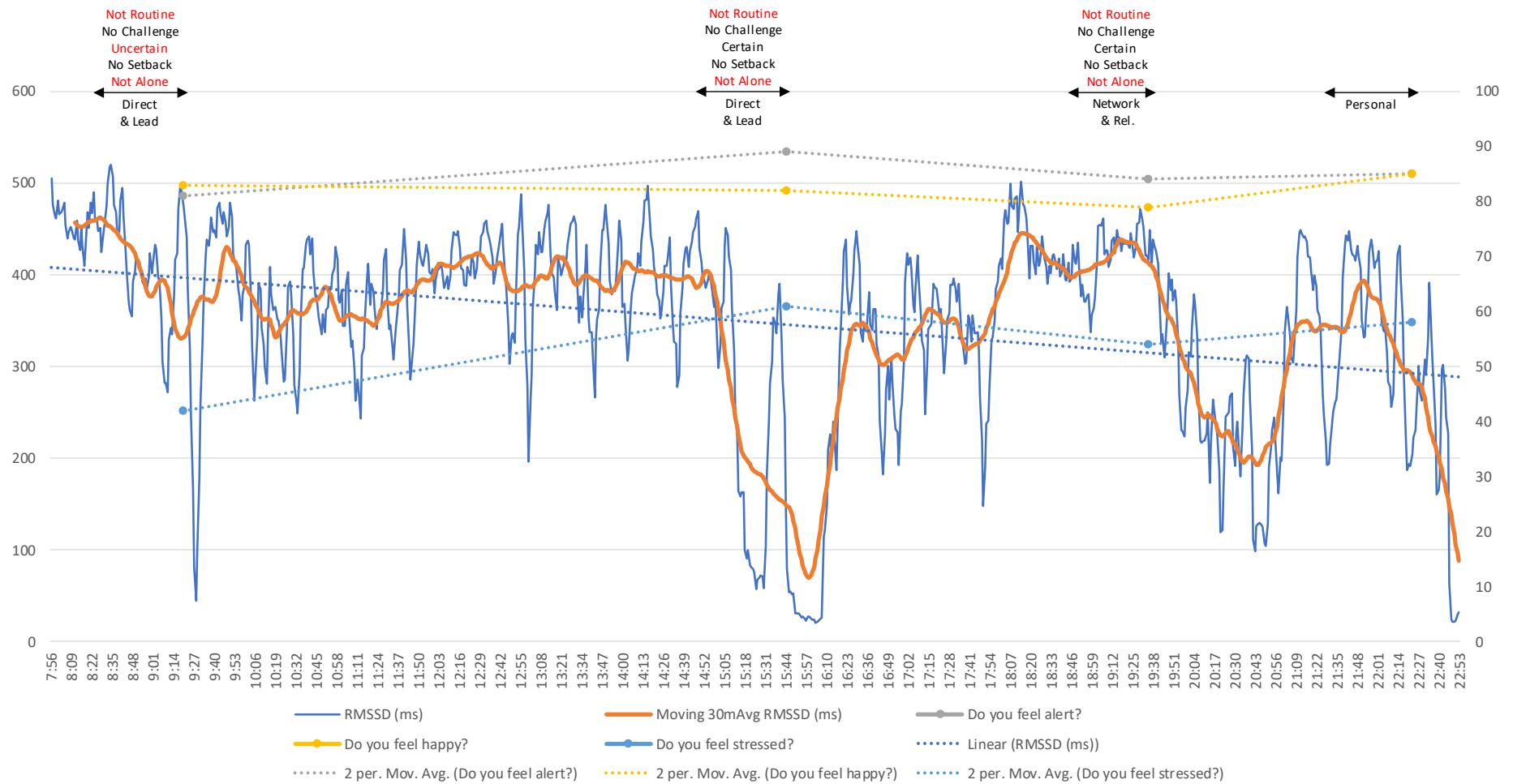
A-P1 Tue 21/Aug/2018



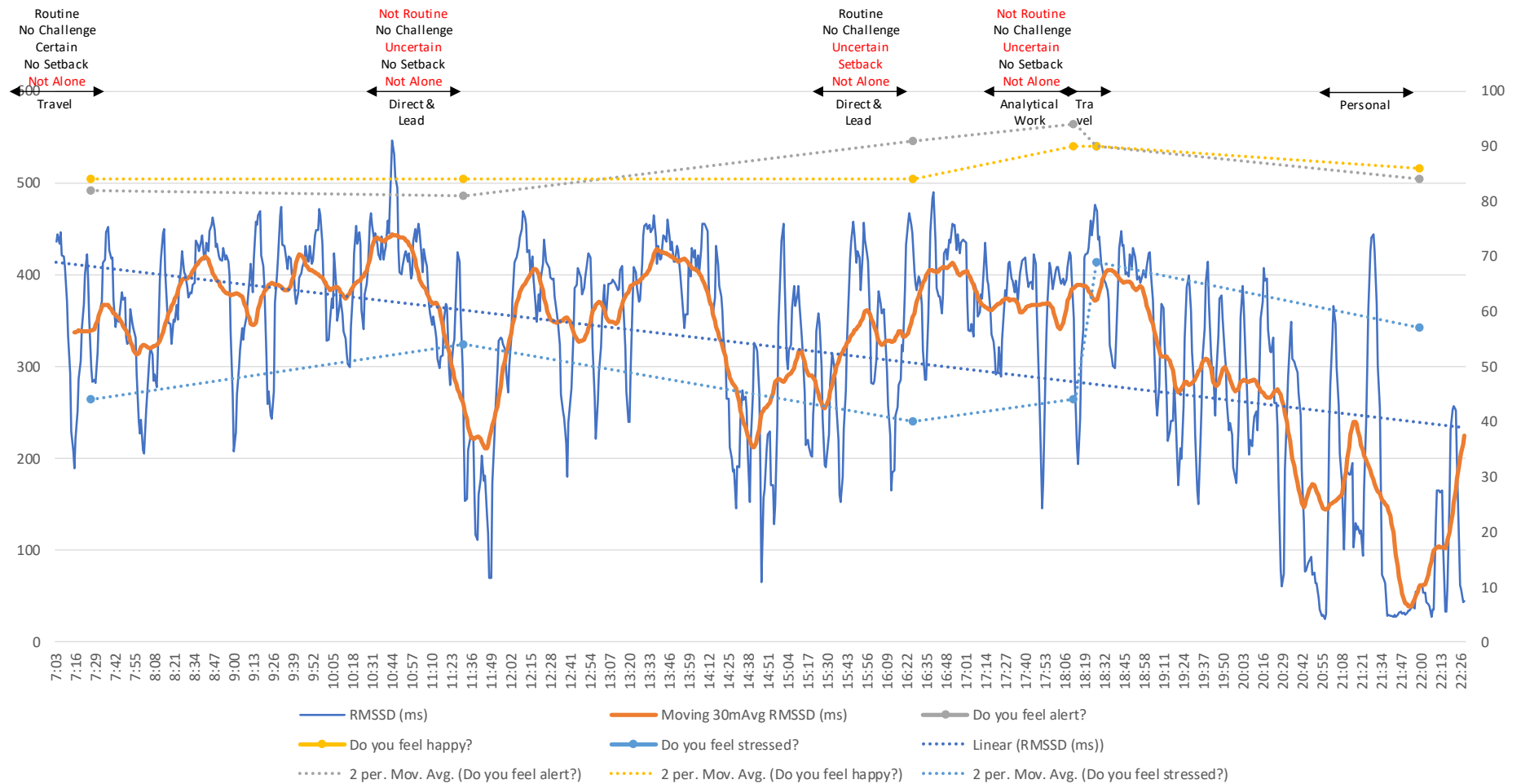
A-P1 Wed 22/Aug/2018



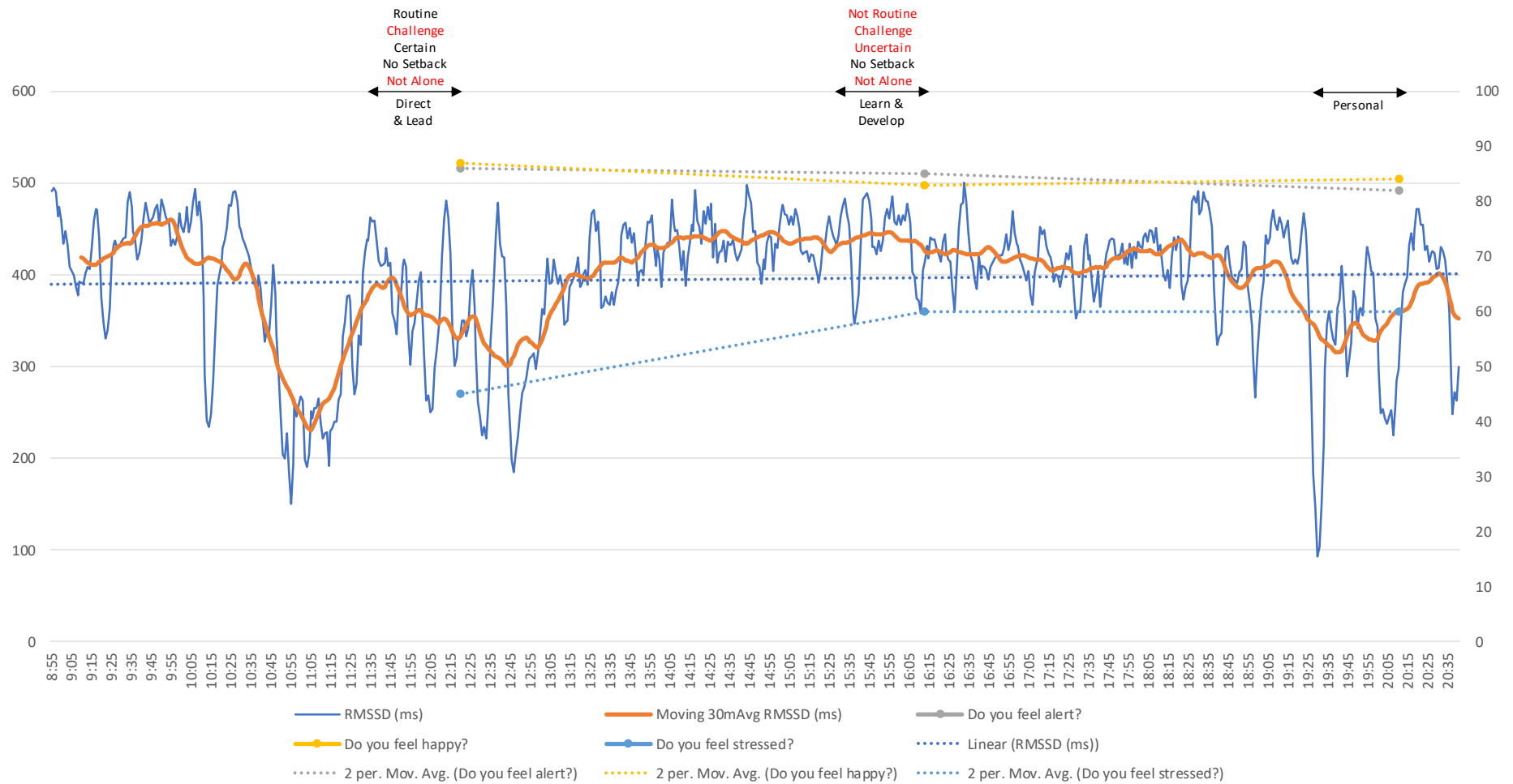
A-P1 Thu 23/Aug/2018

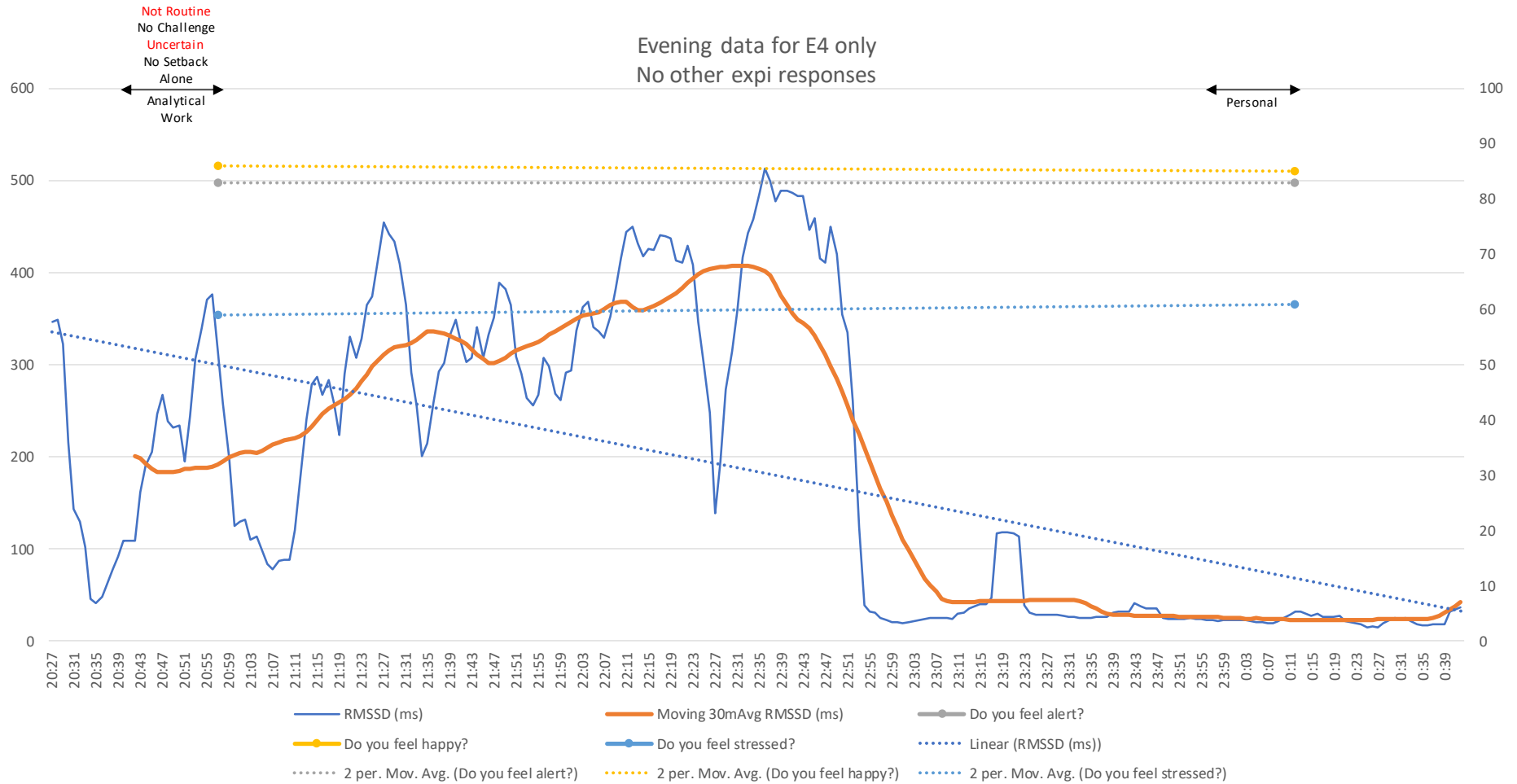


A-P1 Fri 24/Aug/2018

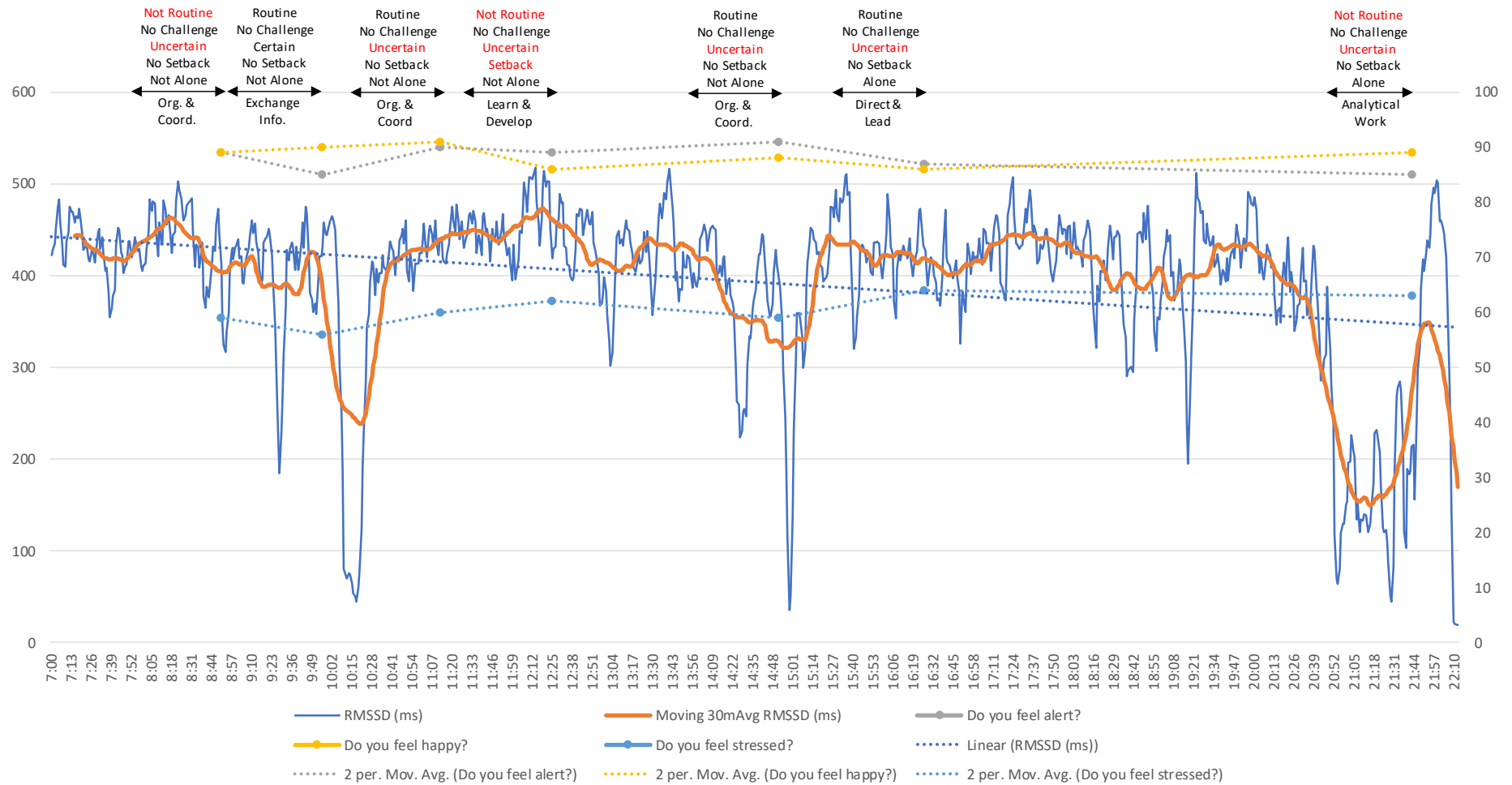


A-P1 Sat 25/Aug/2018

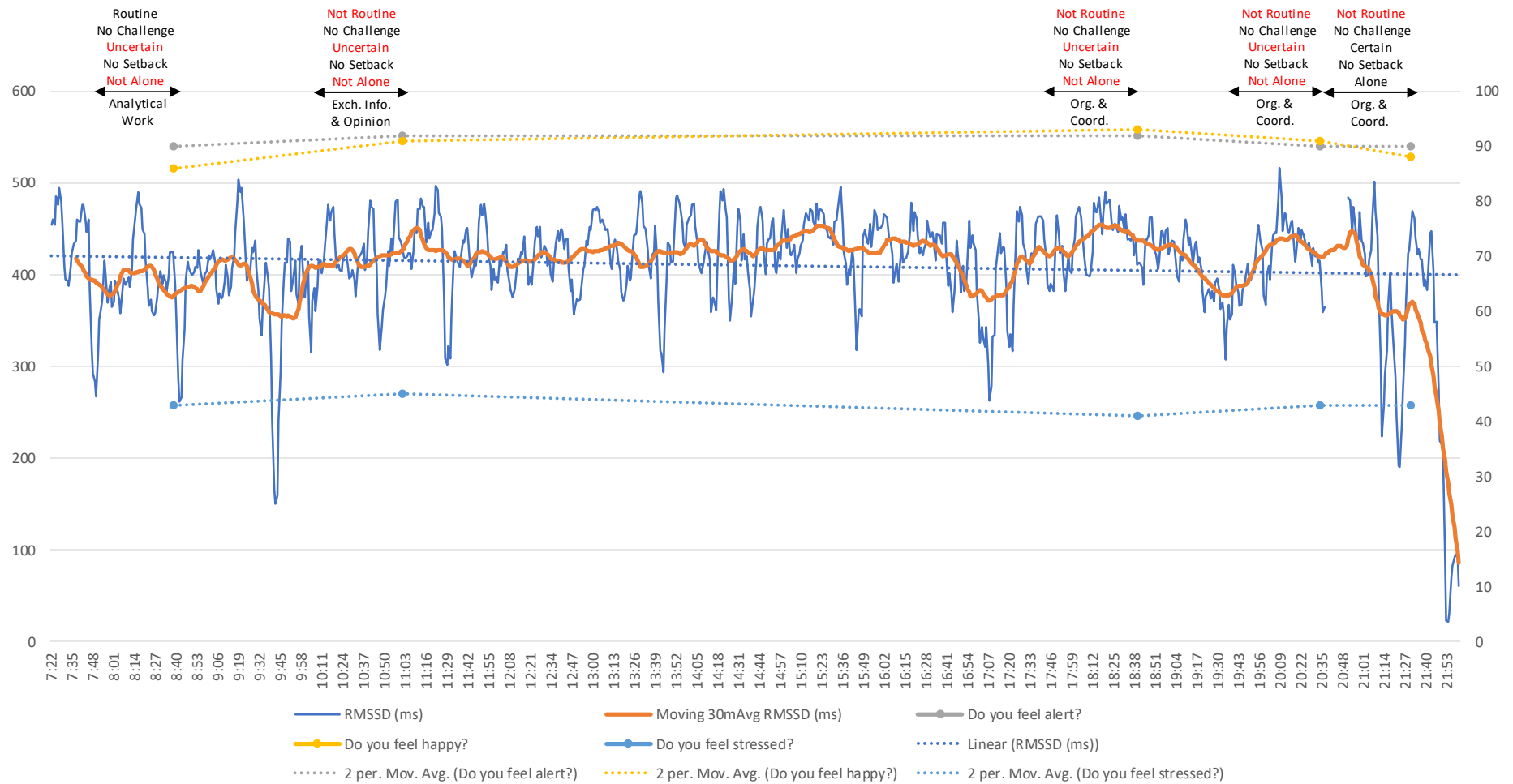




A-P1 Mon 27/Aug/2018



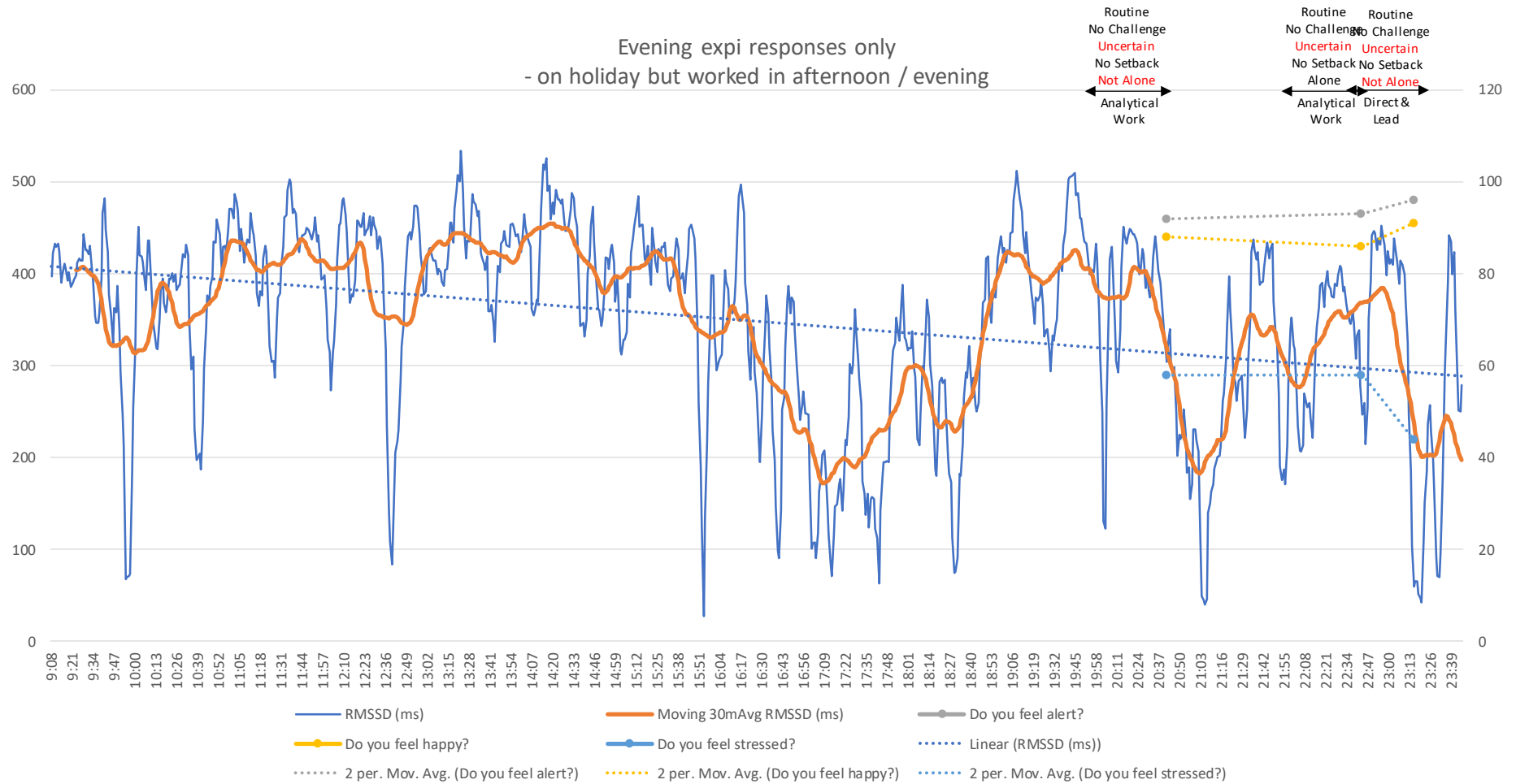
A-P1 Tue 28/Aug/2018

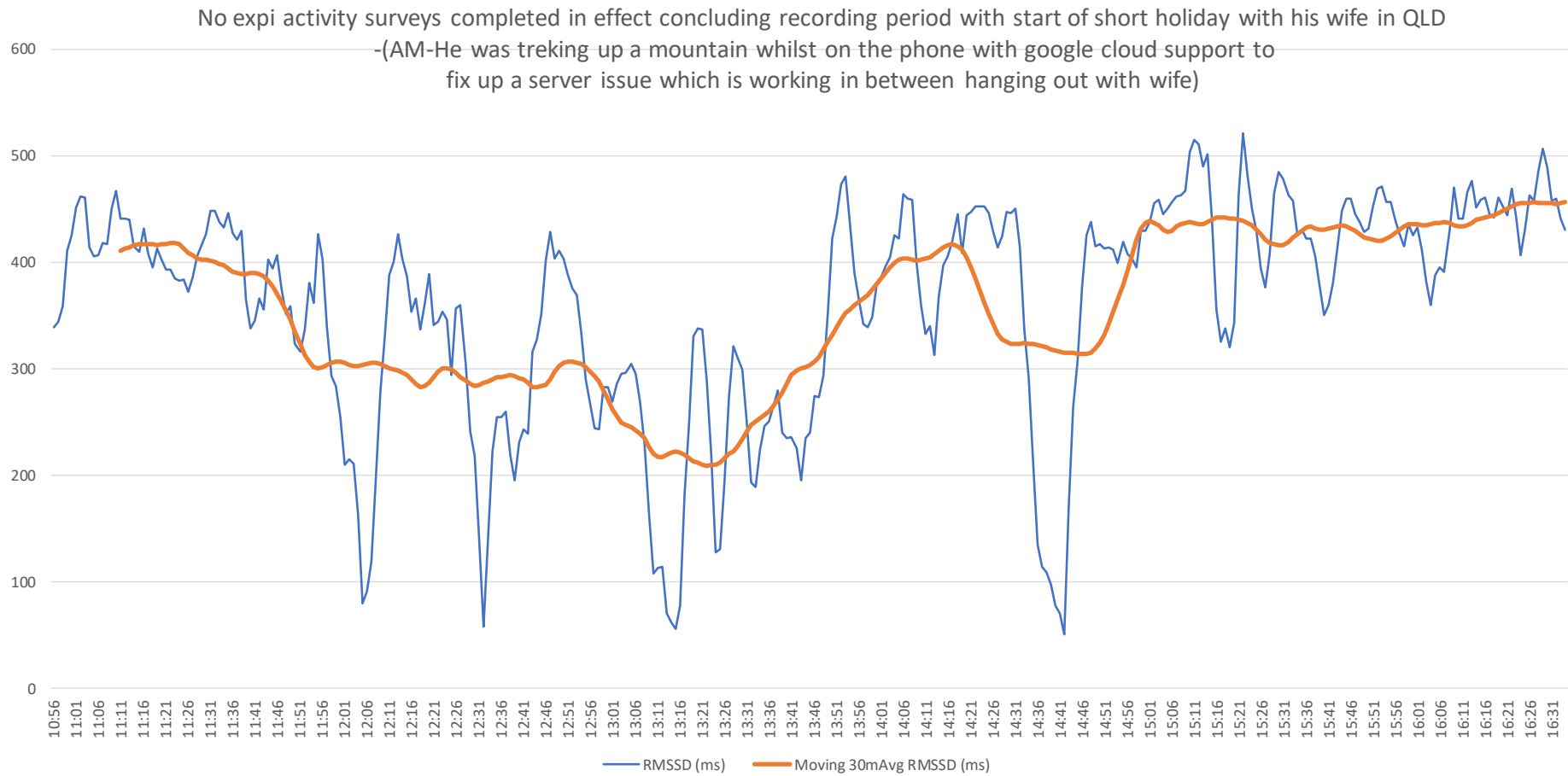




A-P1 Wed 29/Aug/2018

Evening expi responses only  
- on holiday but worked in afternoon / evening





8.6.2. Ongoing and Cumulative Charts

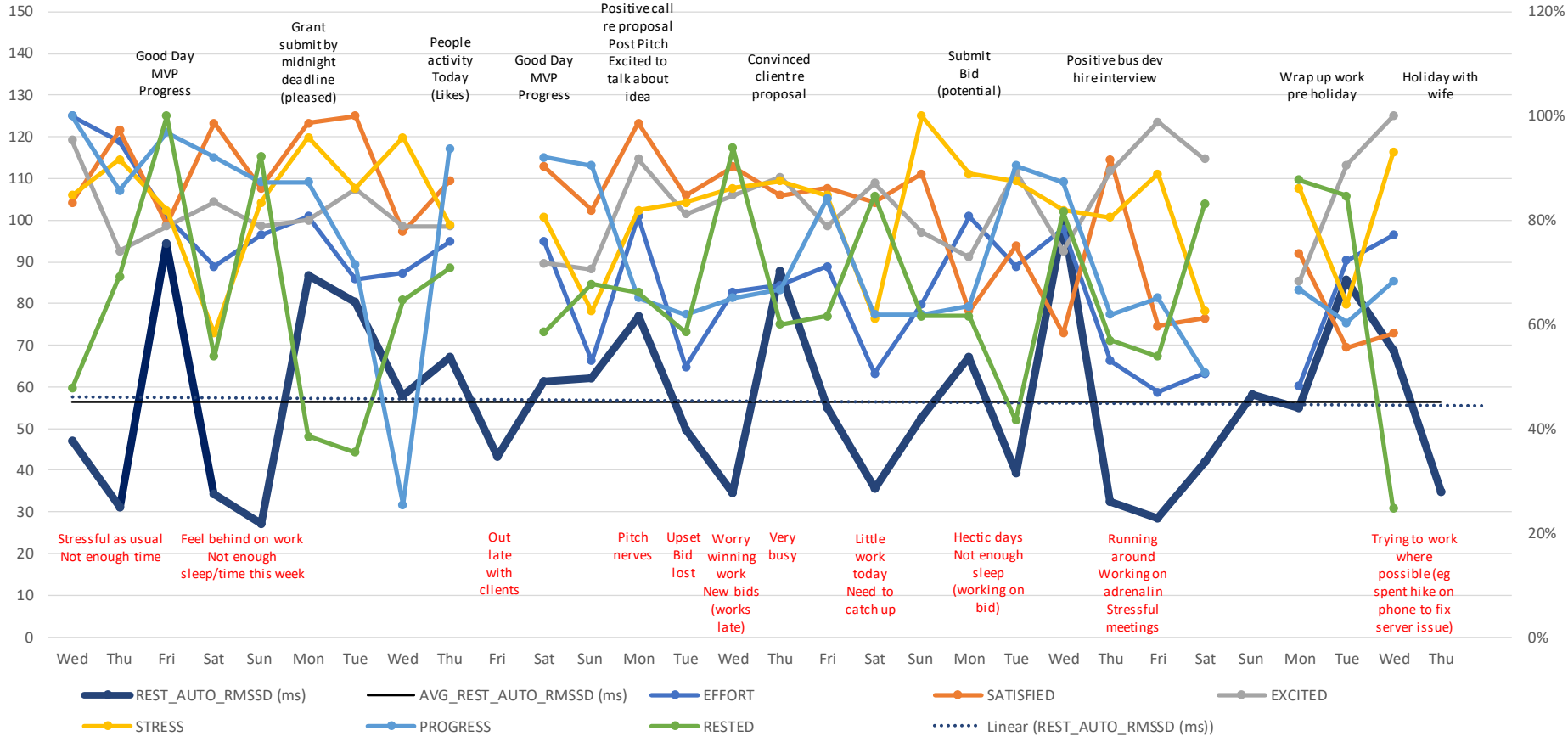


Figure 8-3: Participant A Period 1 Daily Journey

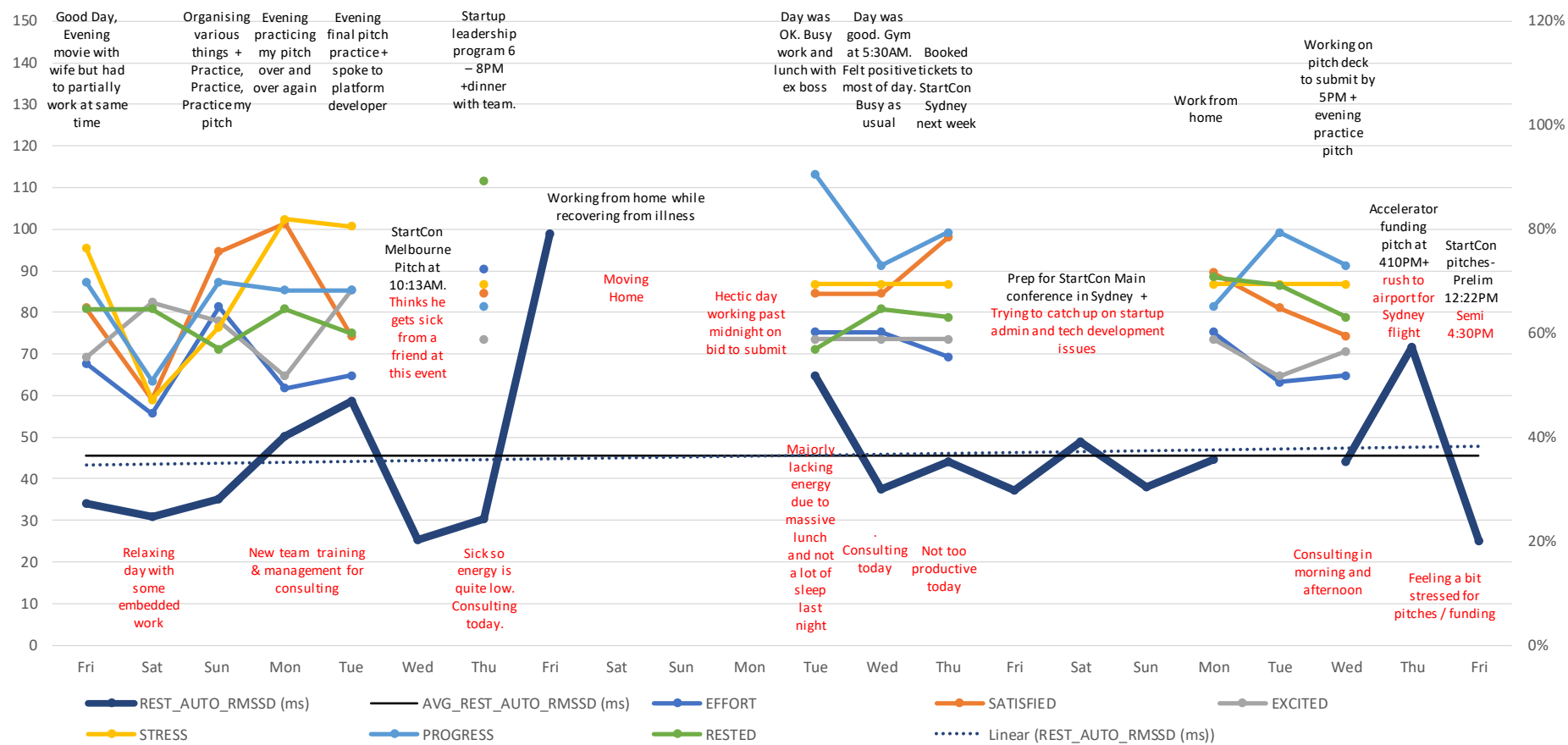
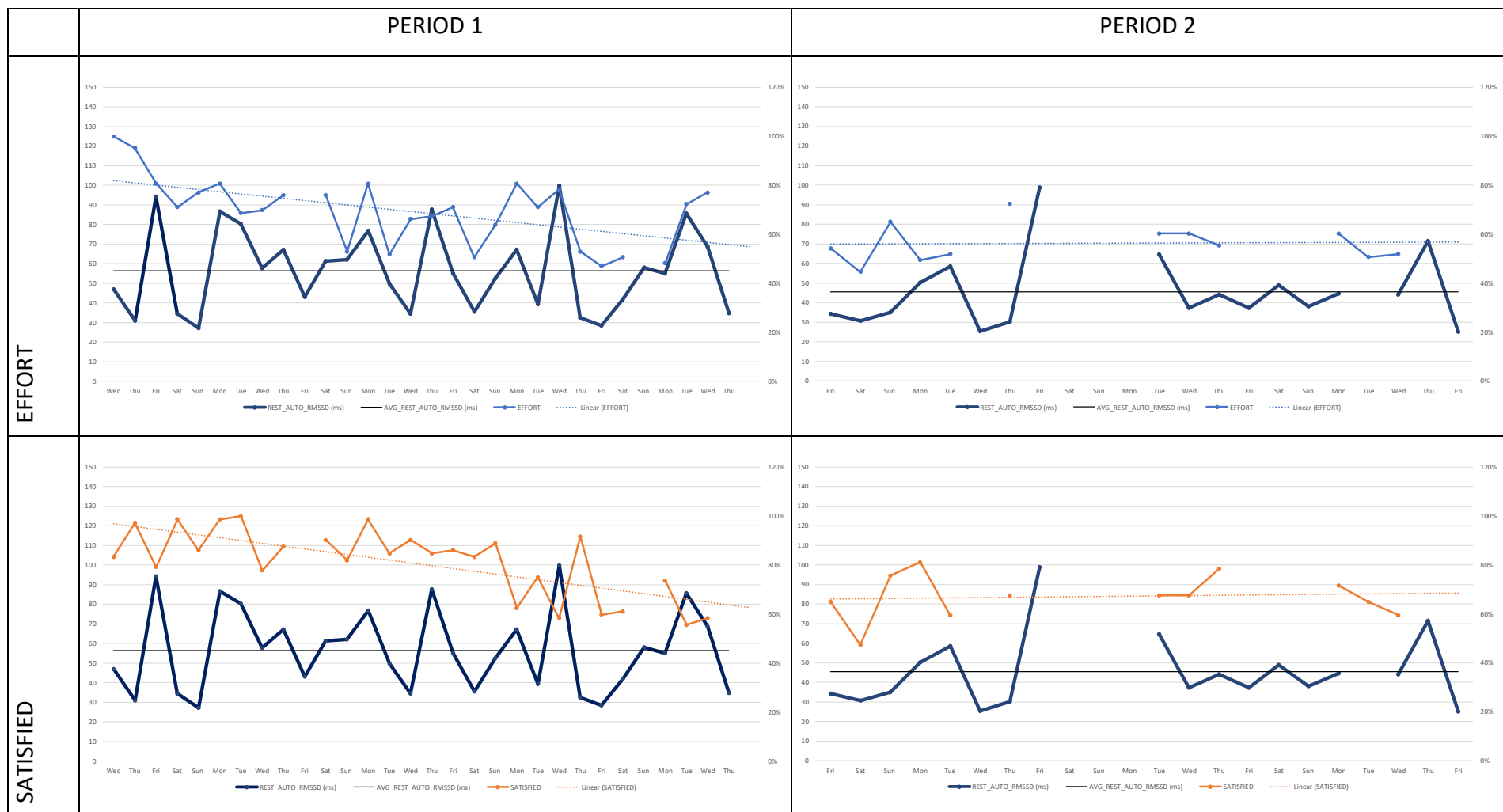
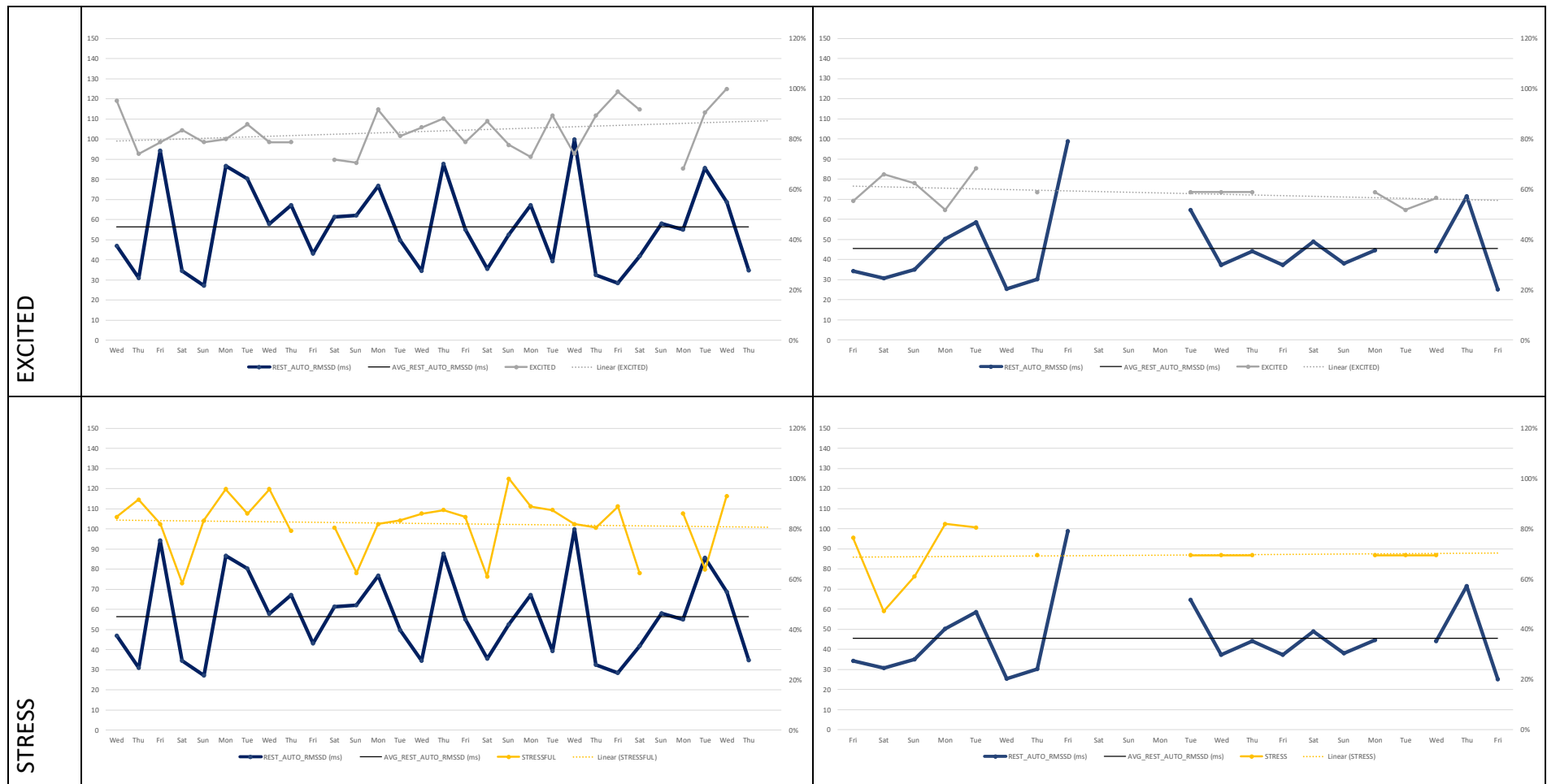


Figure 8-4: Participant A Period 2 Daily Journey





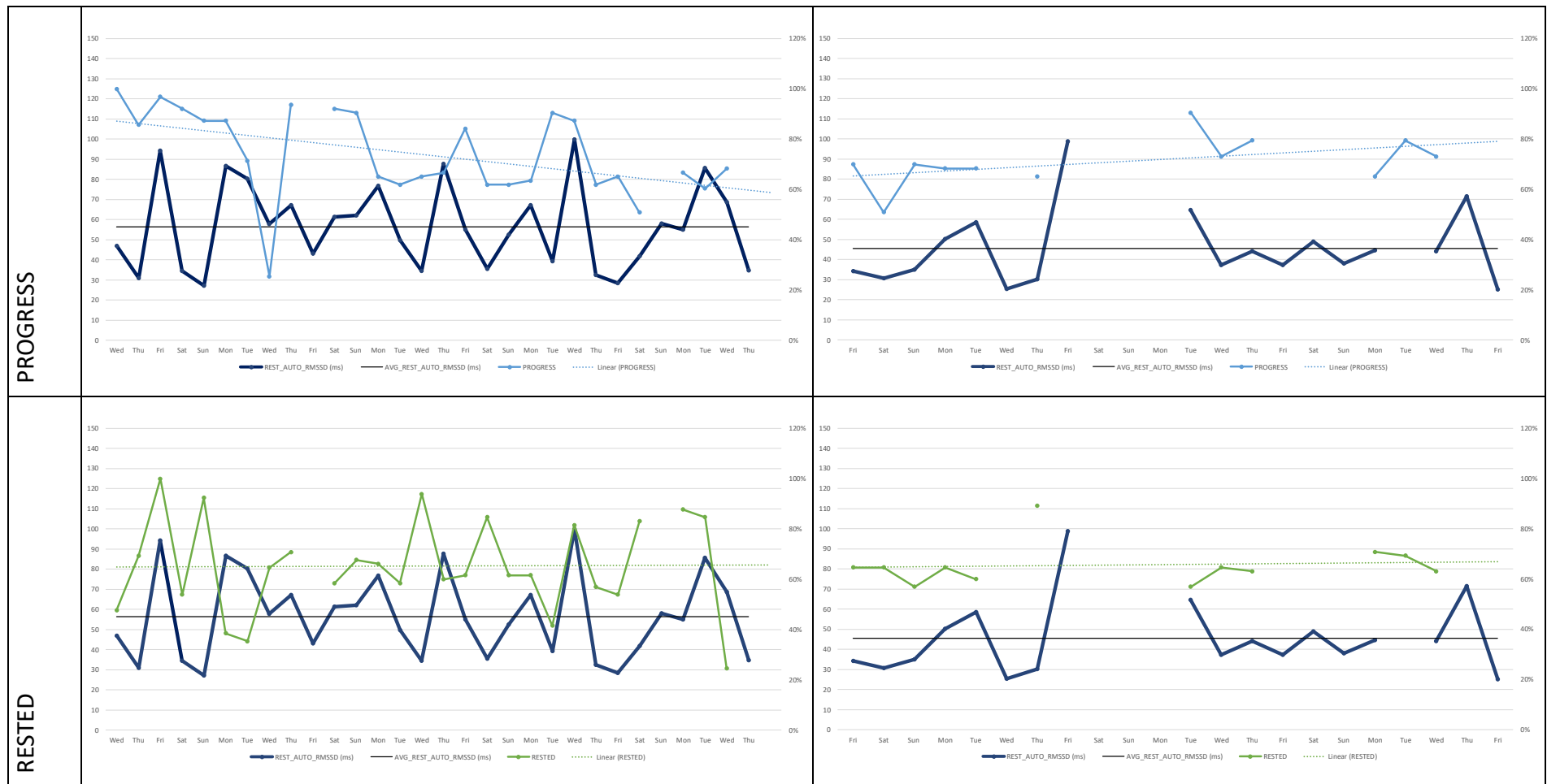


Figure 8-5: Participant A Period 1 & 2 Comparison Subjective Measures vs RMSSD

## 8.7. Conferences and Publications

### Refereed Conference Proceedings and Abstract

Arenius, P.M., Brough, A.P. (2021, June 11). Self-Managing on the Entrepreneurial Rollercoaster: Exploring Cycles of Self-Regulation Depletion and Recovery as Lead Indicators of Performance and Wellbeing Issues of Entrepreneurs. *2021 Babson College Entrepreneurship Research Conference (BCERC)*. June 8-11, 2021.

Brough, A.P. (2021, June 10). Opportunities and Challenges Integrating Physiological, Experience Sampling and Contextual Data for Exploring the Person-by-Situation Interactions and Processes of Within-Individual Change of Entrepreneurs. *2021 Babson College Entrepreneurship Research Conference (BCERC)*. June 8-11, 2021.

Arenius, P.M., Brough, A.P., Huq, A., Aslam, N. (2019, June 8). Insights from Adopting Wearable Sensors for the Study of Entrepreneurial Action and Emotion. *2019 Babson College Entrepreneurship Research Conference (BCERC)*. June 5-8, 2019. Boston, USA

Arenius, P.M., Brough, A.P., Huq, A., Aslam, N. (2019, June 7). Exploration of the Positive and Negative Emotional States Related to Entrepreneurial Actions and the Link to Sustained Entrepreneurial Performance. *2019 Babson College Entrepreneurship Research Conference (BCERC)*. June 5-8, 2019. Boston, USA



Page intentionally left blank